MATERIALS SCIENCE & ENGINEERING
UNIVERSITY of WASHINGTON

UNIT SELF-STUDY

Department of Materials Science & Engineering
College of Engineering
University of Washington, Seattle

Doctor of Philosophy (PhD), MSE
Doctor of Philosophy (PhD), MSE & Nanoscience

Master of Science (MS), MSE
Applied Master of Science (MS), MSE
Bachelor of Science/Master of Science (BS/MS), MSE
Bachelor of Science (BS), MSE

Year of last review: 2004
Chair: Alex Jen
Date submitted: 01/04/16

Table of Contents

Executive Summary

Materials science and engineering (MSE) is an enabling and multidisciplinary field that impacts nearly every aspect of modern society. In fact, its reach is enormous -- advanced semiconductors have stretched the limit of high performance computers and displays; optical fibers and modulators have dramatically increased the bandwidth and speed for information processing; magnetic materials in data storage have revolutionized information access in areas that include the proliferation of the internet; lightweight metals, polymers and composites have transformed aircraft design and fuel efficiency; novel solar cells and batteries now power many things from cell phones to electric cars, and innovation in materials is increasingly at the heart of medicine and biotechnology. As the late William Baker, past president of Bell Laboratories, put it so elegantly; "everything is made out of something and always will be!" In other words, MSE exemplifies "Pasteur and Edison's Quadrants", in which fundamental and applied studies in materials are use-inspired.

The importance of materials research is highly evident on the UW campus, with activities widely dispersed across departments and colleges. To actively interact with other units and transform UW-MSE from a traditional ceramics and metallurgy focus into an interdisciplinary unit conducting vibrant material research, education, and technology translation, a well-thought and coordinated strategy was designed and implemented to significantly improve the quality and performance of the department in the past decade. By embracing an entrepreneurial approach, we have accomplished many things while partnering across the college, campus, state, nation, internationally, and with industry, our alumni and other academic institutions. During this endeavor, we have significantly increased the quality, diversity, and number of faculty (hiring 8 tenure-track and 2 research-track) and students (enrollment increases of 50% for UG and 75% for Graduate), in addition to 50% expanded space for research and education.

Our students have performed very well and are well-recognized academically. For example, two of our recent graduates, Natalie Larson and William Hwang, were awarded the College of Engineering Dean's Medal in 2013 and 2015, respectively, which is the highest honor the COE can bestow on an UG student. Many of our students have also been placed into top-caliber graduate schools, such as MIT, Berkeley, UCSB, UIUC, and Northwestern, and launched their careers in companies such as Intel, Boeing and Micron among others. Our faculty's diverse research expertise and academic/industrial experience allows them to have joint appointments in other departments and colleges. They have played important roles in catalyzing cross-boundary collaborations that are critical to identifying fundamental engineering problems, sharing best practices and novel approaches, and supporting interdisciplinary education among UW, industry, academia and government laboratories. This vigorous effort has resulted in several federally funded large research initiatives in photonics, biomimetics, energy, medicine, and nanotechnology. Our faculty have also been well-recognized by professional societies. Several of them have been named as Highly Cited Researchers by Thomson Reuters (*http://highlycited.com/*), which represents the world's most influential scientific minds that are ranked among the top 1% within their subject field. The Global Research Report published in 2011 by Thomson Reuters also ranked UW as #1 in citation impact among worldwide academic institutions publishing materials science papers between 2001 and 2010. All these distinctions attest to the scientific excellence and impact generated by our faculty's creative research.

Our faculty members and students have also actively engaged in innovative technology development and translation in areas such as ultrahigh-speed information processing, biomedical imaging, biomimetics, drug delivery, printable solar cells, rechargeable batteries, chemical separation membranes, and manufacturing processes. As a whole, the department has been issued with more than 80 patents during this period, with many more are still pending. Faculty, by working closely with graduate students and postdocs, have launched 11 start-up companies. This is very important because it generates significant licensing revenues for the UW to further invest on cutting-edge research and education, and cultivates many new job opportunities for our students.

With a small but internationally recognized faculty, UW-MSE is committed to being both a leader and the focal point in materials related breakthroughs. We will build on our current strengths and also capitalize on exciting new opportunities to further improve the recognition and impact of our department in the future.

Section 1. Overview of the Department Organization

1.1 Mission

The mission of the Department is to be recognized as an outstanding student-centered organization that serves the industrial and academic needs of the University, the State of Washington, the nation and the international community. The department is organized to achieve its mission by:

- Providing the highest quality education and research programs in materials science and engineering that are at the forefront of national trends and integrating with regional strengths/issues/needs so as to prepare our students to function effectively in the evolving global economy;
- Serving as the focal point and catalyst for developing high quality, coordinated and visionary research and educational programs for materials-intensive students and faculty throughout the University so as to maximize our visibility and elevate the MSE department into the top tier in the nation;
- Strengthening our mentoring at all levels in order to promote the development of a diverse successful group of faculty, students, and staff.

1.2 Materials Science & Engineering Educational Programs

The Department currently offers the following degrees:

- BS MSE: Bachelor of Science in Materials Science and Engineering
- BS/MS MSE: A joint Bachelor of Science-Master of Science in Materials Science and Engineering
- MS MSE: Master of Science in Materials Science and Engineering
- AMP MSE: Applied Master in Materials Science and Engineering
- PhD MSE: Doctor of Philosophy in Materials Science and Engineering

The MSE undergraduate program is currently accredited by the Accreditation Board for Engineering and Technology (ABET). The last ABET review took place in 2013 and the last internal 10-yr review by the University was conducted in 2003.

The MSE department is a small-sized unit. Currently, it has:

- 14 tenure track faculty members (with Xiaodong Xu as a 0.33 FTE faculty shared with Physics and Devin MacKenzie as 0.5 FTE shared faculty with Mechanical Engineering)
- 4 research faculty members
- 125 undergraduate students (juniors and seniors) (30% women; 10% underrepresented minorities; 9% international)
- 110 graduate students (26% women; 5% underrepresented minorities; 42% international)
- 2 student counselors, 3 technical and 5 administrative staff members
- 8 adjunct faculty, 12 affiliate faculty, and 4 emeritus faculty
- 20 research associates (postdoctoral fellows)
- Awarded 44 BS degrees (23% to women; 6% to underrepresented minorities; 9% international)(annual average in the past 10 years)
- Awarded ~9 MS degrees (33% women; 5% underrepresented minority; 31% international) (annual average in the past 10 years)
- Awarded ~9 PhD degrees (30% to women; 9% underrepresented minority; 39% international) (annual average in the past 10 years).

1.3 Academic and Non-Academic Staffing

1.3.1 Academic Staffing

The organizational structure of the Material Science and Engineering Department is illustrated in **Appendix A**. There are 14 tenured and tenured-track faculty in MSE, including 2 jointly appointed faculty. There are also 4 research-track faculty. In addition, the Department has 20 adjunct- and affiliate-faculty that participate in advising graduate and undergraduate students. In addition to teaching faculty, the Department engages Teaching Assistants (TA)s and receives 12 quarters equivalent of TA support through State funds. To ensure that our students receive a quality education, the Department increases the TA support to 30 quarters by using funds generated through research overhead return, tuition recovered from the Applied Master Program, and the State proviso fund. Besides the regular teaching faculty, academic support is provided by one Undergraduate Advisor and one Graduate Advisor.

1.3.2 Non-Academic Staffing

The Department Administrator supervises a team of 7 staff members that perform various operational support services including human resources, grants management, fiscal operations, computing, facilities, junior labs, communications, and office support. The Administrator is also responsible for ensuring the compliance of all classified and professional staff positions in the Department. Finally, the large research enterprise is staffed with 20 Postdoctoral Research Associates in addition to 42 Academic Student Employees to perform various research-related tasks.

1.3.3 Leadership

The leadership team (Chair, Associate Chair, and Administrator) works closely to carry out the mission of the Department. The Chair is responsible for the overall operation and implementation of department policies and is assisted by the Associate Chair, whose responsibility is focused on student education and faculty teaching assignments. The Administrator is responsible for all administrative affairs of the Department. The leadership team is responsible for:

- Obtaining adequate resources to support existing and new activities of the department
- Planning all aspects of the department operations
- Reporting to the Dean of the COE and all higher officials at UW
- Advocating for the Department (including fund-raising and publicity)
- Managing all human resource related issues
- Ensuring compliance with governing policies
- Managing compensation and allocating department resources
- Managing and assigning department-controlled space
- Making all decisions that cannot wait for faculty votes

1.4 Department Governance

Department Governance works through a combination of internal and external committees and a democratic process that relies on the active participation of all faculty members. The Department's approach to shared governance is presented in **Appendix B** (Organizational Structure and Governance). The department faculty share responsibility for:

- Educational policy and general welfare
- Scholastic policy, including requirements for admission, graduation and honors
- Approval of candidates for degrees
- Criteria for faculty recruitment, appointment, tenure, and promotion

The standing faculty committees are appointed annually by the Chair to implement departmental policies (**Appendix C**). In general, Departmental policies are developed by the individual committees, either through the periodic reviews of specific issues that arise, or in response to external requirements and changes in need or condition. Proposed policy changes are brought to the biweekly faculty meeting through individual faculty or the relevant committees for further discussion and vote by the whole faculty.

Faculty appointments (new hires, promotion and tenure, endowed chair/professorships) are carried out in accordance with the specific rules of the UW and COE. For faculty recruitment, promotion or tenure cases, an *ad hoc* search committee will be formed with members nominated by the Chair. At the end of each process, recommendation from the committee will be presented to the whole faculty for voting. The Chair then acts on behalf of the faculty to implement the approved decisions. There are some exceptions to this process in cases of joint hiring, which also involve the voting within the other relevant departments.

The MSE faculty empower the Chair to commit departmental resources to retain critical faculty members, or make decisions (after consulting with the Executive Committee) regarding faculty compensation including merit and retention salary increases, endowed and administrative supplements, and the start-up for new faculty.

1.4.1 External Advisory Board (EAB): In addition to the internal faculty committees, the Department also actively seeks advice from the EAB on matters pertaining to the Department's mission regarding education, research, development, and professional service. The EAB was instituted in 2006 and consists of 12 members. The EAB meets with the Chair and faculty to evaluate the annual progress made by the Department and to make suggestions for further improvement. The EAB members consist of alumni and friends of the Department, financial investors, and industrial and academic leaders in materials related research, education, technology development and translation. Approximately 30% of the members are from academia, and the rest are from industry and financial communities. The Department strives to maintain a vibrant and knowledgeable EAB, with diversity in background, as well as in age, gender and occupation (**Appendix D**). The EAB activities include planning, advising and assisting in areas such as:

- Providing input regarding the departmental strategic plans
- Reviewing the curriculum and assessing program effectiveness
- Connecting students and faculty with industry, alumni, and friends of the Department
- Enabling students to identify internships and opportunities for permanent employment
- Helping initiate new research program ideas and funding
- Facilitating technology transfer and translation
- Assisting in the enhancement of state funding
- Helping raise private funds and endowments

1.5 Budget & Resources

Over the past ten years the department experienced serious State budget cuts (~18 - 21%) and salary freezes (4 consecutive years), a hardship experienced across the UW. We had to find creative ways to motivate the faculty and staff to continue working efficiently in development of the Department. By embracing an entrepreneurial approach, we partnered across the college, campus, state, nation, internationally, and with industry, our alumni and other academic institutions to leverage resources for faculty hiring, facility upgrades and expansion. We have also created a new Applied Master's Program that presently provides additional revenue (~$350,000/yr) for the Department to sustain its growth. During this endeavor, we significantly increased the quality, diversity, and number of faculty (hiring 8 tenure-track and 2 research-track) and students (enrollment increases of 50% for UG and 75% for Graduate), in addition to a 50% expansion in space for research and education. Our faculty's diverse research expertise and academic/industrial experience allows them to play important roles in catalyzing cross-boundary collaborations that have resulted in several federally funded large research initiatives in photonics, biomimetics, energy, medicine, and nanotechnology with very significant funding (more than $130M with contributions from the MSE faculty). Consequently, the research expenditure of the department has almost tripled from $2.5M/yr to > $7.5M/yr during this period of time. Moreover, this dynamic growth has substantially elevated the quality of the research and education conducted by the faculty and students. **Appendix E (Figures 1-4)** shows the MSE budget summary of the past 6 years (2010-2015).

1.5.1 Administrative Resources

At present, the Department is served by a team of ten staff members supporting the administrative, instructional, and research needs as outlined in the Organization Chart in Appendix A. The staff to faculty/student ratio in MSE has been the lowest of departments in the COE due to the constraint of State funding. However, the staff has been able to efficiently serve the faculty and students with the same team of 7 since 2005; with the exception of one retirement and two new hires in 2013.

1.6 Fund-Raising and Gifts

1.6.1 Advancement/Endowments & Gifts

In the past ten years, ten new endowments have been established from contributions of current and former faculty, loyal alumni, and family members of alumni to result in $1.66M (**Appendix F**). Each endowment supports strategic and critical elements of the department, including students, programs and operations.

1.6.2 Challenges

Fundraising among the department's loyal alumni has yielded many successes. However, as the department shifts its research focus from the pioneering disciplines of metallurgical and ceramics engineering to those needed to meet society's present-day and future demands, such as biomaterials and energy, some of the alumni may now feel disconnected. The Department's efforts are still guided by the same materials tetrahedron involving structure, processing, properties and properties. Thus, more opportunities are needed to showcase and explain the importance of today's research. Keeping alumni abreast of the achievements through periodic newsletters and social media outlets will help bolster their connection to the department. Likewise, introducing the alumni to today's bright students is a method to bridge the past with the future. Through activities such as guest seminars and receptions, the department has already begun to capitalize on opportunities to impress the alumni and keep them involved with the department.

1.6.3 Outlook

The department is poised to continue raising endowments and significant gifts. Departmental leadership, specifically the Chair, values fundraising and has been a critical partner to the Advancement Officer. Utilizing the EAB to engage potential major donors presents a strong fundraising opportunity. New members have already been recruited and more will join in the coming years to replace existing board members as they complete their service. Continued partnership with the Chair and other faculty leaders will ensure future strategic and successful fundraising initiatives.

Section 2. Teaching and Learning

2.1 Bachelor of Science in Materials Science and Engineering (BS-MSE)

2.1.1 Background

In 2002, the Department completed its transformation to an integrated materials science and engineering program by offering a single-degree, Bachelor of Science program in Materials Science and Engineering (BS-MSE). The BS-MSE program replaced the dual-degree program offerings in Ceramic Engineering and in Metallurgical Engineering. The single-degree program was introduced after thorough discussions among our department's constituents, including our alumni and industry partners, to establish a broader materials education program for our graduates, and to meet the demands and challenges of present and future materials science and engineering technologies. In 2011, the program was further expanded to include a Nanoscience and Molecular Engineering (NME) option to accommodate the vigorous campus-wide development of interdisciplinary research and education in this broad materials-intensive field.

2.1.2. Goals of the Program

An overarching goal of the BS-MSE program is to launch successful and rewarding careers. To maximize the career potential of our graduates, the Department's mission is to provide our students with comprehensive knowledge of the fundamentals and technical skills necessary to excel in materials science & engineering, and to be excellent communicators. Their knowledge and experiences will enable them to perform effectively as next-generation leaders in any broadly-defined materials field and within industrial, government or academic job environments. Our graduates are also expected to succeed in graduate programs, to become leaders in their chosen fields, and to participate in professional societies and organizations in the MSE field and engineering in general, all of which create societal impacts.

2.1.3. Student Enrollments and Graduation Patterns

The Department accepts students into the undergraduate program via three admission paths: (1) Direct Admission, (2) Early Admission, and (3) Upper Class Admission. Enrollment and graduation statistics for the MSE undergraduate program over the past ten years are presented in **Appendix G.**

The Department as a unit has produced 417 BS graduates since 2005. Before 2006, the undergraduate enrollment had reached the maximum capacity of ~90 per year, which could not be increased due to limitations of the existing course structures, an out-of-date infrastructure and insufficient TA and technical staff support for the undergraduate (UG) laboratories and other instructional facilities. To address these issues, we have developed an integrated approach that combines fund-raising to improve infrastructure and to provide student fellowships, streamlining and updating the course curriculum and increasing student advising and technical staff support. As a result, we have not only addressed the challenges to significantly increase student enrollment as mandated by the UW activity-based budgeting (ABB) system, but also accomplished this goal under a period of recent severe budget cuts (totaling 25-30%) by the State of Washington.

Our integrated approach has improved the curriculum lab facilities, lab support and student counseling. The results are impressive. UG student enrollment has increased by over 50%, from 90 students to 140. Funding for lab-upgrades and student fellowships has significantly increased through concerted efforts by COE Advancement, our MSE alumni, staff, and faculty. For example, inspirational efforts from our faculty and staff (Ohuchi, Kuykendall and Szeleczki) in leading student technology fee (STF) proposal competition submissions, has resulted in more than $800,000 additional funding that has allowed us to acquire state-of-the-art equipment and software for the MSE UG teaching laboratories. This funding is especially valuable because it is very difficult to receive federal or state funds to improve UG teaching facilities. The funding awards not only provide our students with access to state-of-the-art instrumentation and software, but also with new opportunities to integrate knowledge from the classroom with their laboratory and project work in material design, synthesis, processing, and characterization. This integration is the core foundation of MSE and is critical to their future career success in industry and academia. Examples of these exciting advancements are described in **Appendix H**.

These exciting new developments, in conjunction with the hiring of new faculty with diverse academic and industrial backgrounds and new academic counselors, have attracted a larger number of higher quality applicants as is evident by the improved GPA and SAT scores of the applicants. The number of granted BS degrees has also dramatically increased over 50 percent from ~ 36 per year from 2005 through 2010 to 55 per year from 2011 through 2014. We have achieved this increase in graduates without compromising the quality of our UG program. Our students have performed very well and are recognized academically. For example, two of our recent graduates, Natalie Larson and William Huang, were awarded the College of Engineering Dean’s Medal in 2013 and 2015, respectively, which is the highest honor bestowed by the COE to an UG student. Many of our students have also been placed in top caliber graduate schools, such as MIT, UCSB, UIUC, and Northwestern, and launched their careers in companies such as Intel, Boeing and Micron among others.

2.1.4 Program Curriculum and Strategy to Achieve Program Educational Objectives

The undergraduate program has three primary curricular components: (1) a set of 100- and 200-level prerequisite courses including math, science and engineering fundamentals, (2) a set of required core 300- and 400-level MSE courses that taken by all MSE students, and (3) 400-level elective courses that senior students can select. Specific requirements for degree and relevant curriculum information are described in **Appendix I.1.**

In order to achieve the departmental educational objectives, we require students to:

- Take courses in the fundamentals of mathematics, physics, chemistry, and mechanics, as well as classes that integrate fundamental core materials science and engineering concepts in a manner that provides a balanced understanding of material systems and emphasizes structure-processing-properties-performance relationships;

- Participate in experiential learning through “hands-on” laboratories in their Junior year;
- Utilize the laboratory courses and the senior thesis as a means to develop skills in designing and conducting critical engineering experiments;
- Develop written/oral communication skills in lab and humanities/social science courses;
- Work with industry to create practical engineering experiences for students. These include presentations from practicing professionals, visits to industrial plants, participation of engineers in teaching and project supervision, and co-op/summer employment opportunities for undergraduates;
- Participate in student chapters of materials-related professional societies, and develop and maintain an active outreach/recruitment program to attract high-quality students from diverse backgrounds;
- Be advised by the technical/administrative staff for a high quality learning experience;

Procedures currently adopted for the assessment and evaluation of student achievement of our educational outcomes are summarized in **Appendix I.2.**

2.1.5 Student Societies

One crucial component of our UG experience is student involvement in professional societies. These societies supplement our curriculum by providing students with additional opportunities for growth that will help them achieve their goals and career potential. The professional societies provide 1) professional development through supplemental educational activities such as plant tours, local and national networking with colleagues and local professionals, conference participation and by informing students about MSE employment opportunities; 2) leadership development through officer service and participation in student-run activities and in fundraising; 3) opportunities for students to learn how to participate in exciting group activities such as nationally sponsored engineering contests, that require the development of important communication and organization skills, and that heighten student morale and esprit-de-corps; 4) an understanding of the importance of disseminating knowledge about MSE and other fields, through participation in educational outreach activities and 5) an opportunity to develop a global awareness of the role of MSE in today’s diverse world.

UW-MSE sponsors three student professional societies that directly benefit our students. They are (i) Material Advantage (MA), a consortium of The Metals, Minerals and Metals Society (TMS), ASM International (ASM), The Association for Iron and Steel Technology (AIST) and The American Ceramic Society (ACerS), (ii) the Keramos ceramics society and (iii) the Society for the Advancement of Material and Process Engineering (SAMPE). Each society is overseen by a national organization and has student leadership, as well as a faculty advisor to provide mentorship, advice and guidance to the Chapter. Chapter leadership collaborates to coordinate many Department activities, such as barbecue fundraisers and other social events, and presentations for the annual College of Engineering Discovery days. Each Chapter also participates in national engineering and speaking contests, and has a presence at national professional conferences. It is to be noted that the Material Advantage student society coordinates outreach activities for the MSE Department (and for the society) during the academic year. Therefore, Material Advantage plays a crucial role within the local educational community in promoting the interest and insight into the fields of materials science and engineering.

There is a great deal of local support for the student societies from local professional chapters. The Puget Sound Chapter of the ASM subsidizes student MA membership costs, and sponsors an annual student speaking night where undergraduate and graduate students can present their materials engineering research. They also provide awards for two students to participate in the annual MS&T conference.

2.1.6 Student Surveys and Satisfaction

All courses in the department conduct anonymous student surveys devised by the University’s Educational Assessment Services. This is an important assessment tool that provides student feedback on effectiveness of our courses in meeting specified outcomes. The Center for Instructional Development and Research (CIDR) also conducts an in-class review of the program in the spring for graduating seniors, in order to evaluate the degree of their satisfaction of the program in academic standards, adequacy of training and facilities, quality of the faculty and mentoring and career preparation. The feedback is used by MSE to set directions for the curriculum, address specific curriculum and resource issues, and set Departmental priorities. Summaries of previous reports are presented in **Appendix J.**

2.1.7 UG Career Placement

Student placement is assisted by our faculty, who identify available positions through their professional contacts. The department also provides students with placement information, advertisements of specific job openings, and maintains a comprehensive, full list of material-related companies in the U.S. The Academic Counselor is the focal point for gathering placement information, coordinates visits by recruiters and works with the University Career Center to develop workshops and training sessions for our students. Career placement is also discussed in several courses (MSE 310, MSE 491, MSE 492 and MSE 499). We encourage students to pay attention to future career planning and job opportunities in the introductory course MSE 310 and in the capstone course MSE 491. In MSE 310, the students generate their resume.

The career placement data collected between 2005 and 2014 for our UG students indicates that >90% of our BS graduates are employed by industry or enrolled in graduate/professional schools within one year of graduation (see **Appendix K**). Our graduates find employment in the aerospace, automotive, biomedical, chemical, construction, electronics, energy, telecommunications, and transportation industries. Before 2004, ~18-20% of our graduates chose to pursue advanced degrees in graduate schools, and this trend has significantly increased to >30% in the past few years. This testifies to the effectiveness of our broader course coverage that includes current materials topics, and the interdisciplinary research opportunities provided to the UGs by the faculty that greatly enrich their learning experiences. These factors have inspired many of our UGs to pursue a deeper understanding of the MSE field in graduate school. We are very proud of the excellent foundation laid for our students to embark on their careers in a diverse array of academic and industrial career paths.

2.1.8 Future plans

The materials engineering community is becoming more diverse and specialized as new materials are continually being created and integrated into the fabric of our society. Universities across the country are adapting to this new reality, and our department has evolved accordingly, having combined several disciplines since the early 2000s. While the current UG program provides a comprehensive curriculum to meet today's societal needs, it also produces well-prepared BS-MSE professionals with the needed knowledge and skills in the basic areas of MSE. This prepares our students with deeper insights into specific career paths prior to graduation. Since the materials field and the needs of our students and the state of Washington are constantly evolving, our Department continually revisits ways to restructure and improve our course curriculum to best meet current demands and future expansion. Currently, in terms of UG admission, there are plans to implement direct freshmen admission to the COE, engage freshmen and sophomores more actively in the MSE program through new course offerings and better advising, and to increase the selectivity of the upper division UG admission process. We will continually monitor the development of our students and their achievement of program outcomes.

2.2 BS/MS, MS, and Applied Master (AMP) Programs in MSE

2.2.1 Background

The Department has three different programs leading to a Masters degree, the Bachelors of Science/Masters of Science (BS/MS), the Masters of Science (MS) and the Applied Masters Program (AMP). The BS/MS program enables those undergraduates with demonstrated promise for success in research to begin their graduate work as an undergraduate. Typically, this begins by the student performing independent research with a faculty member as a junior and/or senior. Although not a requirement of the program, the majority of BS/MS students carry out substantial research, culminating in a thesis, a public presentation of the work completed, and often in publication of their work in archival journals.

The Masters of Science program is a degree track that is not offered to new students. In instances where a Ph.D. student encounters extenuating circumstances or has a change of heart, they may be recommended to finalize their work early and earn an MS degree. Completing the MS degree requires a thesis and a public presentation of the work accomplished.

The AMP's Master's degree was approved in 2012 and is currently in its 4th year. It was developed to provide a pathway for rapid technical training in areas of national need (e.g. aerospace materials, biomaterials, energy, etc.) as well as to increase the student/faculty ratio of the MSE department. This program attracts a diverse group of students, including students who have intentions to pursue a Ph.D. degree but are still exploring MSE fields, students from other majors who are attracted to the field of materials science and engineering and students who wish to find employment in the Pacific Northwest and then seek applicable training. The AMP involves an integration of coursework and a special project, which culminates in a public presentation of the work completed.

2.2.2 Goals of the Programs

The primary goal of the BS/MS program is to provide the Department's most promising undergraduate students a more direct route to graduate studies. The program is designed to enable students to earn both the BS and MS degrees within 5 years. Additional goals of the program are to introduce these students to exciting opportunities that are beyond the standard BS experience and to help them develop into excellent scientists. The BS/MS students often contribute substantially to the faculty research endeavors.

The goals of the AMP depend on a student's individual needs. Some enroll in this program as a stepping-stone to the Ph.D., while others hope to strengthen their skills in preparation for their desired employment. As the AMP is a relatively new program, the MSE department is working to best accommodate the breadth of the student backgrounds and interests. The primary Departmental goals include: 1) offering courses that support a variety of student endeavors from fundamental science to applied engineering courses, 2) utilizing the resources generated from the AMP to further the Departmental mission in education and research (e.g. providing student stipends, new initiatives, travel awards, etc).

2.2.3 Student Enrollments and Demographics

Enrollment in the BS/MS program is student-driven and requires a minimum GPA of 3.4. Enrollment often results from the encouragement of a faculty member. While this program has historically attracted 3 or 4 students per year, more than 10 students applied for the 2015-2016 year and enrollment has increased to 7 students. We attribute the growth to an increase in BS enrollment, the exciting faculty research programs, and efforts of the UG and Grad coordinators in publicizing the opportunity. The BS/MS program is expected to attract between 5 to 8 new excellent graduate students per year in the future and is an effective tool for recruiting graduate students. Additional undergraduates that are not eligible for the BS/MS are recommended to enroll in the AMP.

A summary of the annual admissions data and enrollments for the AMP is shown in **Appendix L (Figures L1-L3)**. Although the distribution varies with year, on average the new admits have been approximately 40% domestic and 60% international. There are two important applicant pool highlights. First, there has been a very large growth in the number of applicants (from 13 in 2012 to nearly 150 in 2015) representing an increase by over a factor of ten in four years! There has also been a substantial increase in the yield from the admission offers (to over 50%). Both highlights indicate that the reputation of the program is improving. In 2014-2015 and 2015-2016, the program enrollment has been limited to 25 students each, in order to ensure continuing high program quality. Due to the increased number of applications and admission offers, the program has become substantially more competitive. Consequently, the quality of the students enrolled is also increasing. A recent comparison of the performance between AMP and Ph.D. students in selected courses shows that the AMP students are performing nearly as well as the Ph.D. students, which is very encouraging. Another observation is that students are electing to stay in the program longer than a single year, due to their' desire to participate in faculty research and/or in industry as interns. Additional details concerning the enrollment figures and demographics are listed in the Appendix **L**.

2.2.4 Curriculum

Students within the BS/MS, MS and AMP programs enroll in many of the same courses, although there are differences in the number of courses and research/project credits required for the programs. For the BS/MS students, they must complete 36 additional credits beyond the BS, including 9 research credits. The MS program requires 27 credits of coursework and 9 research credits. The AMP requires 30 credits of coursework (10 x 3 credit courses) and 6 credits of independent study. Those 6 credits may also be fulfilled by an internship. While the BS/MS and MS programs culminated in a thesis, the AMP students do not generally write a thesis.

The AMP has two general tracks that accommodate students interested in i) fundamental science and ii) applied engineering. Two new courses have recently been developed to accommodate students in the "applied" track of the AMP: (1.) MSE 599M: Materials in Manufacturing, and (2.) MSE 599E: Entrepreneurship and Commercialization in MSE. The second course will be offered for the first time in the Winter Quarter of 2016. To meet the needs and interests of the AMP students, additional new courses are in the planning stage. For the AMP students there are two options for fulfilling the project component: research performed within a research laboratory on campus, or an internship. Both options require a project report and a public presentation summarizing the work.

2.2.5 Job Placement

Students in three programs have a number of sources to help them prepare for job searches, obtain internships and obtain full-time employment. In addition to faculty contacts, the Career Center provides services, job listings and arranges interviews. The Department also distributes new job opportunities to the students via e-mail notices of as they become available. A new MSE Intern Program is currently under development the purpose of which is to increase the number of student internships that frequently lead to full-time positions. The AMP graduates have been successful at obtaining positions in industry and in gaining acceptance into competitive Ph.D. programs. For example, after an internship at Boeing, Jake Plummer (AMP 2014) accepted a position as a Materials Engineer for Boeing's Next Generation Composite program. Samantha Yuan (AMP 2014) accepted full-time appointment as a Materials Scientist at Cymer in San Diego, CA where she is utilizing new light sources for patterning semi-conductor chips. After completing her MS degree, Xiaolin Zhang (AMP 2012) is presently pursing a Ph.D. degree in MSE. John Felts (AMP 2015) is completing his project on dermal needles and has been accepted to the Ph.D. program at UC Santa Cruz. The program has also ignited entrepreneurs: Dan Sedlacek (AMP 2013) started Uphill Designs, a company that designs sustainable trekking gear.

2.2.6 Student Surveys and Satisfaction

The AMP has an annual "pizza-chat" where it solicits student feedback about the program. Positive feedback includes student enjoyment of program flexibility, and the opportunity to work with faculty. Although there has been no negative feedback, the students expressed an interest in having MSE offer more option courses and more help in finding internships. Both concerns are currently being addressed, through the development of new courses including MSE 599E: Entrepreneurship and Commercialization in MSE and MSE 533: Principles of Materials Characterization. In addition, Prof. Jihui Yang is developing an internship program. Surprisingly, many students commented that they would like the program to last more than one year (e.g. 2 years to allow more time to engage in internships and to include an extended summer period for research, etc.). This concern is easily addressed because of the program flexibility. In a recent survey, the students also expressed interest in improving their access to developing skills in microscopy, clean room, etc. that will provide even greater program impact. Clearly the AMP is improving and the students value the available opportunities.

2.2.7 Future Plans

The BS/MS and MS programs are expected to continue without substantial change. Future plans for the AMP are targeted on increasing the quality and quantity of the students, as well as expanding the research and professional opportunities. The program currently enrolls 25 students, which will remain constant until all student needs can be fully met. It also provides the Department with a new significant revenue source that can be used to further strengthen our program. There are tentative plans to increase the program to more than 25 students, but that will require identifying ways to increase the course offerings and the number of student project advisors. Expanding the number of internships and industrial opportunities will help in this regard as well. There are plans to initiate a global engineering traineeship program that involves opportunities for international education and in industrial projects with partners in Japan.

2.3 Ph.D. Program in MSE

2.3.1 Background

Over the past 10 years, the Ph.D. program in the MSE department has maintained a size of 60-70 students. However, we have made a significant improvement in the quality of enrolled students, which is reflected by the 9-15% increase in average GPA and GRE scores of the incoming classes over the past 10 years (**Appendix M, Figures M1-M2**) and as described in Section 3, the department has seen significant growth in the research that is being performed. We attribute the increased grades/scores to our ability to be more selective during our admissions process. We have been able to be more selective because we have seen a large increase in the number of applicants over the 10 years, which in turn has been affected by greater visibility of our department within the country and internationally.

Given that our Ph.D. students facilitate undergraduate education by serving as teaching assistants, and they are our principal researchers in the department, the success of both the undergraduate program and the department relies strongly upon them. The Ph.D. program has been run over the past 10 years with the belief that the quality of the students who comprise the program are critical to Department's success as a whole, and significant efforts have been put forth to attract the best students possible.

2.3.2 Goals of the Program

The Ph.D. program offers educational and research opportunities in processing, characterization, properties, and applications of all classes of materials. Our primary goal is to prepare our students for careers as the next generation leaders in industry and academia. We do so by providing a set of core courses and teaching practices common to all materials scientists, and then through student research, where results are published in peer-reviewed journals appropriate to their specific research areas. The students are encouraged to attend technical conferences to present their work so that they can develop professional communication skills and to provide networking opportunities. Our graduating students are expected to have an in-depth understanding of the fundamentals of materials science and engineering; have expertise in specialized areas necessary to complete their thesis work; be able to apply knowledge in their specialized areas to a variety of science and engineering problems; be prepared to teach materials science and engineering at the undergraduate and graduate levels; and be able to apply their knowledge to solve commercially viable problems for generating societal impacts.

2.3.3 Student Enrollments and Demographics

The number of applicants received annually has increased dramatically in the past 10 years. In 2005, the number of applicants was 112, and this number peaked at 358 in 2012. In the most recent admission cycle, the number of applicants was 219. Note that the drop in number of applicants since 2012 coincides with the beginning of the AMP. Until 2012, both MS and Ph.D. students applied to one program. Since the inception of the AMP, MS students have applied through a separate channel. Maintaining an upper bound on the size of the Ph.D. program as the number of applicants has increased has allowed us to be more selective in admissions, resulting in an increase in the quality of incoming students as has been mentioned above. In 2005, 25% of applicants were offered admission, but in the past 3 years, we have only offered admission to only 11-15% of our applicants. The number of students admitted each year has remained steady, at an average of 12 students per year.

Our demographics have remained relatively constant over the past 10 years with an average enrollment of ***26% women, 5% minorities and 42% international students***. We have made a concerted effort to focus our attention on recruiting women and minorities. Specifically, while 15% of all applicants were given offers in 2014, 23% of women applicants and 35% of minority applicants were given offers. In 2014, only 9.4% and 4% of Ph.D. students, for the entire University and for the College of Engineering, respectively, were minorities. Furthermore, 24% of the Ph.D. students in the College of Engineering are women. These numbers highlight that our efforts are helping us increase diversity. We work closely with Anthony Salazar, the diversity specialist at the Graduate School, to ensure that we are reaching out to underrepresented groups for recruiting.

2.3.4 Curriculum

Students in the Ph.D. program are required to complete a minimum of 24 course credits, which includes 6 credits of MSE 520, our seminar series. For the remaining 18 course credits, the students are required to obtain 9 core course credits (three 3-credit classes which are required for all students), and 9 elective course credits (usually three 3-credit classes). The 3 required core classes cover the fundamentals of materials science and are MSE 510: Bonding, symmetry, and crystallography (fall); MSE 541: Defects (winter); and MSE 525: Kinetics (spring). The students can choose elective courses from a list of eleven, and may take classes outside the department to count towards their degree if the course is pertinent to their research. We encourage our students to take two classes per quarter in their first year so that they can complete most of the course requirements early in the careers, thereby allowing our students to spend more time on their research from their 2nd year onward.

In the fall of the 2nd year, the students are required to take a written qualifying exam. If they pass the written exam, they are required to take an oral qualifying exam within 6 months. Once they pass the oral qualifying exam, students put their written and oral qualifying materials together in a portfolio, and the faculty vote to approve them for a MS degree.   Students then must pass their General exam and Final exams in order to earn a PhD.

The students may retake the written qualifying exam once in the spring if they fail on their first attempt, with a second retake being allowed under exceptional circumstances. The students are required to formally petition the five faculty members of the Graduate Committee for a second retake. Until 2014, the written exam was based on an undergraduate level textbook "Fundamentals of Materials Science". However, after much discussion within the faculty, in the spring of 2015, it was decided that the written exam should be more rigorous and should test the students' knowledge at the graduate level. As such, the new format now consists of one question each from the required core classes, with a 4th elective question chosen by the student from one of four areas of materials science: mechanical properties; functional materials and properties; polymers; biomimetics and biomaterials.

2.3.5 Job Placement

We have seen a significant change in the career trajectory for our students since our last 10-year review. While previously many of our students pursued local industry jobs rather than pursuing an academic career, we are now seeing an increased number of students who pursue post-doctoral opportunities before moving onto faculty appointments. In the past 10 years, 89 Ph.D. students have graduated from the program. Out of these graduates, 19 have gone on to become faculty or have obtained permanent positions at National Labs, 66 have joined industry or are currently working as post-docs, and only 4 have entered non-science or non-engineering careers; >20% of our students are choosing an academic track. Our graduates now have tenure-track/tenured positions at Universities such as Texas A&M, UC

Riverside, and Arizona State. In the Ph.D. program, student job placement is primarily facilitated by the faculty. We believe that the new vibrant, research-active faculty that have been hired in the past 10 years are having a significant impact on the career trajectory chosen by their graduates.

2.3.6 Student Surveys and Satisfaction

An annual "pizza chat" is held to acquire feedback on the Ph.D. program where the Graduate Program Coordinator, Graduate Program Advisor, and Chair meet with students during the spring quarter. The format of this discussion is informal and allows the students to air their thoughts in a non-intimidating environment. Every year, positive feedback is obtained from the students regarding their research environment. Student suggestions typically focus on the number of courses that are offered. As stated in Section 2.2, these concerns are being addressed in conjunction with issues related to the AMP.

2.3.7 Future Plans

The Ph.D. program is expected to continue along the current trajectory. Total enrollment numbers are expected to remain the same, and our attention will be focused on ensuring that we continue to increase the quality of our incoming students, while remaining dedicated to enhancing diversity in the graduate student body. We will work together to increase the number of courses that are offered to serve students in both the Ph.D. program and the AMP, so as not to add an additional burden to our faculty's workload.

2.4 MSE Internship Program

One of the Department's overarching objectives is to "*serve local and national industry needs through coursework at all levels and through focused research initiatives and partnerships*". That objective is partly met by engaging with various industries on short-term technological projects, long-term research and development partnerships, intellectual property transfers, etc., which enrich the Department's fundamental research-oriented portfolio. To make greater impact, in 2015 we initiated a pilot "*MSE Internship Program*".

The Internship Program was motivated by a few observations and some concerns that have developed in recent years. First of all, according to recent statistics released by the COE, the existing UW College of Engineering (COE) Co-op and Internship Program has been predominantly CSE- and EE-centric. For instance, MSE Co-op/Interns consist of < 1% of the total COE count. This is due to the size and strength of UW's CSE and EE programs, and to the composition of the Pacific Northwest industries. Secondly, MSE has recently been experiencing "growing" challenges, due to the rapid increase in our undergraduate enrollment in recent years, as our senior class approaches 60 students. The newly established Applied Master Program (AMP) also brings in approximately an additional 25 graduate students per year. The need to accommodate such a large number of senior UG and AMP student research projects has put a strain on our lab facilities, faculties, and senior graduate students.

In an effort to alleviate the challenges with MSE growth in the near future, to bridge the gap between our student talents and industry needs, and to align the MSE core research initiatives with industry needs, we have initiated a pilot MSE Internship Program. This internship program would offer students training opportunities with real-world applications, as well as provide them with the knowledge and skills that are necessary to build a successful career. In addition, a paid internship is particularly beneficial, because it enables economically disadvantaged students to find some financial relief. Meanwhile, the program is also very valuable to companies who hire these students. Most of the companies hiring interns view the internship programs as an effective, low-risk channel for identifying talented full-time employees, and for gaining access to cutting edge research in the universities. Moreover, the program could enable the faculty members to recruit top-notch students and establish stronger connections with industry.

To further facilitate the program, we plan to offer a 2-credit MSE internship course at a reduced tuition/fee. We would also like to negotiate with the COE/UW to allow MSE to retain the tuition/fee to support full-time staff and other program needs. Furthermore, we envision the development of summer classes on synthesis, processing, and measurement that are tailored for industry needs by partnering with industries, the Clean Energy Institute, and the Institute of Molecular Engineering & Science.

In the 2015 pilot internship program, we were able to place seven undergraduate and graduate student interns in large and small corporations. These students are Zachary Neale (at Toyota Motors), April Li (at General Motors), Dion Hubble and Matt Lim (both at EnerG2), Stefanie Roesli, Erik Engstrom, and Ryan Trella from (two UG and one Graduate at Epic Aircraft, LLC). Prof. Jihui Yang started this MSE Intern Program by working with Brian Flinn, Alex Jen, Mehmet Sarikaya, and many industrial members of the MSE External Advisory Board. We have made good progress in securing several future intern positions at Apple, Intel, HRL, Dupont, PNNL, Oak Ridge National Lab, Analog Devices, among others, and are looking forward to expanding the program further.

Section 3: Research Impact

3.1 Impact of MSE Faculty Research and Creative Work

With 9 new faculty hires over the past decade, the MSE department is one of the fastest growing and dynamically changing departments on the UW campus. The Department conducts vibrant research through a variety of programs, leads materials science and engineering education efforts, and is involved in technology translation, at the forefront of energy, composite material, nanotechnology, photonic, opto-electronic, biomaterial, biomimetic, biomechanic and nanomedicine fields, among others. As a consequence, the Department has gained significant national and international visibility and recognition.

Our faculty have introduced many innovative approaches and new techniques for the efficient synthesis, processing, and self-assembly of materials, creating arrangements of organic and inorganic functional materials, the extraordinary properties of which can be explored for use in energy, photonic, opto-electronic, nanomedicine, information technology, and nanotechnology applications. Our faculty also contribute to bridging the gap between medicine and biomaterials, helping to establish, new emerging fields, such as molecular biomimetics, that can potentially have significant impacts on engineering medicine, healthcare, and electronics. In addition to these exciting developments, many novel and clinical relevant biomaterials have also been explored for biomedical applications such as tissue repair, regenerative medicine, and cancer diagnosis and treatments.

Due to our faculty's diverse research expertise and academic/industrial experience, many of them have joint appointments in different departments and colleges. They have played an important role in catalyzing cross-boundary collaborations that are critical to identifying fundamental engineering problems, sharing best practices and novel approaches, and supporting interdisciplinary education among the UW, industry, academia and government laboratories. This vigorous effort has resulted in several large campus-wide research initiatives in photonics, energy, medicine, and nanotechnology. Teams led/participated in by MSE faculty have succeeded in establishing several prestigious programs after vigorous nation-wide competitions, such as the NSF MRSEC, STC, IGERT, DoD-MURI and DURINT, NIH/CEGS, NIH/TR32, DOE Sunshot & Solar America Initiatives, the DARPA Molecular Photonic Center, and the Murdock Foundation Instrumentation, etc. These large interdisciplinary programs have not only provided very significant funding for faculty and students to conduct cutting-edge research, teaching and outreach, but have also catalyzed the formation of several new interdisciplinary research institutes at the UW. For example, the Institute of Advanced Materials for Energy, the Institute of Molecular Engineering & Science, and the Clean Energy Institute were formed based on the promise of the programs to develop innovative materials and devices for engineering medicine, clean energy, and other priority applications of national and global interest.

These creative efforts have also resulted in many important papers and review articles published in high caliber journals, including Nature, Science, Nature-series journals, Nano Letters, Advanced Materials, Physics Review Letter, and J. of American Chemical Society, which have generated significant global impact and recognition. Three MSE faculty members have been named as the *Highly Cited Researchers* in 2014 and 2015 (http://highlycited.com/) by Thomson Reuters, which represents the world's most influential scientific minds that are ranked among the top 1% cited in their subject field and year of publication, earning them the mark of exceptional impact. The Global Research Report published in 2011 by Thomson Reuters also ranked the UW as #1 in citation impact among all academic institutions worldwide for materials related papers published in the past 10 years. (Global Research Report, *http://www.stratresearch.se/Documents/Strategiprocessen/grr-materialscience.pdf).* These outcomes attest to the extremely high level of scientific excellence and the disproportionately large impact generated by our faculty's creative research in the materials community.

The individual impact of each faculty's research and creative work is highlighted below:

Prof. Arola has made substantial contributions to the field of restorative dentistry and in addressing the impact of aging. He joined MSE in December of 2013 and conducts research on the development of structure-property relationships for hard tissues and natural and engineered structural materials.

Prof. Brush has developed theory and models to improve fundamental understanding of the engineering and science of thin liquid films, of evolving metallic foams and of crystal growth. These efforts are crucial to the production of materials for use in transportation, medical and energy industries.

Prof. Cao's research impact is reflected in part by the recognition as a highly cited researcher in Materials Science in 2014 and 2015 by Thomson Reuters, a large number of publications (>340) with high citations of >17,000 and an H-index of 66, and by his 20 invited review articles covering various topics in materials science and engineering.

Prof. Hinds has demonstrated pioneering work in active membrane platforms for a broad spectrum of applications. He joined the UW MSE in 2014. A key breakthrough of his work was reported in *Nature 2005* demonstrating 10,000-fold faster fluid flow in carbon nanotubes than in conventional porous materials. Further impact has been made in voltage driven membranes that actively pump expensive pharmaceuticals and act as biochemical platforms (*Adv. Funct. Mater. 2014* and *ACS Nano* 2014).

Prof. Jen has played a central role in advancing the performance of molecular photonics and electronics. He pioneers the application of organic electro-optic (OEO) materials. He and his collaborators have incorporated OEO materials into silicon photonic circuitry to demonstrate ultrafast signal processing under low drive voltage (*Nature Mater*. **2006**; *Nature Photonics,* **2007**). His work published in *Science* (**2011**) for controlling favorable geometry of single molecular photoreaction in self-assembled monolayer has attracted worldwide attention. His work published in *Nature* (**2013**) helps reveal the role of spin in kinetic control of charge recombination. He is recognized as a highly cited researcher in materials science in 2014 and 2015 by Thomson Reuters through his publications (>540 papers which were cited >26,000 times) and a high h-index of 83.

Prof. Ohuchi has made significant contributions in understanding the atomic and molecular effects controlling the transport, electronic, optical, magnetic and thermal properties of metal-chalcogenide and oxide materials. A series of papers has been published in prestigious journals, like *PRB*, *PRL* and *APL.*

Prof. Krishnan has pioneered chemical synthesis of nanoparticles (*Science*, 2001; *Nanoscale* 2015), nanoimprint lithography of large arrays and complex structures of nanoscale elements (*Adv. Mat. Interfac*. 2015), epitaxial thin film growth (*Phys. Rev. Lett*. 2005), and application of sophisticated electron microscopy (*Phys. Rev. Lett*., 2006; *Phys. Rev. B* 2008) and synchrotron radiation (*Phys. Rev. Lett*., 2008) methods. In spintronics, he identified a new class of TM-doped wide band-gap semiconducting oxides (*Phys. Rev. Lett*. 2005), termed dilute magnetic dielectrics, which are both ferromagnetic and insulating.

Prof. Luscombe's research is focused on developing semiconducting polymers for photovoltaic applications. Her group is recognized for developing synthetic methodologies for creating defect-free semiconducting polymers, and is one of only a handful of groups in the world to be able to do so. Her work was selected as the Editorial Board top 10 picks by Polymer Chemistry Journal. More recently, their work has been used to create highly controlled organic-inorganic hybrid semiconductors.

Prof. Mayer has made contributions to the field of bio-inspired materials including toughening and adhesion mechanisms of natural composites, and synthesis and characterization of biomimetic materials.

Prof. Rolandi has developed a new branch of bioelectronics called bioprotonics. His paper in Nature Communications (2011) was highlighted *in The New York Times, the New Scientist, Materials Today, and the front page of the Daily*. He has developed a revolutionary test for Tuberculosis (TB) that involves chitin microneedles and is much easier to use and more reliable than the traditional test.

Prof. Ma and his collaborators have contributed significantly in the design, synthesis and processing of self-assembled organic semiconductors/dielectrics (*J. Am. Chem. Soc.*, 2006; *Adv. Mater.* 2008**)**, and interface engineering via molecular self-assembly (*Adv. Mater.*, 2008**)** for low-power organic field-effect transistors (OFETs) and highly efficient polymer solar cells.

Prof. Pauzauskie has demonstrated the first experimental laser cooling of condensed liquids, including liquid water and physiological buffers.

Prof. Sarikaya has established two interdisciplinary centers (DURINT and MRSEC) to form the foundations of Molecular Biomimetics, in which biology and genetics are mimicked and implemented acellularly. This key interdisciplinary field had a significant impact in many disciplines in the 2000s and is likely to define many scientific and technological disciplines in the future.

Prof. Yang's research and industrial experience are focused on the design, synthesis, testing, and understanding of advanced thermoelectric materials and li-ion battery materials for energy conversion and storage. Prof. Yang joined UW MSE in 2011.

Prof. Xu's group has pioneered the field of the optoelectronics of two-dimensional (2D) quantum materials. His leadership in the field is reflected by 22 papers published in Nature family journals. His major scientific achievements span three areas: (1) theoretical discovery and experimental demonstration of unique spin and pseudospin physics in atomically thin semiconductors; (2) development of 2D optoelectronic devices, including first light emitting diodes, ultralow threshold nano-cavity laser, nonlinear optical transistors, and single quantum emitters; (3) synthesis of atomic seamless 2D heterostructures between two monolayer semiconductors for the first time.

Prof. Zhang is a leading expert in nanomedicine and biomaterials for tissue engineering applications. She has published papers and invited review articles in high-impact materials, chemistry, and biomedical journals. Her work is highly cited and she is named as one of Highly Cited Researchers in 2014 and 2015 in two categories ("Materials Science" and "Pharmacology & Toxicology") by Thomson Reuters. Her research has received wide recognition from the scientific community and society, as signified by the broad coverage of national and international media (*e.g.*, the MIT Reviews, the National Geographic News, King 5 News, Fox News, the Wall Street Journal, Nature Nanotechnology, The Economist, etc.).

3.2 Technology Development & Translation

Our faculty members have made significant impacts on technology development and translation. In the past decade, novel materials and devices have been developed for diverse applications such as ultrahigh speed information processing, biomedical imaging, drug delivery, solar energy harvesting, electrical energy storage and membranes for chemical separation. The MSE faculty have been granted more than 80 patents during this period, with many more patents pending. Besides activity in protecting the IP created by the innovative research, the faculty is also very proactive in technology commercialization. This is especially important because commercialization can generate significant technology licensing fees for the UW to invest in cutting-edge research and education, and it cultivates many new employment opportunities for our students.

By working closely with graduate students and postdocs, 11 start-up companies have been launched since the last review. The most successful example is EnerG2 which is a company focused on the development of supercapacitors and rechargeable batteries. It has received significant venture capital investment and a large contract from the Department of Energy and has several R&D sites in Seattle and Oregon. Our faculty have also received research funding from local, domestic, and foreign companies to develop new technologies and to improve existing technologies. For example, our faculty members have received significant research funding from Intel to develop high performance electro-optic polymers for highly integrated silicon photonics and roll-to-roll printable solar cells for energy harvesting, from Boeing to improve composite materials performance, noninvasive detection of composite failures and for the development of flexible piezoelectric sensors and actuators, from General Motors, to develop efficient thermoelectric materials to recover waste heat, from UniEnergy Technology for flow battery production, and from Korean Atomic Energy Research Institute for Li-O_2 battery development. Our faculty members are also actively recruited by companies for consulting services due to their comprehensive knowledge of materials and devices.

The impact of each faculty member's technology development effort is highlighted below:

- Prof. Jen and his co-inventors have been awarded 28 patents. He is the co-founder of Soluxra, LLC and Advanced Electroluminescence Systems, LLC, which focuses on developing technologies based on organic/hybrid photonic and electronic materials and devices. He also served on the Scientific Advisory Board of GigOptix (NASDAQ: GGOX) for the past 6 years, a company that manufactures high-performance optical network components using OEO polymers developed in his lab. He was appointed by the governor of Washington to the Board of Directors of the Washington Technology Center (WTC), whose mission is to spark ideas and form connections between people and resources, and foster job growth to position Washington State as a national technology leader. He was the only active researcher serving on this Board to provide advice on the technical directions of the WTC. WTC has awarded millions of dollars to support industrial-oriented research and to stimulate startups in the State of Washington.
- Prof. Krishnan's start-up company, LodeSpin Labs, is working on translating Magnetic Particle Imaging technology into the clinic for cardiovascular imaging. His IP portfolio at UW also includes media architecture for Bit Patterned Media involving information storage and the design of logic gates for Magnetic Quantum Cellular Automata.
- Prof. Ma and his co-inventors have been awarded 6 patents related to self-assembled monolayers, interfacial materials for solar cells and organic/polymer nonlinear optical materials. Two patents have been licensed to Lumera/GigOptix.
- Prof. Ohuchi developed a new experimental protocol named *Combinatorial Materials Exploration* with financial support provided by the Micron Foundation during 2007-2011.
- Prof. Yang holds 18 US patents (before he joined UW) on sensors used in automotive engine control; on thermoelectric technology for automotive waste heat recovery, on high capacity battery electrode materials, and on thermal management of Li-ion batteries. He developed an automotive waste heat recovery system, which was highlighted by many news agencies.
- Professor Brush's work in liquid films is applicable to device processing for energy applications, to protective coatings in structural materials, and metallic foams for light-weight materials for transportation vehicles and medical devices.
- Professor Zhang has contributed to the development of biomaterials for clinical use. Her group has been issued 7 patents and has 19 pending patents. She is the co-founder of Essential Biomatrix (EB) Inc. and Globe Preventive and Pharmaceutical Medicine (GPPM), Inc., both of which focus on the development of porous and gel biomaterials for tissue repair and drug screening and advanced nanoparticles for the prevention, diagnosis, and treatment of diseases. One of her patents has been licensed by Blaze Biosciences. More than 10 patents have been licensed to GPPM.
- Professor Cao has been granted 14 US patents and was named the Presidential Entrepreneurial Faculty Fellow in 2012. Based on the technologies developed in Prof. Cao's lab, four startup companies have been launched in the past 10 years (EnerG2 focus mainly on supercapacitors and ultracapacitors, LivinGreen Materials on solar cells, Lumisand on silicon quantum dot phosphors, and C&C Materia for rechargeable batteries).
- Professor Rolandi has been awarded the Commercialization Gap Fund and a Coulter Translational Grant from the UW to explore his new biomaterial-based devices. He also has several patent

applications filed. He is the scientific founder of ***KitoTech Medical***, which licenses these patents. KitoTech Medical has recently closed its Series A funding, and has obtained excellent pre-clinical results.

- Professor Hinds is working on new membrane designs to be used for applications in drug delivery controlled by smart phone applications, expensive biomolecule/pharmaceutical separations, flow batteries, trace element concentration/separations and water purification. He has 2 awarded patents related to carbon nanotube membranes for drug delivery devices and active chemical separations.
- Professor Sarikaya recently established the start-up company Seattle Biomimetics Sciences Inc., in partnership with UW's CoMotion and Intellectual Ventures. Focusing primarily on the development of dental materials and therapies, and extending to other health and technology fields, the technology is protected by 5 patents and other IPs worldwide.
- Professor Pauzauskie is developing engineered optoelectronic nanomaterials for photothermal theranostics. This has led to 4 issued patents. He is collaborating with EnerG2 on using graphene aerogel materials for capacitors.

3.3 Scholarly Impact on the Field

The faculty of the department has had scholarly impact in all areas of the MSE tetrahedron: in the development of new materials for traditional and novel applications; in establishing structure–property-processing-performance correlations at all length scales and dimensionalities, ranging from the nanoscale and surfaces/interfaces to the bulk in a wide range of materials – metals, alloys, ceramics, polymers, biomimetic, and various hybrids or composites; in using innovative characterization method toolboxes involving electrons, photons, and scanning probes, as well as in synthesis and fabrication; in developing materials theories, and combining materials theory with experiment; and in tailoring properties of structural and functional materials for medicinal, energy, information processing, and environmental applications. Further, in this review period, the faculty have published numerous highly cited manuscripts in prestigious and professionally-relevant engineering journals (*Cao, Jen, and Zhang have been selected by Thompson Reuters in 2014 as the Highly Cited Researchers in the world over the past 10 years)*, written various review articles providing an authoritative snap-shot of the status of sub-fields, and have published two comprehensive, single-author textbooks, entitled, "*Nanostructures and Nanomaterials: Synthesis, Properties and Applications"* (*Cao*), and " *Fundamentals and Applications of Magnetic Materials*" (*Krishnan*), books that may define our collective knowledge of these two broad classes of materials for years to come. ***The Global Research Report published in 2011 by Thomson Reuters also ranked the UW as #1 in citation impact among all academic institutions worldwide for materials related papers published in the past 10 years***. This recognition speaks to the exceptionally high scholarly impact of the faculty and students of our MSE department. Some select scholarship highlights of this period follow:

New Materials:

- Pioneering work (*Xu*) in the field of optoelectronics on two-dimensional (2D) quantum materials with 22 papers in the *Nature* family of journals and over 40 invited talks.
- First experimental demonstration (*Pauzauskie*) of the laser cooling of condensed liquids, including liquid water and physiological buffers [*PNAS*, under review] and the synthesis & characterization of diamond aerogel materials [*PNAS*, **2011**].
- Demonstrated (*Jen*) the unprecedented electro-optic activities (more than one order higher than the best inorganic materials used in devices) in dendrimers for ultrafast information processing [*J. Am. Chem. Soc*., **2007,** *Nature Photonics*, **2007**, *Adv, Mater.* **2009**].
- Developing (*Yang*) materials with chemical-bond hierarchy that are part-crystalline and part-liquid state [*PNAS*, **2014**].
- Identification (*Krishnan*) of a new class of TM-doped wide band-gap semiconducting oxides [*Phys. Rev. Lett.*, **2005**], termed dilute magnetic dielectrics, which are both ferromagnetic and insulating and of importance in room-temperature spintronics.

- Wide recognition (*Luscombe*) for developing synthetic methodologies for creating defect-free semiconducting polymers, [*J. Am. Chem. Soc.*, **2009**], and using this methodology to create semiconductor polymer architectures that were not previously accessible [*Macromol.*, **2014**].
- Development of (*Ohuchi*) intrinsic vacancy-ordered nanoscale-wires for non-linear optics [*Phy. Rev. Lett.*, **2005**], and high temperature n-type thermoelectric oxides [*J. Ame. Cera. Soc.*, **2012**].

Nanoscience, Nanotechnology & Nanostructured Materials:

- Controlling favorable geometry (*Ma & Jen*) of single molecular photoreaction in self-assembled monolayer has generated much interest in molecular electronics [*Science*, **2011**]
- Pioneering (*Krishnan*) chemical synthesis of nanoparticles [*Science*, **2001**; *Nanoscale* **2015**], nanoimprint lithography of large arrays [*Jour. Micromech. & Microeng.*, **2014**] and complex structures [*Adv. Mat. Interfac*. **2015**] of nanoscale elements. The latter technology was used to develop purely magnetic logic gates for information processing [*Jour. Appl. Phys.* **2014**] and new media architectures [*AIP Advances*, **2015**] for next generation magnetic information storage.
- Incorporating (*Jen*) highly efficient organic electro-optic materials into silicon photonic circuitry with dimensions as small as 25 nm to provide ultrahigh speed and low energy consumption in information technology [*Nature Mater.*, **2006**).
- Breakthrough research (*Hinds*) reporting of fluid flow in carbon nanotubes that was 10,000 fold faster than in conventional porous materials [*Nature* **2005**].

Materials in Biology and Medicine:

- Internationally recognized research (*Arola*) on aging of hard tissues, especially in the field of dental materials. He was the first to show that changes in microstructure of dentin and enamel cause detrimental changes to their fatigue and fracture resistance [*Biomaterials*, **2009** & **2005**].
- Advances (*Sarikaya*) in genetic design and dental tissue repair [*IJOS (Nature)* **2012**]
- Development of forefront research (*Zhang*) in three distinct areas: nanotechnology in cancer therapy [*Adv. Drug Del. Rev.*, **2008**], tissue engineering for soft/hard tissue regeneration [*Adv. Drug Del. Rev.*, **2010**], and cell-based sensors for anti-cancer drug development and screening and for toxin detection
- Introducing and pioneering (*Sarikaya*) the new field of Molecular Biomimetics [*Nat Mater*, **2003**]
- Recognized as a world leader (*Krishnan*) in Biomedical Nanomagnetics [*IEEE Trans. Mag*. **2010**] and in particular, for the development of the emerging biomedical imaging technique of Magnetic Particle Imaging [*IEEE Trans. Med. Imag*. **2015**; *Biomaterials,* **2014**].
- Pioneering biomimetic work (*Hinds*) on membranes actively pumping chemicals across barriers with voltage activated gatekeepers [*J. Amer. Chem. Soc.* **2005**] leading to the development of trans-dermal drug delivery devices for controlling nicotine addiction devices [*PNAS*, **2010**]. Further impact has been made in voltage driven membranes that actively pump expensive pharmaceuticals and act as biochemical platforms [*Adv. Funct. Mater.* **2014** & *ACS Nano* **2014**]
- Development (*Rolandi*) of a new branch of bioelectronics called bioprotonics that deals with devices that control and monitor the flow of hydrogen ions for biological applications [*Nature Communications*, **2011**; *Nature Scientific Reports*, **2013**)].

Materials Characterization & Structure-Property Correlations:

- Epitaxial thin film growth [*Phys. Rev. Lett*. **2005**), and application of sophisticated electron microscopy (*Phys. Rev. Lett*., **2006**; *Phys. Rev. B* **2008**) and synchrotron radiation (*Phys. Rev. Lett*., **2008**) methods to elucidate the structure-magnetic property correlations in thin film heterostructures (*Krishnan*).
- Work (*Mayer*) with advanced characterization and testing of very fine, normally brittle fibers, has illustrated new capabilities for dynamic mechanical analysis, helium ion microscopy, and laser confocal microscopy methods in Materials Science and Engineering.

<u>Materials Theory</u>:

- Fundamental insight (*Brush*) into the kinetics of transformations and the concomitant interface evolution of growing crystals and other phases and into the hydrodynamics and evolution of thin liquid film by means of theory, modeling and computation [*J. Fluid. Mech.* **2005, 2008, 2010**]
- Mechanisms (*Brush & Krishnan*) governing crystal nucleation and growth phenomena for successful synthesis of nanoparticles with tailored size and properties [*Langmuir*, **2014**].

<u>Materials for Energy</u>:

- A combined experimental and theoretical approach (*Yang*) for discovering, designing, and optimizing advanced thermoelectric materials [*JACS*, **2011**].
- Design, synthesis and processing (*Ma & Jen*) of self-assembled organic semiconductors/dielectrics [*Adv. Mater.*, **2011**], and interface engineering via molecular self-assembly [*Adv. Func. Mater.*, **2010**] for low-power organic field-effect transistors (OFETs) and highly efficient polymer solar cells towards applications in flexible/printable electronics and renewable/clean energy.
- Manipulating the role of spin (*Jen*) in kinetic control of charge recombination, important in increasing the efficiency of organic solar cells [*Nature*, **2013**].
- Comprehensive work (*Cao*) on solution-based synthesis, characterization and control of morphology — aggregation, surface/interface modifications — of materials for energy related applications for solar cells, batteries, supercapacitors, and hydrogen storage as well as piezoelectric films for actuators and sensors.
- Coherent nanocomposites (*Cao*) with tunable microstructure and interface chemistry for energy storage

3.4 MSE Collaborative and/or Interdisciplinary Efforts

In the past ten years, the MSE faculty has worked as a small but dynamic unit with campus-wide units (COE, A&S, Radiology, Medical and Dental Schools, Fred Hutchison Cancer Research Center), companies (Intel, Boeing, HP, Microns, Microsoft, EnerG2), and PNNL National Laboratory to conduct very exciting interdisciplinary research and education in critical areas of materials science & technology development. The MSE faculty and students have led or participated in the establishment of several high profile centers (NSF-Materials Science & Engineering Center, NSF-Science & Technology Center, NSF-Materials Genome Initiative, NIH-Center of Excellence for Genome Sciences, TR-32 training grant, DARPA Molecular Photonics) and research institutes (Institute of Advanced Materials for Energy, Institute of Molecular Engineering Science, and the Clean Energy Institute) which have generated enormous impact on campus-wide research and education. These efforts have resulted in high-tech developments in fields of telecommunications, nanomedicine, bionanotechnology, renewable energy, aerospace, and dental treatment.

The strengths of our faculty's research lie on functional materials and biomaterials, from modeling, design and synthesis, processing, characterization, properties and devices. This has generated many exciting research breakthroughs and technology advancements, including ultrahigh speed information processing, bionanotechnology for tumor imaging and treatments, biomimetic and bio-inspired materials for better dental treatments and light harvesting, more efficient and lower cost solar cells, rechargeable batteries, and transistors for energy generation and storage. Based on their excellent expertise, the MSE faculty has created collaborative research teams within the department, across the UW campus, among US and international top-tier universities, national labs and industrial partners. Many high-profile large research centers and institutes have been established and have attracted substantial funding through the leadership or major contribution of MSE faculty.

NSF-funded projects: Two MSE faculty played key roles in a NSF-Science and Technology Center (STC) on "Materials and Devices for Information Technology Research" ($45M). The STC had more than 30 esteemed participants from seven universities including the UW (leading), CalTech, U. Arizona, Georgia Tech, Cornell, U. Maryland, and Central Florida. Prof. Alex Jen served as the Co-PI and the

Associate Director and Thrust Leader for 11 years in the NSF-STC. His responsibility was to coordinate research, education, and outreach activities in photonic materials and devices. Prof. Christine Luscombe served as the Associate Director of Education for the NSF-STC to lead the Hooked on Photonics REU program.

As the PI, Prof. Mehmet Sarikaya lead the establishment of the NSF-Materials Research Science & Engineering Center named the “Genetically Engineered Materials Science & Engineering Center” ($7.7M, co-PIs: Jen & Luscombe (MSE), and faculty from other five departments). GEMSEC is an interdisciplinary team working on marrying the science and technology of biology and materials sciences and engineering, at the fundamental level. The center has diverse partnerships and collaboration with other universities, including New York U. and Istanbul Technical U. An important aspect of the Center includes a range of education and outreach activities.

MSE faculty also played significant roles in other NSF-funded collaborative projects. Prof. Jihui Yang was the PI of a NSF Materials Genome Program on developing hierarchical thermoelectric nanocomposites withco-PIs Li (ME) and Jen (MSE). Prof. Luscombe participated in NSF-Emerging Frontiers in Research and Innovation on “Towards zero-energy buildings based on electrochromic windows and energy-harvesting” and the NSF-Center for Chemical Innovation on “Center for Selective C-H Functionalization”. Prof. Rolandi worked with faculty from EE (Anantram and Dunham - funded by NSF), and Visual Communication Design (Cheng-NSF). Prof. Xu was the co-PI of a NSF EFRI award: Spin-Valley Coupling for Photonic and Spintronic Devices (PI: D. Cobden in Physics). Prof. Cao and Prof. Luscombe were the co-PIs of a NSF SOLAR award: Hybrid Semiconductors: Overcoming the Excitonic Bottleneck in Low Cost Solar Cells (PI: Jenekhe (Chem Eng). Prof. Ohuchi was the PI of a NSF Materials World Network award: Phase Change Materials for Nanoelectronics with international partner from National Institute for Materials Science (Japan), and the co-PI of a NSF-DMR award: Controlling Conductivity in the UV-Transparent Conducting Oxide Ga_2O_3, PI: Olmstead (Physics). Prof. Ma was the PI of a NSF-Energy for Sustainability award: Molecular Environment-Tailored, Self-Assembled and Nano-morphology Controlled Electron Acceptors for High-Performance Solar Cells (co-PI: Jen (MSE). Professor Brush was the PI of a NSF-CMMI award: “Collaborative Research: Dynamics and Stability of Metallic Foams: Network Modeling".

MSE faculty also made significant contribution to obtaining awards for major research instrumentation (MRI). As the PI, Prof. Krishnan established an integrated laboratory for physical property measurements of advanced materials and novel devices funded by the Murdock Foundation (co-PIs: Ohuchi (MSE), Parviz (EE) and Gamelin (Chem)). Prof. Krishnan was also the PI of a NSF-DMR award: Acquisition of a Scanning Probe Microscope system for research and education in nano-magnetism and spin-electronics (co-PIs: Gamelin (Chem) and Olmstead (Physics)), and the co-PI of a NSF MRI award: Acquisition of a SAXS Facility for Research and Education in Nano-Structured Materials in collaboration with Chem. Eng.. Prof. Yang and Prof. Cao were the co-PIs of a NSF MRI award that included Ginger (Chem), Li (ME), and Overney (ChemE). Prof. Xu was the co-PI of another NSF MRI award: Acquisition of a Nanotopography Capability at the UW Microfabrication Facility (PI: K. Bohringer in EE). Prof. Pauzauskie and Prof. Xu were the co-PIs of a Murdock award: A Nanomaterials Synthesis and Spectroscopy Laboratory (PI: Gamelin, Chem). Profs. Hinds and Jen are the faculty participants in the National Nanoscale Center Infrastructure (NSF-NNCI) ($7.5M) collaborative grant for the campus nano-fabrication user facility.

DOE-funded projects: Prof. Jen served as the PI of a DOE Solar America Initiative (SAI) grant: interfacial engineering to improve the efficiency of polymer-based photovoltaic devices (co-PIs: Luscombe, Ma (MSE), Rehr (Physics), and Ginger (Chem.). It was one of 25 PV research projects at universities and companies across the nation as part of SAI. Prof. Jen was also the co-PI of a DOE SunShot award: Development of Hybrid Perovskite Tandem Solar Cells (PI: Hillhouse, ChemE.). This was one of the Next Generation Photovoltaics-3 projects in advancing solar cells to reach 30% efficiency. Prof. Cao is the co-PI of a DOE BES award on solar cells (PI: Jenekhe, ChemE.), and Prof. Luscombe is the co-PI of a DOE-Energy Frontier Research Center “Center for Interface Science: Solar Electric Materials” (PI: Armstrong at U. Arizona). Prof. Ohuchi is the PI of two DOE awards from NTEL on high temperature energy materials.

NIH-funded projects: Prof. M. Zhang led several interdisciplinary teams of engineers and clinicians in 6 NIH R01s and 1 NIH N01 projects. She is also the PI for a NIH T32 program: Nanotechnology and Physical Science Training Program in Cancer Research which involves 35 faculty members as mentors from the COE, Col. of A&S, and School of Med. at UW, Fred Hutchinson Cancer Research Center, Harborview Medical Center, and Seattle Children's Hospital. Prof. Krishnan was a co-PI in a NIH-RO1 grant with Conolly (UC Berkeley) on Magnetic Particle Imaging (MPI). Prof. Jen was a co-PI of the NIH Microscale Life Sciences Center (MLSC) grant. It was a NIH National Human Genome Research Institute (NHGRI) Center of Excellence in Genomic Science (CEGS). The MLSC was one of the first three CEGS funded by the NHGRI in 2001, and was renewed for a second five-year period in 2006.

DOD-funded projects: As the PI, Prof. Sarikaya led a DURINT project: Genetically-Engineered Proteins for Functional Nanoinorganics (co-PIs: Jen, Ohuchi, Tamerler and others). Prof. Xu was the PI of the AFOSR Basic Research Initiative award: 2D Heterostructures for Integrated Nano Optoelectronics. This team has 7 PIs from 5 universities. Prof. Rolandi worked with Omenetto from Tufts on chitin – silk biocomposites (ONR). He has recently received $1.5M from the AFOSR Cyborgcell program to develop ciborgtissue with Khademhosseini (Harvard) and Almutairi (UCSD). Prof. Cao was the co-PI of a AFOSR MURI project: Design of Energy Harvesting Storage System for Future AF Aero Vehicles" PI: Taya (ME). Prof. Jen was the co-PI of two DARPA and AFOSR projects: Development of two photon absorption and Raman materials for optical Zeno switches (ZOE: DARPA-DSO), and Development of polymethines for all-optical signal processing (COMAS: MURI-AFOSR) with collaborators at Georgia Tech.

Leadership in Interdisciplinary Centers and Institutes: Prof. Jen served as the Director of the state-funded Advanced Technology Initiative (ATI) to build up the photonics community at the UW through cluster faculty hiring in photonics. As the director, he led the establishment of the UW Institute for Advanced Materials and Technology, later becoming the Advanced Materials for Energy Institute. This effort catalyzed the state-funded Clean Energy Institute (CEI). He is now serving as the Chief Scientist for Technology Integration at the CEI. Profs. Luscombe, Xu, and Yang are all serving on the CEI Faculty Advisory Board.

3.5 Development of Junior Faculty

The MSE department believes the ongoing success and productivity of junior faculty to be vital going forth into the future, especially given the aging of senior faculty. Since the department is comparatively small, responsibility for mentoring junior faculty rests with the department chair and the entire senior faculty. Senior faculty share research ideas and provide mentoring regarding research, teaching, and grant proposal opportunities. Junior members of the MSE faculty are given the opportunity to organize the departmental seminar in order to build professional connections with speakers visiting from academic institutions and companies. The department also invites junior faculty to join the graduate-student recruitment committee to ensure they have the opportunity to recruit the best and brightest graduate students to the MSE department. New MSE faculty are also encouraged to participate in various training activities offered at the UW and by the COE, such as the Faculty Fellows Program, the New Faculty Orientation, the Provost's Workshops on Teaching and Learning, and also NSF-CAREER proposal-writing workshops. The MSE department has also made efforts to support junior faculty during their transition to parenthood by providing reduced teaching loads after the birth of new children.

Junior faculty members are encouraged to be aggressive and independent in building their own research programs by providing the needed start-up and facility renovation funds. The efforts have proven very successful, as the development over the last ten years of several state-of-the-art experimental research labs by ambitious and capable junior faculty members including Luscombe, Rolandi, Xu, Pauzauskie, and

Ma. Junior faculty also have been provided with travel support to funding agencies to meet program managers, and have been invited to join prestigious centers including NSF-STC (Luscombe), NSF-MRSEC (Luscombe, Pauzauskie), and UW's Clean Energy Institute (Luscombe, Xu) in order to increase their opportunities for winning additional funding. In order to assist junior faculty in building their reputations, the department seeks to improve their recognition by nominating them for several local (COE Innovator), national (NSF Career-, 3M-, Kavli-, Sloan-, AFOSR-, DARPA-, Beckman- Young Investigator), and international (Italian TR35, NAE Frontiers of Engineering) awards.

3.6 Strategy to Recruit and Support the Career Success of Under-Represented Faculty

Diversifying our faculty by recruiting women and under-represented minorities (URM) is a top priority for the Department. During any open faculty search, women and URM applicants are actively recruited. Efforts include personal communication with colleagues who have students and postdocs in the job market, contacting participants in workshops specifically aimed at women and URM scientists and engineers interested in faculty careers, consulting lists of recent women PhDs in physical sciences and engineering, among others. The Department also works with the UW ADVANCE Center for Institutional Change, which participates in the search process by meeting with women candidates when they interview for the position, as well as helping to support the career success of women and URM faculty after they join the UW. We were fortunate to have added two female faculty during this period including Professor Luscombe (2006-) and Research Professor Tamerler (2006-2013), to bring the percentage of our female faculty to 19% (including Miqin Zhang). Our attempt to recruit additional URM faculty in 2013 and 2014 failed because our top candidates decided to join other institutions (UIUC & UT-Austin) with stronger financial capabilities and programs. In 2015, by partnering with the EE department, the Institute of Molecular Engineering & Science, and the Clean Energy Institute, we have successfully recruited a printable electronics expert, Professor Ana Arias (Hispanic origin) from UC-Berkeley's ECE department to join us.

To ensure success in their academic career, Professors Luscombe and Tamerler were mentored and helped by MSE senior faculty to join two very prestigious NSF Centers (STC, Luscombe and MRSEC Luscombe and Tamerler). They were provided with seed funds and state-of-the-art facilities to facilitate their research, student recruiting, and networking with top researchers in the field during the early stage of their career. This strategy was very effective for jump-starting their research and helping grant applications to NSF, DOE, and DoD. To help them build their professional reputations, the MSE Chair has nominated them for several local (COE Innovator Award), national (NSF Career, DARPA-Young Investigator, and Kavli-, Sloan-Fellow, and Sigma Aldrich Lectureship), and international (NAE Frontiers of Engineering Symposium) awards. As a result of these concerted efforts, Christine Luscombe was recognized and awarded with early promotion to Associate Professor in 2011.

Section 4 Future Directions

4.1 Where is MSE coming from?

MSE is an interdisciplinary field in the discovery, design, and use of new solid-state materials with key emphasis on understanding the scientific principles governing the interrelation among processing, structure, and properties of materials towards predictable performance. During the past 70 years, MSE has undergone a profound and rapid evolution. The basic concepts of traditional metallurgy, which encompassed extraction of metals from minerals and the utilization and understanding of their properties as useful engineering materials, have been quantified and immensely broadened. MSE now includes a wide variety of materials, such as metals, ceramics, semiconductors, polymers and composites, and most recently biological and biomimetic systems, in which the structural and functional properties can be controlled and related directly to the needs of engineering design. In addition, MSE contributes to the important socio-technological issues of information technology, energy, infrastructure, and environment, including both sustainability and recyclability.

4.2 Where is MSE Headed?

Many of the most pressing scientific and technological problems currently faced by society are due to the lack of suitable materials to perform needed functions; therefore, there is a strong need to have major material breakthroughs to generate societal impact. Although traditional MSE involves metals and alloys, as needs developed and new materials became more available, the field has expanded, during the 40s through the 80s into ceramics polymers and their composites, and through the 80s and 90s into semiconductors and nanomaterials, and 90s and 2000s into biological, biomimetic and hybrid materials. Right now, MSE is at the center of all engineering fields from bioengineering to computer and electrical engineering, to mechanical and aeronautical engineering, as all of these rely on fundamental scientific concepts and advanced materials for further innovations in their specialized fields and emerging technologies. Currently, as the Earth's raw materials are dwindling, and there are more environmental concerns for resource management and sustainability, it is becoming clearer that new materials for infrastructure and technological development have to be developed along with materials and systems for clean energy production, storage and distribution. In accordance with the developments of these concepts, there is also the recent recognition that materials could be developed via bioinspired approaches and new materials and systems as well as fundamental concepts that describe materials behavior in the synthetic world may actually be also used in all fields of medicine.

MSE is now entering a new age: controlling matter and energy at the electronic, atomic and molecular levels as observational science is giving birth to a new paradigm in directing the placement of atoms and the flow of energy to initiate and control chemical and physical phenomena in materials. Materials scientists now could be called "atom whisperers." Advanced theory and computational models predict the behavior of these hypothetical materials that may be constructed in the lab and, once made, their behavior can be observed at the electronic and atomic levels and their structures can be fine-tuned to optimize their properties. Extrapolating these recent advances, new opportunities are emerging that will transform the way we live in the future and in which materials are occupying the central role. Based on the progress made during the last two decades, the future of MSE is likely to follow four key areas: *clean energy materials and engineering; materials for maintaining and renewal of the infrastructure and technology: biomimetics; biological and medical materials science and engineering; and environmentally-benign mining, manufacturing, and materials development.*

Along with the development of new concepts and capabilities, especially during the last two decades, there have been transformational changes in the availability of knowledge and data at one's fingertips. Accelerated by the ascent of the internet, novel methods of teaching, learning and even finding are emerging, such as crowdsourcing, cohort teaching, and online classes. In the not so distant future, the challenges facing the society need to be tackled by MSE graduates, especially UGs, who will need novel curricula to follow, those that include experiential learning, project management, and entrepreneurship, as well as acquiring the essential fundamental science and advanced engineering knowledge.

4.3 Challenges and Goals for the Next 5-10 Years

4.3.1 Challenges: Despite the rapid and unprecedented development of the Department that has taken place during the last decade, there are still several challenges that need to be addressed in the coming decades. The world still relies on fossil fuels with severe environmental consequences, while efficient ways of splitting water to produce hydrogen or scalable highly efficient PV cells have not yet been designed. As societal infrastructure is aging and new, efficient materials with longer life span are required, there is increasing need for effective assessment and monitoring of the infrastructure. Biomimetic or bioinspired materials and systems are still in their infancy and far from technological implementation. Despite enormous efforts in developing materials for medicine, there are still major challenges in tissue engineering, biosensing, and delivery systems. Significant innovations will emerge at the intersection of fundamental science with the discovery of advanced materials and devices, and there is clear advantage of focusing on curriculum and research efforts at this intersection. The challenge for MSE is that it must participate/lead UW's efforts in the continuing national and international competition for discoveries of future materials and systems, using the most advanced facilities and instrumentation, while providing an exceptionally well-trained work-force at all levels of expertise to face these challenges.

4.3.2 Goals:

The future goals should include three key focus areas:

i. Curriculum Development: MSE should refresh its hands-on UG labs to fully represent the materials of today and tomorrow, and lead materials education with college-wide introductory MSE classes. Keeping internships a priority, MSE should also incorporate new UG and graduate classes, e.g., materials design and synthesis, theory, computational and modeling; self-assembly and novel processing; biomaterials and synthetic biology, multifunctional materials and devices, in conjunction with integrated training in leadership, management and entrepreneurship. Project topics should be relevant to the key areas defined by the professionals in these fields, i.e., energy, information technology, health science as well as smart composites. Publishing scientific papers should go hand-in-hand with IPs/patents. MSE should also develop curriculum to lead the traditionally separate departments, such as medical (tissue engineering and drug delivery), dentistry (dental materials), energy materials and systems, chemical, bio- and environmental (embedded) sensors, and electro-optic materials and devices. The Applied Masters Program should include both practical classes and applied projects. Attracting young talent should start at K-12, with teaching modules extending to high schools and community colleges.

ii. Research:

Pooling their talents, expertise and interests, MSE faculty should focus on areas in the three key fields. In energy, scalable and printable PVs, ultrafast and low energy consumption information technology (*Internet of Things*), printable/wearable electronics, energy storage materials and devices, are some of the focus areas. In biomimetics, biomaterials, and materials in medicine, focus areas include cell-based tissue engineering and scaffold design, cell-free tissue engineering via biomineralization, biosensors, drug delivery and control release systems, biomonitoring, implant biofunctionalization, dental materials and procedures, and biomimetic photosynthesis. In infrastructure and manufacturing, embedded smart sensors and systems, additive manufacturing and printable manufacturing are areas of focus. The best way to jump start these activities and acquire leadership roles is through the formation of major collaborative and interdisciplinary projects such as MURIs, federal funded Centers, and Institutes. MSE has plans for the next 5-10 years in pursuing such large projects through a variety of pathways through federal funding and institutional programs, each relevant to our expertise, strength, and leadership.

***iii. Facilities*:**

MSE is an instrumentation/facilities-intensive field. With the sophistication and the expense of new equipment and facilities, characterization has been shifted into centralized facilities. Thus, MSE should house facilities for training and research, and lead in the development of centralized facilities and anchor on these to facilitate collaborative teaching, training and research.

> *MSE plans to create these materials focused teams to close gaps between needs and capabilities in synthesis, characterization, theory, and computation of advanced materials. Institutional leadership requires MSE to lead a national effort to aggressively recruit the best talent, with outreach, UG, grad and early career programs aimed at inspiring today's students and young researchers to be the discoverers, inventors, and innovators of tomorrow's materials solutions.*

Unit Defined Questions

1. **Are our curricula (BS, MS, PhD) preparing our students to be leaders in diverse positions utilizing Materials Science and Engineering? How can the department improve curriculum topics (fundamental and applied) to increase employment opportunities for our graduates?**

BS program - the curriculum was modified in 2002 with the merger of Ceramics and Metallurgical Engineering programs to create a single-degree program to represent the broad scope of the Materials discipline and that also includes topics ranging from electronics, energy, composites to biomedical materials. The program is primarily based around the Synthesis-Processing/Structure/Properties/Performance tetrahedron which is widely considered as the heart of MSE. A series of courses in each of those components is the core of the curriculum. 53 credits address the MSE core, 16 credits technical electives, and 111 credits other requirements (Math, Natural Science, Engineering Fundamental, Written and Oral Communication, VLPA, I&S and Diversity). This is one of the top 5 programs in the country in terms of the number of graduates (~60/yr) and the recent ABET accreditation gave the longest possible time between reviews with only minor concerns. Of concern from the last UW 10 year review was the status of lab facilities. A full time instructional staff and addition of >$800k of new equipment now provides our students with easy access to the state-of-the-art instruments and software that can be used to interface with the knowledge they learned from classroom and provide practical experience for future career progression. Lab courses have characterization (chemical, mechanical, electrical), processing (metals, ceramics, polymers, composite materials) as well as experimental design components.

A key concern expressed by faculty and students is job placement at graduation. At the graduation ceremony, roughly 60% had attracted a professional position. However, Appendix E shows >90% job placement after 1 yr. The delay is generally attributed to our condensed MSE curriculum during Junior/Senior years. This late start of their official degree limits internship opportunities, as well as delays the job search process for many students until after graduation. The proposed changes for COE direct admissions would have the majority of MSE majors admitted in their sophomore year, which would them in making steady career progression outside of coursework. Although the 90% job placement shown in Appendix E is encouraging, the types of jobs are not specified and we need to develop an effective mechanism to track their career on a 3, 5 and 10 year basis. Additionally, there is a need to set up an employer survey system (in addition to our advisory board) and engage in curriculum modification of the elective offerings as well as core skills. As a measure of student success, there are numerous notable success stories. Two of our recent graduates (Natalie Larson and William Hwang were selected by the College of Engineering to receive the Dean's Medals in 2013 and 2015, which is the highest honor for all COE undergraduate students. Many of our graduates also continue to pursue advanced degrees in highly ranked universities such as MIT, Berkeley, UCSB, UIUC, Northwestern, etc.

The current UG curriculum has produced well-prepared BS-MSE professionals, but the development of focused curricula for specific materials, such as metals, ceramics, polymers, biomaterials and composites may also assist students targeting specific careers prior to graduation. For this, restructuring of the course curriculum with employer and student input is planned to meet the current needs and future expansion of the discipline. In addition, mentorship and student activities are almost as important as the curriculum in career development. In past years, we have brought in recent alumni (emphasis on women and men, about 5 years out), who have described their job experiences to the Juniors and Seniors at informal events with active discussions. Boeing industry mentors also routinely teach introductory MSE 310. We have also used Capstone projects with industry mentors as an opportunity to develop MSE/industry ties for both students and the Department. Also we are developing internship opportunities for Juniors in the summer before the Senior year. This gives important professional experience to put into their resumes as well as an opportunity to develop personal contacts. We are also increasing emphasis and participation of student societies in the undergraduate education program as a focal point for community engagement. The key organizations are Material Advantage (the umbrella organization for ACerS, TMS, ASM and

AISI), SAMPE and KERAMO. Material Advantage organizes many tours/visitations to local companies aiding in the professional development of our undergraduate students and maintain local industrial contacts for the department. Materials Advantage also develops and organizes about a half dozen outreach demonstrations to local k-12 schools. There is a large student presence annually at the MS&T conference which is another avenue of professional development. Of particular importance to the goal of more active student organizations is an earlier admission (Sophomore year) to the MSE program to allow a less condensed course load and more time to develop a stronger student community.

MS/AMP program- is designed to provide an applied focus for MSE students to enhance career opportunities. Target cases are: A) local BS-level professional engineers expanding their skill set to attain higher level career positions; B) Non-MSE technical majors wishing to earn an MSE degree; C) international students wishing to gain marketable technical skills and internship experience/connections in the US. The AMP program is capped at 25 students from >120 applicants. Students are nearly exclusively self-supported and paying tuition. In general, the AMP curriculum uses a part of the core PhD program curriculum with expanded offerings for applied focus and non-MSE backgrounds. Further expansion of offerings is resource limited in terms of faculty/instructor lines. For many applied focus areas such as metallurgy, ceramics, composites, industrial processing, there is not a strong alignment with funded academic research areas, thus faculty offerings are limited. Solutions include industrial adjunct instruction (potentially team taught) and faculty hires with manufacturing focus. In Fall 2015, Devin MacKenzie was hired with industrial experience of high-throughput manufacturing for energy applications. Student surveys are split between those wanting to pursue an industrial position or academic research with a PhD at highly ranked US institutions, thus our curriculum must satisfy both goals. The MS/AMP program average 3.5/5 on 'quality of academic program' in the graduate school graduation survey. This would likely improve with applied offerings. For some AMP students, the intern experience is a critical component of the program. This year we have initiated a pilot summer intern program which placed 7 graduate and undergraduate students in large and small companies; we plan to grow the annual placement to 30 in 5 years.

PhD program- the curriculum is designed to give an expanded MSE core (bonding, defects and kinetics), seminar and ~3 electives related to PhD thesis. Since a PhD is a research degree, the emphasis is on research productivity and developing an impactful thesis topic. This reduction in number of required courses forces that a very well-defined core list of the topics are taught. Graduate surveys given in September 2015 indicated a desire for more PhD core courses, thus the process of curriculum modification has been initiated in the Graduate Program Committee. Other comments request more electives related to PhD thesis. From surveys of the graduate school, the 10yr average is 4.2/5 on quality of program. Graduation PhD's publish an average of 7 papers in peer-reviewed journals. Students have ~45% job placement in academic routes (Post-doc) and National lab and industry (~55%). Thus the program is serving students well in their pursuits as independent scientists.

2. **What criteria should we consider in evaluating our program relative to our peers and how do we market to key constituents such as students, alumni, academia, industry and entrepreneurs?**

Criteria: The evaluation of our program with respect to peers often relies on a ranking system, which varies widely depending on the organization performing the ranking. We find it best to identify to core criteria and use marketing to target any specific ranking system. These core criteria are:

- Student placement (employment rates, prestige of positions)
- Student awards
- External funding (including Research Centers)
- Publication numbers and impact (citation numbers)
- Economic impact (patents, licensing, start-up formation)

- News items in popular press

The U.S. News & World Reports (USNWR) are widely used since it is readily available to potential students, alumni, industry and the general community. For the Departmental rankings, the process is mainly based on Dept. Chairs' impression, hence networking/marketing of department successes is critical. The most recent National Research Council (NRC) is seriously flawed (self-inconsistent), not usable and largely ignored. The World University Ranking is based on quantified metrics and UW does well at 26th worldwide but rankings are not at the department level. Thus we are largely reliant on the USNWR rankings, in which MSE is ranked in the upper to mid 20's nationally. The best strategy is to ensure success in the above categories and follow through with marketing to Dept. Chairs and constituents. Criteria such as graduation numbers, faculty productivity (funding, papers, citations, patents), and startup company numbers are easily comparable to peers with available data and offer concrete goals or target values.

Marketing: Though the productivity of the department and faculty are very high, the visibility of the department won't benefit without effective marketing of successes. For ranking purposes, this needs to filter up to the Dept. Chair level nationwide. However, there are numerous benefits to marketing to the general public, potential students, current students, alumni and local industry. The department website is the central communication platform since it is a public and searchable document. The key challenges to an effective departmental website is active/dynamic updating and reaching out to a diverse audience. This active/dynamic updating is facilitated by an efficient system to get department news posted in a marketable way (news writing and professional graphics). Reaching out to diverse audience will require use of social media to direct individuals to the department web pages specifically designed for the audience. The College of Engineering is supporting website updates to the new UW structure. However, this will still require significant faculty/committee dedication to design audience-targeted pages, update with news, and actively use social media to direct audiences to the department. Professional graphics/writing consultants would aid in pushing out press/news items and the final web site product and newsletters.

Although the website is the central marketing tool, it is an inherently passive way to reach an audience. Events with the public are critical. MSE is active in Engineering demonstration and summer Materials Camp, which can be expanded upon with an emphasis on creating material to help people choose MSE as a career. This should also highlight alumni success. Industry outreach opportunities can grow through Senior Design/Capstone projects and job fairs.

3. **How do we achieve high research productivity while maintaining excellence in teaching with limited state and federal support?**

Research productivity is most closely tied to numbers of supported students. Federal funding is stagnant while student costs (tuition, insurance, overhead) have dramatically increased above inflation impacting what can be achieved with typical grant awards. In this funding environment, it is critical to be highly competitive, with proposals in the top 10% among peers at well-ranked universities. Both single PI and cluster collaborative grants are needed in innovative/emerging areas. Being competitive is a mixture of innovative ideas as well as successful track record. It is also very important to explore opportunities for industrial sponsored research and team up with companies to compete for new manufacturing and energy related initiatives that need more technological readiness. Time/duty management is a primary challenge to both starting and established faculty. Potential strategies include:

- Increasing faculty member numbers will help distribute teaching, committee and administrative duties
- Use of lecturers for large courses will allow a more focused attention onto students and faculty attention to smaller higher level courses and research programs
- Increasing TA numbers will enhance course grading/feedback, including the larger graduate AMP courses

- Adaptable staff that is efficiently used is critical to faculty efficiency
- Mentorship of assistant and associate professors in research: specifically with committee to help with team formation and internal grant/paper review

Since staff position duties are defined by job descriptions and are often static, adapting to changing needs of department and interaction with the public can be a challenge. This is further complicated by a wide variety of faculty requests that may not be reasonable or rewarded/acknowledged. Setting up a process for the Chair to adapt position duties/emphasis with faculty input would increase efficiency and adaptability. Mentorship of starting faculty is important, since they represent a very large investment in start-up resources. In particular, setting up a peer review process for proposals and high impact papers would help in a competitive submission. Formal assigned faculty mentors for monthly meetings would be valuable addition to the current annual evaluation process.

4) **How do we effectively compete for funding in major group/center activities that have MSE in leadership roles and are nationally competitive? What research areas should be strengthened and/or contracted by targeted hiring and facilities development in the next 10 years?**

Strong individual faculty is the basis for building large group grants. Strength is represented in the form of publications, funding and visibility (news, honors). Nationally competitive grants require highly innovative ideas (i.e. the next big thing) and require substantial preliminary/published results. This requires flexibility to develop a focus niche with faculty generally take turns in leading efforts. Leadership roles in major grants include key technical contributions, traditionally with new synthesis or characterization capabilities.

MSE has a strong record for involvement in large center activities in the past 10 years (STC-CMDITR, DARPA-MORPH, GEMSEC, NIH-TR32, NIH-CEGS, CEI, MolES, NNI/NNCI) totaling over $130M to the university community. Direct benefits to the department include high visibility in the area of energy and biomaterials, 15,000 sq feet of new space in Bagley, Physics, MolES, Benjamin Hall and new Nano building. The Clean Energy Institute (CEI) was directly involved with the start-up of 2 faculty hires (MacKenzie, Arias). Through CEI $8M investment in roll-to-roll processing and test-beds for battery and solar cells, MSE faculty (Yang, MacKenzie) providing key technical leadership in both material systems and processing methods.

Energy and Biomedical material applications will continue as critical societal needs, and are currently the primary MSE target areas. Generally, half the faculty are focused in each of those areas with most having active efforts in both. Manufacturing/processing is an important departmental growth area by: a) supporting both Energy and Biomedical applications b) serving as a foundational part of the MSE tetrahedron curriculum mission and c) building better faculty/student industry ties to industry. For NSF center grants, strong industrial ties are a requirement to be competitive. MSE will continue to target strategic senior faculty hiring for center-level proposals/programs in these areas of strength.

The COE has initiated a competitive Strategic Research Initiatives (SRI) as a mechanism to provide seed funding to bring multidisciplinary teams together. MSE is involved with i-TEAM for entrepreneurial medical device teams and printable integrated device manufacturing development. This SRI process for seed funding allows the department to remain flexible on supporting topics to foster 'the next big thing'

5) How to establish the MSE department as a vibrant and cohesive "Hub" for materials-related research, education, facilities, and technology/entrepreneurial translation on the UW campus and region to positively impact societal needs?

The MSE field is best defined by the Processing/Structure/Properties/Performance tetrahedron with characterization tying them together. In many regards, we need to market the Processing/Structure/Properties/Performance as the primary identification of the MSE discipline.

Another important point is that all applications are ultimately materials limited, so that breakthroughs in material performance will lead to breakthroughs in applications.

Traditionally most collaborators would come to MSE for help with characterization (microscopy, mechanical testing) or processing/synthesis. Presently, characterization is primarily housed within the large centers (TEM, FIB, synchrotron) largely due to cost. While MSE has opportunities to be lead users and develop instruments with world-class performance, many important simple tools (such as sample prep, thermal and mechanical test, optical microscopy) will continue to be enhanced/maintained in shared resources such as in the UG lab. Much of this equipment was purchased with UW Student Technology Funds, therefore access to all UW students is compulsory and sets the stage for student-led innovation hubs.

To develop industrial ties, we need student training in areas of demand related to processing/characterization and science of specific systems of industrial interest. With Capstone Senior Design short projects we can build closer interactions with industries and train students with desired skills. This can be primary and secondary manufacturing. Net-shape forming methods including reaction injection molding, superplastic forming, 3-D high-value processing are areas of manufacturing demands that can integrated into the undergraduate experience. In many regards, the MSE lab infrastructure can serve as an extension of 'maker space' where student teams (undergraduate and graduate) come together to solve materials problems and enable innovative applications. This is expected to develop dynamics of sprit de corps of a Materials Hub.

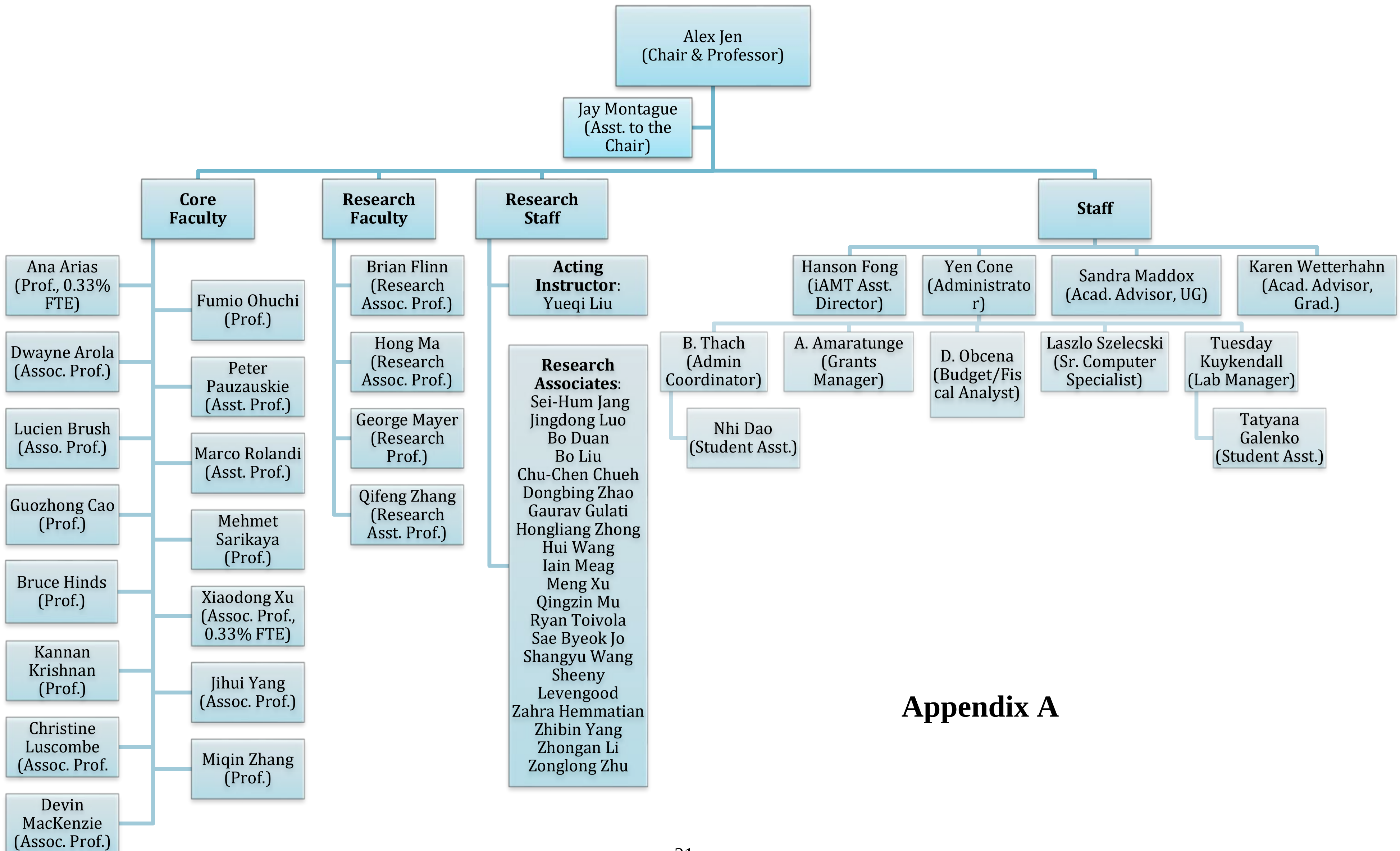
Although the Processing/Structure/Properties/Performance tetrahedron is a powerful core curriculum, translating these skills to societal impact requires talents in problem identification, creative use of technical knowledge, and team building. These talents need to be developed during the educational experience. For undergraduates this is done with summer interns, lab research experiences and the team Capstone Senior Design Projects. With the Senior Design Project, instead of only industry sponsored projects, a track can be developed with co-motion center/entrepreneur programs to utilize maker space and undergraduate facilities. With minor curriculum changes we can have entrepreneur courses as a technical elective for this track. Also in the 'direct admit to college model' (start in Engineering freshman year, then MSE in sophomore year), students will have more time for problem identification and team formation. This can be enabled with formally enrolled 1-unit courses in a capstone development track.

A part of the PhD program can also be structured with an entrepreneur track of: Intern/Clinic experience -> project/science development -> entrepreneur team formation. This is in-line with the structure of the COE sponsored i-TEAM SRI and will be the foundation of training grant proposals to be submitted in this and following years. In this education model, PhD theses are enabled to culminate in a team product with technology transfer or start-up company formation.

UNIVERSITY *of* WASHINGTON

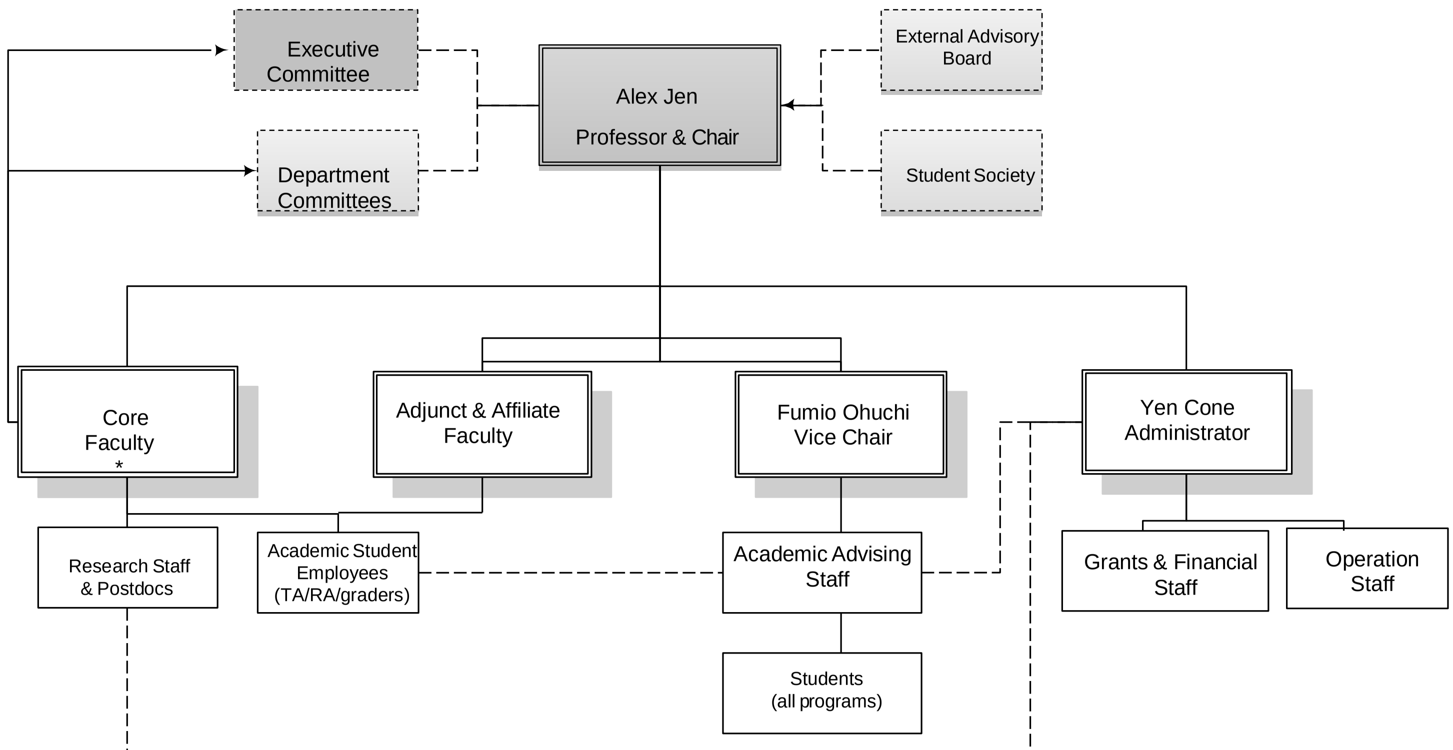
MATERIALS SCIENCE & ENGINEERING

Appendix A



Appendix B

Organization Structure & Department Governance



Appendix C
Materials Science and Engineering
COMMITTEE LIST 2015-16

rev. 10/07/15

DEPARTMENT COMMITTEES

ABET (ACI)
Lucien Brush, Chair
Stanley Choi
Fumio Ohuchi

170 Oversight
Mehmet Sarikaya
Miqin Zhang
Marco Rolandi

Executive Committee
Alex Jen
Christine Luscombe
Fumio Ohuchi

MSE Safety (11/1/14)
Tuesday Kuykendall, Chair
Hamed Arami (KK)
Yingxin Deng (MR)
Ariane Erickson (MZ)
Hanson Fong (MS)
Pegah Hassanzadeh (MR)
Sei-Hum Jang (AJ)
Jingdong Luo (AJ)
Hong Ma (AJ)
Sandra Murcia (DA)
Zachary Stephen (MZ)
Kevin Strong (RB)
Sabin-Lucian Suraru (CL)
Ryan Toivola (BF)
Ashley Tracey (BF)
Ching-Ting Tsao (MZ)
Evan Uchaker (GZ)
Carolina Vinado (JY)

External Curriculum Review Committee
Steven Daly
Nathan Schwartz
Jonathan Thibado
Brian Smith

Seminar Advisor
Peter Pauzauskie

Adjunct/Affiliate Review
Fumio Ohuchi, Chair
George Mayer
Mehmet Sarikaya

Advancement Advisory
Tom Delimitros
Clare Nordquist
Alex Jen
Tom Stoebe

Qualifying Exam
Jihui Yang
Kannan Krishnan

Graduate Committee
Christine Luscombe, Chair
Dwayne Arola
Kannan Krishnan
Hong Ma
Marco Rolandi
Jihui Yang

Graduate Admissions
Christine Luscombe, Chair
Jihui Yang
Dwayne Arola
Hong Ma
Peter Pauzauskie
Marco Rolandi

Undergraduate Comm
Fumio Ohuchi, Chair
Lucien Brush
Dwayne Arola
Jihui Yang
Miqin Zhang

Space, Facility & Instruments
Guozhong Cao, Chair
Fumio Ohuchi
Marco Rolandi
Hong Yen Cone

COLLEGE COMMITTEES

Executive Committee
Alex Jen, Chair

College Council (3-yr term)
Guozhong Cao *(1st term, exp. 6/30/17)*

Accreditation & Continuous Improvement (ACI)
Lucien Brush

Engineering Library Liaison Committee
Guozhong Cao *(no set terms or limits; mostly phone contact)*

Council on Educational Policy (3-yr term)
Jihui Yang *(1st term, exp. 9/15/16)*

Council on Promotions and Tenure (3-yr term)
Guozhong Cao *(1st term, exp. 6/30/18)*

College Safety Committee
Laszlo Szeleczki

Nanoscience & Molecular Engr. Option Comm.
Christine Luscombe *(no set terms)*

UNIVERSITY COMMITTEES

Faculty Senate (shared w/HCDE, 2-yr term)
Jennifer Turns, HCDE (9/16/15 – 9/15/17)

C4C Intellectual Property & Mgmt Committee
Miqin Zhang *(this is for informal advising only; not an actual sitting committee that holds meetings)*

UW Group 9 Safety Committee
Karen Wetterhahn

Graduate & Professional Student Senate (GPSS)
Eric Teeman & Michael Crump (2015-16)

Appendix D
EXTERNAL ADVISORY BOARD

rev. 12/02/15

Mr. Stephen Ching (BS CerE 72)
(Retired, President of Isolink, Inc.)
1148 Glenn Avenue
San Jose, CA 95125
(408) 297-8534; sching272@yahoo.com

Dr. Bonnie Dunbar (BS CerE 71, MS CerE 75)
(Member NAE)
M.D. Anderson Professor of Mechanical Engineering
Director, UH STEM Center
University of Houston
124E Cullen Building
Houston, TX 77204-2015
(713) 743-9223; bjdunbar@central.uh.edu
Assistant: Leslie Upton
(713) 743-2072

Dr. Aaron Feaver (PhD MSE 07)
Chief Technology Officer
EnerG2
100 NE Northlake Way, Suite 300
Seattle, WA 98105
(206) 547-0445 x107; cell: (206) 679-2671
afeaver@energ2.com

Mr. Donald Gorski, (BS CerE 78)
(Retired)
5045 Forest Ave SE
Mercer Island, WA 98040-4623
cell: 206-790-9766
gorskdon@msn.com

Prof. Alex Jen
Chair, Materials Science & Engineering
University of Washington
Box 352120, 302 Roberts Hall
Seattle, WA 98195
(206) 543-2626; Cell: (206) 909-6166
ajen@uw.edu
Asst: Jay Montague, montague@uw.edu
(206) 543-2615

Dr. Jun Liu (MS CerE 86, PhD CerE 90)
Lab Fellow
Pacific Northwest National Lab
PO Box 999, MS K3-59
Richland, WA 99352
(509) 375-4443 ; jun.liu@pnl.gov

Dr. Biljana Mikijelj (MS Engr 84, PhD MSE 86)
Laboratory Mgr, AdMD, Ceramics Platform
Ceradyne, Inc., 3169 Redhill Avenue
Costa Mesa, CA 92626
(714) 549-0421 x8401
bmikijelj@mmm.com

Dr. Mansour Moinpour (MS MetE 81, PhD MetE 87)
Engineering Manager
Fabrication Materials Organization
Intel Corporation
2200 Mission College Blvd., Mail Stop RNB-2-92
Santa Clara, CA 95052-8119
(408) 765-9475; mansour.moinpour@intel.com

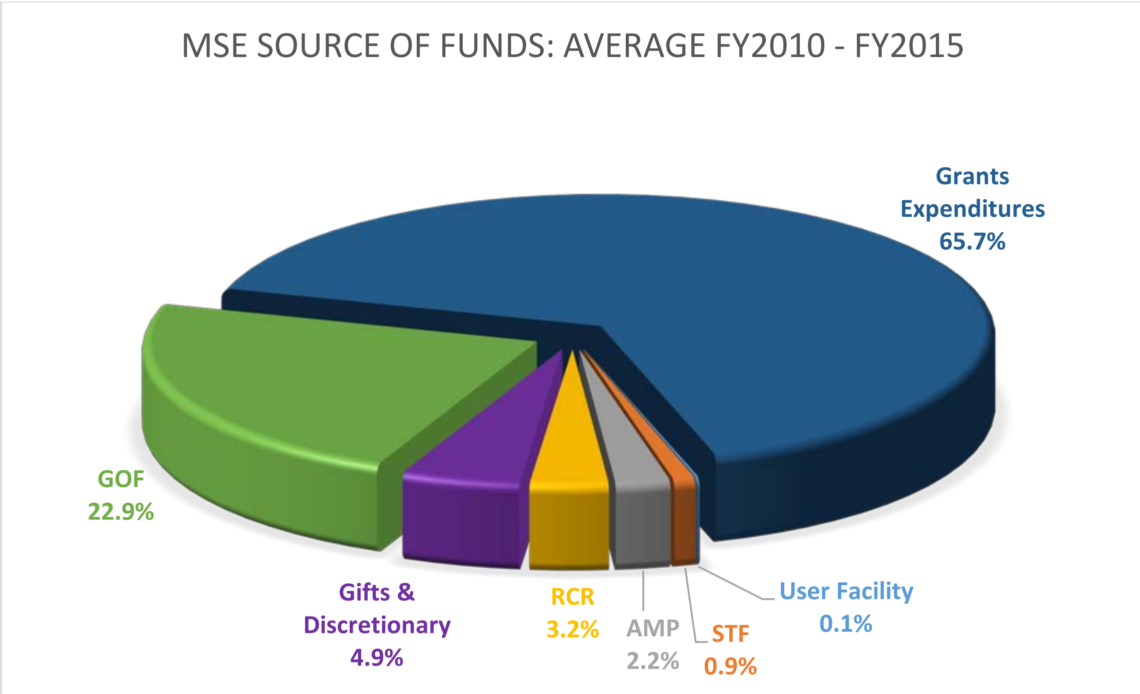
Mr. Brian W. Smith (BS MetE 79)
Director, Composites Technology
Boeing Research & Technology
P.O. Box 3707 MC 41-45
Seattle, WA 98124-2207
TEL: (206) 662-6669; cell (425) 923-5680
brian.w.smith@boeing.com;
Assistant: kristina.a.warnes@boeing.com

Dr. John Smythe, III (EAB Vice-Chair)
(BS CerE 80, MS MSE 04, PhD MSE 09)
Development Lead, Advanced Technology Lab
Micron Technology, Inc.
P.O. Box 6, Mail Stop 1-719
Boise, ID 83707-0006
(208) 363-2920 ; Cell (208) 577-0681
jsmythe@micron.com

Mr. J. Hayden Thomas (BS CerE 82) **(EAB Chair)**
(Retired, Sr. VP & Gen Mgr, Worldwide Manuf. & Operations Group, LSI Corporation)
216 SW Parkside Drive
Portland OR 97205
Tel: 503-248-9302; cell: (503) 708-7785

Appendix E

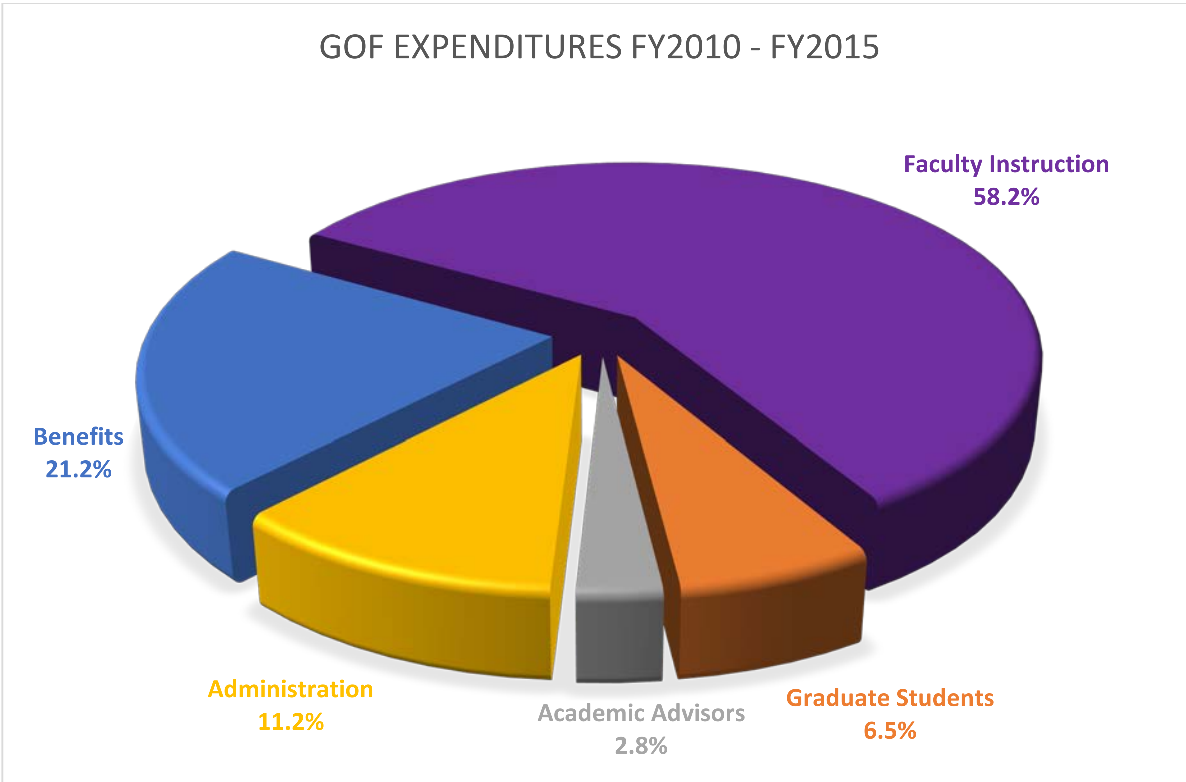
Figure 1



Total Awards/Revenue by Fiscal Year

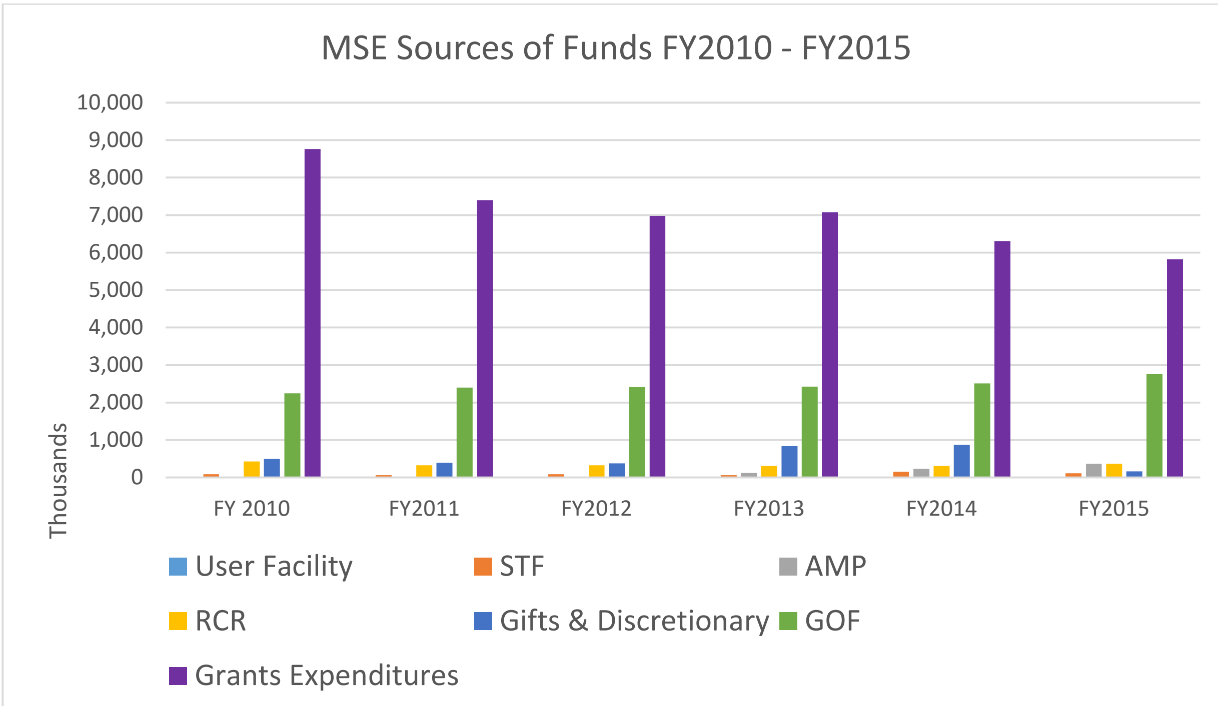
Award/Revenue Type	FY 2010	FY2011	FY2012	FY2013	FY2014	FY2015	Average 2010-2015
User Facility	11,200	11,500	12,760	13,550	14,000	14,400	12,902
STF	84,000	64,800	89,000	65,498	152,732	113,880	94,985
AMP	0	0	0	119,163	230,000	372,000	240,388
RCR	429,299	326,908	327,084	305,321	311,037	372,000	345,275
Gifts & Discretionary	498,794	398,446	381,633	834,063	868,775	163,914	524,271
GOF	2,245,061	2,400,696	2,417,867	2,421,876	2,514,044	2,760,023	2,459,928
Grants Awards	6,331,400	6,984,739	5,093,172	4,943,698	5,178,720	4,969,883	5,583,602
Total	9,599,754	10,187,089	8,321,516	8,703,169	9,269,308	8,766,100	9,261,350
*Grants Expenditures	8,760,972	7,394,541	6,977,244	7,073,99	6,302,755	5,817,345	7,054,474

Figure 2



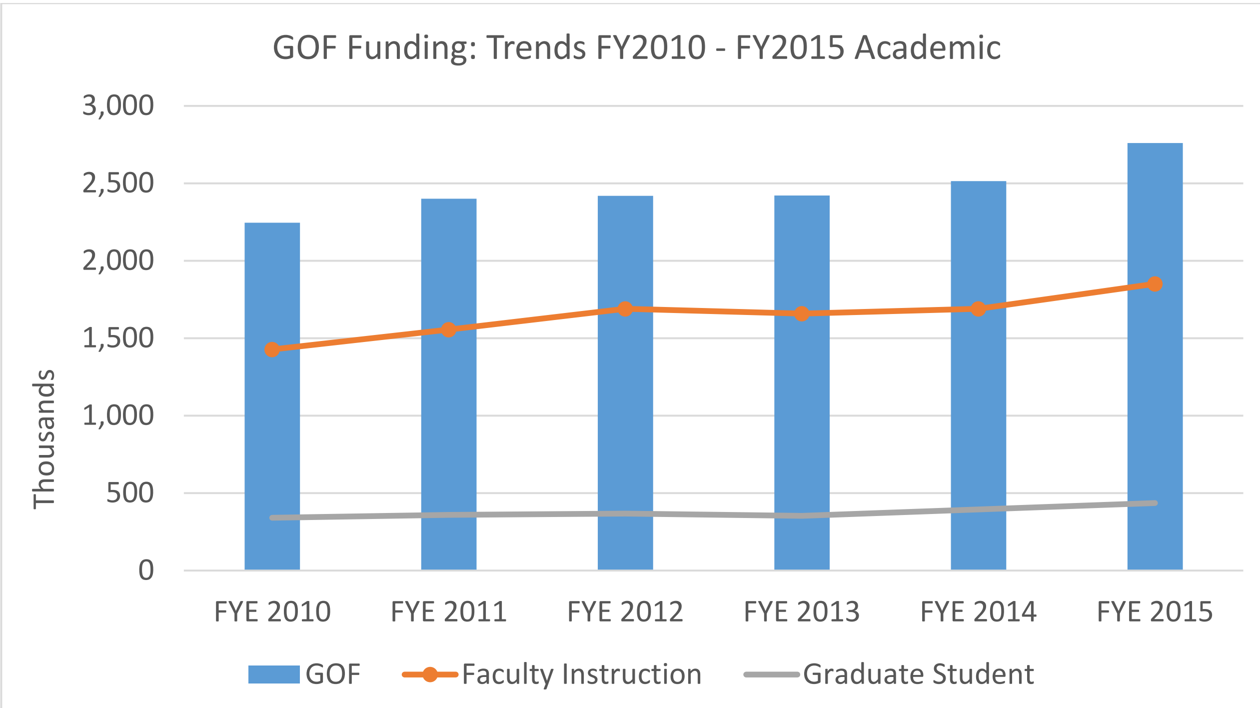
Financial Summary - GOF	2010	2011	2012	2013	2014	2015	2010-2015
Faculty Instruction	1,245,956	1,349,989	1,478,199	1,450,569	1,465,492	1,595,565	1,430,962
Graduate Students	158,998	154,409	155,845	145,408	170,230	181,348	161,040
Academic Advisors	52,300	52,300	54,912	55,210	96,100	105,100	69,320
Administration	344,447	343,986	212,909	262,258	235,000	257,540	276,023
Benefits	443,360	500,012	516,002	508,431	547,222	620,470	522,583
Total Direct Costs	2,245,061	2,400,696	2,417,867	2,421,876	2,514,044	2,760,023	2,459,928

Figure 3



Award/Revenue Type	FY 2010	FY2011	FY2012	FY2013	FY2014	FY2015
User Facility	11,200	11,500	12,760	13,550	14,000	14,400
STF	84,000	64,800	89,000	65,498	152,732	113,880
AMP	0	0	0	119,163	230,000	372,000
RCR	429,299	326,908	327,084	305,321	311,037	372,000
Gifts & Discretionary	498,794	398,446	381,633	834,063	868,775	163,914
GOF	2,245,061	2,400,696	2,417,867	2,421,876	2,514,044	2,760,023
Grants Expenditures	8,760,972	7,394,541	6,977,244	7,073,992	6,302,755	5,817,345
Total	12,029,326	10,596,891	10,205,588	10,833,463	10,393,343	9,613,562

Figure 4



YEAR	GOF	Faculty Instruction	Graduate Student
FYE 2010	2,245,061	1,427,733	340,775
FYE 2011	2,400,696	1,554,994	359,414
FYE 2012	2,417,867	1,689,760	367,406
FYE 2013	2,421,876	1,659,026	353,865
FYE 2014	2,514,044	1,689,853	394,591
FYE 2015	2,760,023	1,849,958	435,741

Appendix F

Advancement Summary

Two of the ten endowments resulted from generous gifts given by current and former faculty members. Five endowments were made possible by gifts from loyal alumni. To recognize and honor the legacy of a late family member who earned a degree from the department, the families of two alumni created endowments in the name of their loved one. Finally, the tenth endowment was created by a much beloved professor emeritus. Several alumni generously support this fund in celebration of the outstanding teaching and mentoring provided during 40+ year tenure of this professor.

	Endowments	**Total Value**	**Annual Distribution**
Scholarship Support	1	$515,960	$20,638
Fellowship Support	5	$616,935	$24,677
Program Support	4	$529,675	$21,187
TOTAL	10	$1,662,570	$66,503

Appendix G

Student Enrollments and Graduation Patterns

G.1. Admission Requirements and Admission of Students

The general guidelines for evaluating students for admission include:

Direct Admission: The general guidelines for evaluating the quality of the students include:

- High School GPA (GPA) of at least a 3.7 or higher and SAT scores (or equivalent) of at least 1300 or higher.
- The overall academic record of the student, and
- Motivational factors as evidenced by previous internship or work experiences, science and engineering activities, a written statement or other documented evidence.

Early Admission: The general guidelines for evaluating the quality of the students include:

- Student grade point average (GPA). Students must have a minimum 2.0 in each prerequisite course and an overall GPA of 2.5 or higher.
- Completion of prerequisite coursework including 15 credits of mathematics (MATH 124, 125, 126), 10 credits of physical science from PHYS 121, PHYS 122, CHEM 142, CHEM 152 and 5 credits of English Composition.
- The overall academic record of the student, and
- Motivational factors as evidenced by previous work experience, a written statement or other documented evidence.

Upper Admission: The general guidelines for evaluating the quality of the students include:

- Student grade point average (GPA). Students must have a minimum 2.0 in each prerequisite course (mathematics, chemistry, physics, engineering fundamentals and English composition) and an overall GPA of 2.5 or higher.
- Completion of prerequisite coursework including 18 credits of mathematics (MATH 124, 125, 126, 307), 20 credits of physical sciences (PHYS 121, PHYS 122, CHEM 142, CHEM 152), 4 credits of computer programming (A MATH 301 or CSE 142), MSE 170, and 5 credits of English Composition.
- The overall academic record of the student, and
- Motivational factors as evidenced by previous work experience, a written statement or other documented evidence.

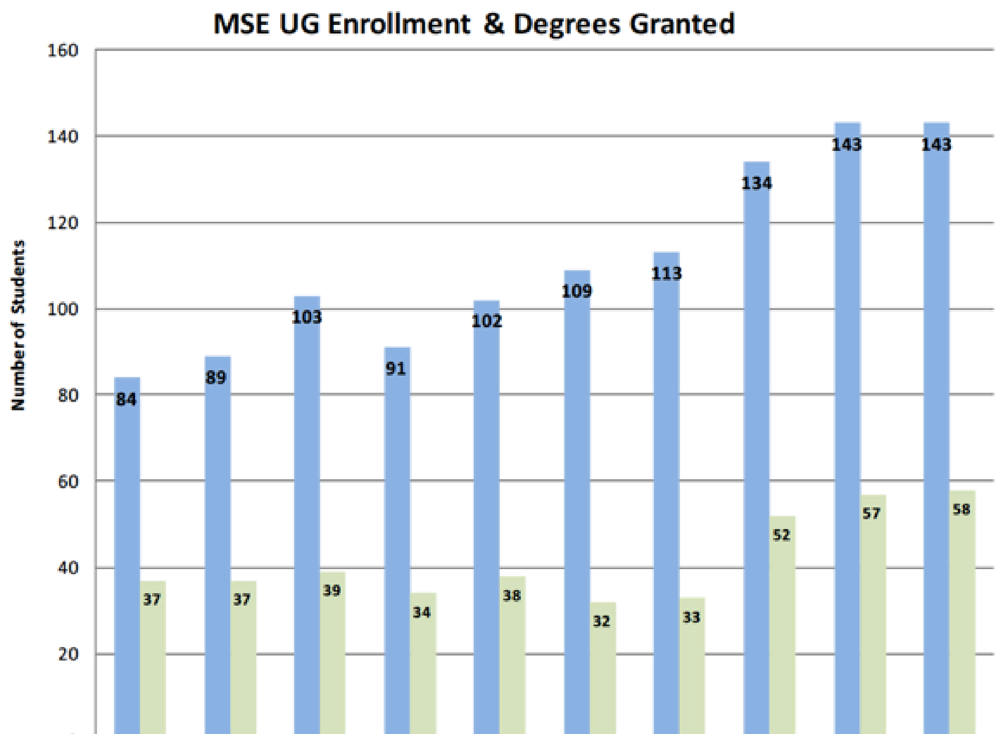
G.2. Student Enrolments

Undergraduate enrolment and graduation from 2005 to 2014 are shown in Fig. G-1. Undergraduate enrollment during the 2000's only gradually increased from ~85 to ~100 students, but there was a significant growth from 109 in 2010 to 143 in 2014. This growth spurt was due to an increase in the lab equipment and facilities after successful fundraising from the lab-upgrade campaigns, the increased number of applicants, as well as gaining an additional academic advisor. As a result, the number of degrees granted increased in recent years. Historically, the BS-MSE degree program has been an upper-division only (i.e., junior and senior) program; however, beginning in the late 1990s, the department began a process of inviting high-achieving, lower-division students to join the department at the start of their sophomore year as Early Admissions students. The number of Early Admits entering the department steady increased as seen in Fig. G-2. Currently, about 19% of students in the junior class were originally admitted through the Early Admission process.

Direct Freshman Admissions in our department began in 2010 with 3 students who were admitted to the department at the start of their freshman year. While the total number of applicants steady grew from 55 to 132, the amount of Direct Admits remained fairly consistent as seen in Figure G-3.

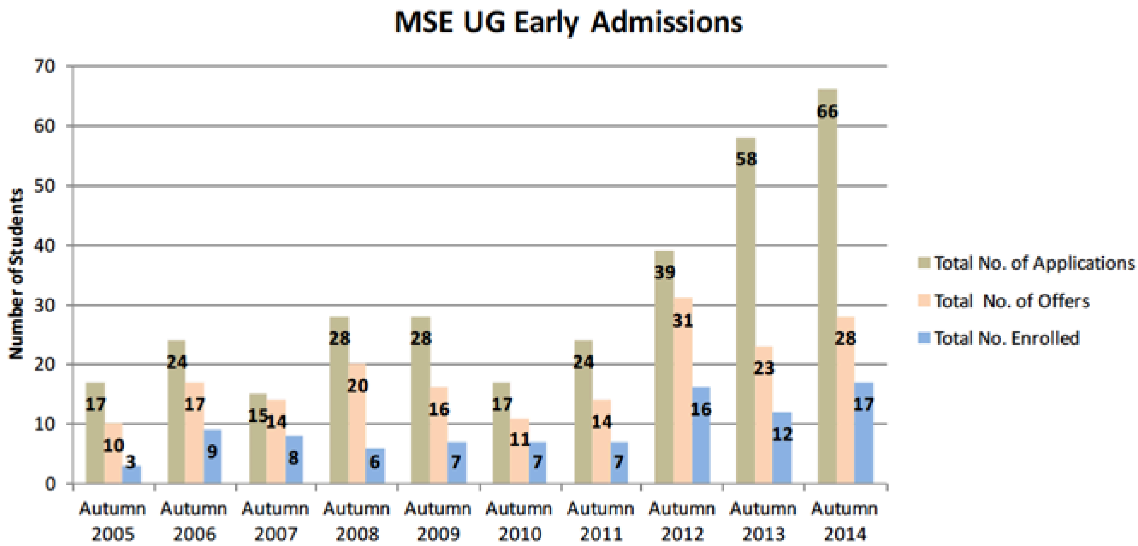
Upper Admissions has increased steadily with the number of applicants, admission offer acceptances and enrollment (Figure G-4). This allowed for a more competitive application process and a higher quality of students joining the department.

The fraction of underrepresented minorities (URM) in the MSE undergraduate program, shown in Figure G-5, continues to fluctuate, but generally remained at 3-5% over the years. This number rose to 8% in 2014-15. The enrollment of females ranged from 20% to 29% throughout the years (Fig F-6). The department continues to make efforts to increase the URM and female MSE population. The advisors participate in various outreach events, especially ones geared at these two groups of potential students. The department expects to see these numbers increase as the MSE continues to evolve.



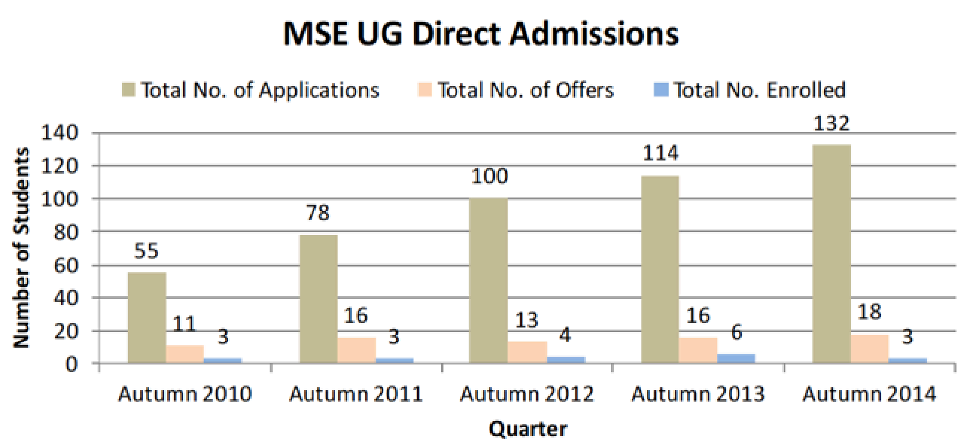
	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15
Total Enrollment	84	89	103	91	102	109	113	134	143	143
Total Degrees Granted	37	37	39	34	38	32	33	52	57	58

Figure G.1. MSE UG enrollment and degree granted.



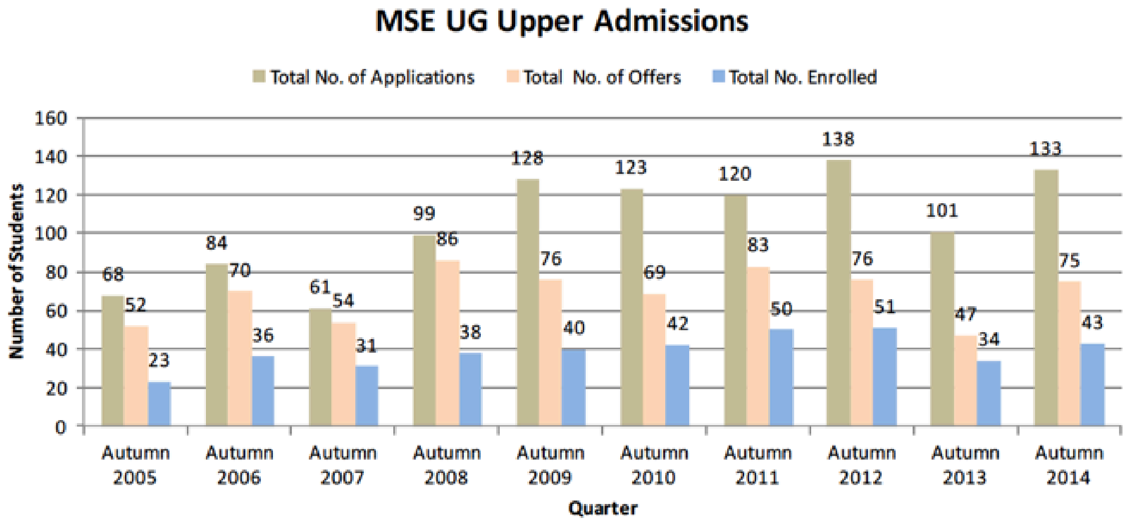
MSE Early Admissions	Total # of Applications	Total # of Offers	% of Offers	% of Offers	Total # Enrolled	% of Enrolled	% of Enrolled	Avg Prereq GPA of Offers	Avg Cumul GPA of Offers
Autumn 2005	17	10	59%	59%	3	30%	30%	3.39	3.47
Autumn 2006	24	17	71%	71%	9	53%	53%	3.49	3.51
Autumn 2007	15	14	93%	93%	8	57%	57%	3.34	3.40
Autumn 2008	28	20	71%	71%	6	30%	30%	3.54	3.56
Autumn 2009	28	16	57%	57%	7	44%	44%	3.46	3.49
Autumn 2010	17	11	65%	65%	7	64%	64%	3.43	3.47
Autumn 2011	24	14	58%	58%	7	50%	50%	3.64	3.63
Autumn 2012	39	31	79%	80%	16	52%	52%	3.42	3.45
Autumn 2013	58	23	40%	40%	12	52%	52%	3.67	3.67
Autumn 2014	66	28	42%	42%	17	61%	61%	3.62	3.63
10-Yr Average	41	21	57%	64%	9	56%	49%	3.56	3.57

Figure G.2. MSE UG early admissions



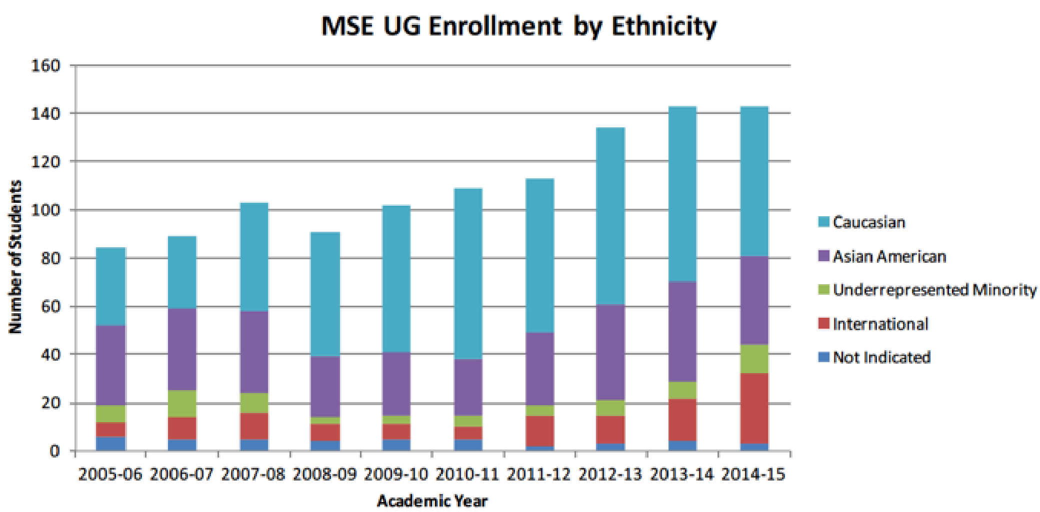
MSE Direct Admissions	Total No. of Applications	Total No. of Offers	% of Offers	Total No. Enrolled	% of Enrolled	Average HS GPA of Enrolled MSE Majors	Average SAT Scores of Enrolled MSE Majors
Autumn 2010	55	11	20%	3	27%	3.86	1420
Autumn 2011	78	16	21%	3	19%	3.88	1420
Autumn 2012	100	13	13%	4	31%	3.90	1430
Autumn 2013	114	16	14%	6	38%	3.91	1400
Autumn 2014	132	18	14%	3	17%	3.97	1380
5-Yr Average	**87**	**15**	**16%**	**4**	**26%**	**3.90**	**1410**

Figure G.3. MSE UG direct admissions



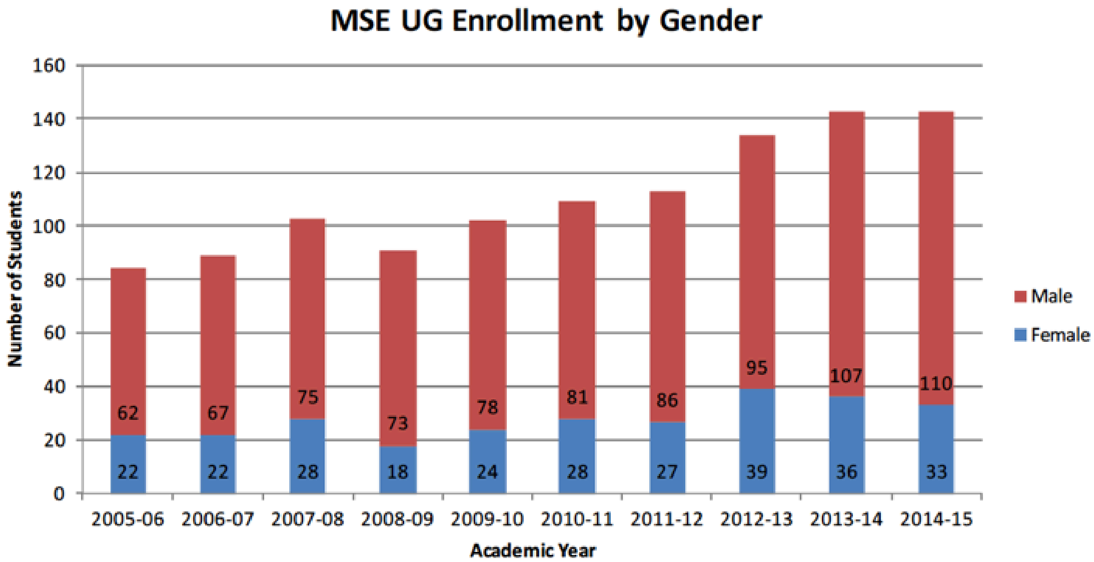
MSE Upper Admissions	Total # of Applications	Total # of Offers	% of Offers	Total No. Enrolled	% of Enrolled	Avg Prereq GPA of Offers	Avg Cumul. GPA of Offers
Autumn 2005	68	52	44%	23	44%	3.16	3.24
Autumn 2006	84	70	83%	36	51%	3.05	3.18
Autumn 2007	61	54	89%	31	47%	3.05	3.15
Autumn 2008	99	86	87%	38	44%	3.15	3.24
Autumn 2009	128	76	59%	40	53%	3.27	3.33
Autumn 2010	123	69	56%	42	61%	3.32	3.36
Autumn 2011	120	83	69%	50	60%	3.38	3.42
Autumn 2012	138	76	55%	51	67%	3.23	3.31
Autumn 2013	101	47	47%	34	72%	3.33	3.35
Autumn 2014	133	75	56%	43	57%	3.37	3.38
10-Yr Average	**106**	**69**	**65%**	**39**	**56%**	**3.23**	**3.30**

Figure G. 4. MSE UG upper admissions



Historical Enrollment by Ethnicity	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15
Not Indicated	6	5	5	4	5	5	2	3	4	3
International	6	9	11	7	6	5	13	12	18	29
Underrepresented Minority	7	11	8	3	4	5	4	6	7	12
Asian American	33	34	34	25	26	23	30	40	41	37
Caucasian	32	30	45	52	61	71	64	73	73	62
Total Enrollment	84	89	103	91	102	109	113	134	143	143
% Underrepresented Minority	8%	12%	7%	3%	4%	5%	4%	4%	5%	8%

Figure G. 5. MSE UG enrollment by ethnicity



Historical Enrollment by Gender	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15
Female	22	22	28	18	24	28	27	39	36	33
Male	62	67	75	73	78	81	86	95	107	110
Total Enrollment	84	89	103	91	102	109	113	134	143	143
% Female	26%	25%	27%	20%	24%	26%	24%	29%	25%	23%

Figure G.6. MSE UG enrollment by gender

Appendix H

Upgrading Campaign of the Undergraduate Labs

The bottleneck of UG student enrollment in MSE was exacerbated by the capacity of the lab facilities for many years. To improve the situation, the department initiated several fundraising campaigns to improve the UG lab facilities over the years. In 2006, the department adopted LabVIEW interfacing technology into the Junior Lab after receiving a $50,000 Intel Higher Education Grant. These workstations served for LabVIEW training conducted as part of the labs during the full school year. Every year since 2010, the department has submitted proposals to the UW Student Technology Fund (STF), and obtained ~$100,000/year on average (or total of $613,913 from 2010 to 2015). Summary of the STF funds is shown in Table below. In addition, the department successfully raised $200,000 in private giving in 2013. These funds were further matched with $50,000 from the COE to leverage everyone's donations by 25 %.

Results of the STF Funding 2010 - 2015

Funded	Item	Cost	Su-total
2010	UV-Vis Spectrophotometer	$19,000.00	
2010	Ellipsometer	$35,000.00	
2010	Optical Microscopy/Software Equip/ Software	$30,000.00	
			$84,000.00
2011	Particle Size Analyzing System	$60,000.00	
2011	Digital SEM Imaging Upgrade	$4,800.00	
			$64,800.00
2012	Differential Scanning Calorimeter	$24,930.00	
2012	Thermogravimetric Analyzer	$33,050.00	
2012	DSC Auto-Sampler	$10,030.00	
2012	Shipping and Tax	$20,990.00	
			$89,000.00
2013	Bruker VERTEX 70 FTIR spectrometer	$31,275.00	
2013	ATR units 9 A225/QI	$9,357.80	
2013	Reflection Unit 8 A518/Q	$3,905.00	
2013	OPus Software Package	$1,476.80	
2013	Configured PC CS81/25+	$1,689.80	
2013	Pike FTIR to TGA adaptor_FTIR_ACC-O	$11,127.00	
2013	Shipping	$750.00	
	Estimated Tax	$5,919.18	
			$65,500.58
2014	JEOL 6010 Scanning Electron Microscope	$133,000.00	
2014	IR Camera for SEM Positioning	$3,800.00	
2014	SEM Maintenance agreement - 1Year	$14,220.57	
2014	Tax for IR camera and Maintenance	$1,712.00	
			$152,732.57
2015	X-Ray Fluorescence (Ranger)	$93,000.00	
2015	Sample prep station and standards	$11,000.00	
2015	Tax	$9,880.00	
2015	Ugrade to New Instrument (Tornado)	$44,000.00	
			$157,880.00
		Total $	**$613,913.15**

Appendix I
Program Curriculum

I.1 BS-MSE Graduation Requirement

Students need *180 credits* to complete for their degree in BS-MSE. For this, students are prepared for engineering practice first through basic education in math, physics and chemistry (55 credits; included in this total are 6 credits of science electives). This is followed by engineering fundamentals (24 credits). Students also need to take a total of 24 credits of Visual, Literary and Performing Arts (VLPA) and Individual & Societies (I&S), as well as courses in Written and Oral Communication (8 credits). Materials fundamentals (35 credits) are taught in the junior year, beginning with an introductory course where they are involved in a materials selection problem posed by industrial representatives, followed by courses in structure, property and processing relationships in materials. Students continue required courses (14 credits) into their senior year, and their senior project (4 credits). They then apply their knowledge to technical electives (16 credits) during their senior year. A minimum of 8 of these must be MSE courses at the 400-level or higher except MSE 520 and MSE 599 (graduate courses); however, courses chosen as technical electives are not classes already required for graduation. In order to meet the needs of our graduates (gathered from feedback from students and their employers), the courses that can be used for the technical electives has been significantly expanded recently, in which two significant changes include the use of up to 6 credits from the advanced science courses and a selected list of business courses as technical electives. The following page is a concise summary of current BS-MSE degree requirements.

MSE Materials Science and Engineering Graduation Requirements
University of Washington
depts.washington.edu/mse

Requirement Sheet Key
♦ = Upper-Division Admission Requirements

Mathematics (24 Credits)
♦MATH 124 (5cr) – Calculus I
♦MATH 125 (5cr) – Calculus II
♦MATH 126 (5cr) – Calculus III
♦MATH 307(3cr) – Differential Equations *[pr: Math 125]*
MATH 308 (3cr) – Matrix Algebra *[pr: Math 126]*
One (1) math elective from the following list (3cr):
INDE 315, MATH 309, MATH 324, MATH/STAT 390
(AMATH 351/352/353 may substitute for Math 307/308/309)

Natural Sciences (31 Credits)
♦CHEM 142 (5cr) – General Chemistry with lab
♦CHEM 152 (5cr) – General Chemistry with lab
♦PHYS 121 (5cr) – Mechanics with lab *[pr: Math 124]*
♦PHYS 122 (5cr) – Electro/Oscillatory with lab *[pr: Math 125]*
PHYS 123 (5cr) – Waves with lab *[pr: Math 126]*
Two (2) science electives from the following list (6cr):
BIOL 180, 200, 220; CHEM 162, 223, 224, 237, 238, 239;
PHYS 224, 225, 227, 228

Written & Oral Communications (8 Credits)
♦English Comp (5cr) – English Composition
HCDE 231 (3cr) – Intro to Technical Writing [pr: Engl. Comp]

Visual, Literary & Performing Arts/ Individuals & Society (VLPA/I&S) (24 Credits)
Minimum 10 credits in VLPA required.
Minimum 10 credits in I&S required.
Remaining 4 credits can be either VLPA or I&S.

Engineering Fundamentals (24 Credits)
♦AMATH 301 (4cr) – Beginning Scientific Computing
-or-
CSE 142 (4cr) – Computer Programming I
♦MSE 170 (4cr) – Fund. of Material Science *[pr: CHEM 152]*
AA 210 (4cr) – Engineering Statics *[pr: Math 126, PHYS 121]*
CEE 220 (4cr) – Intro to Mech. Of Materials *[pr: AA 210]*
Two (2) engineering electives from the following list (8cr):
AA 260 (4cr) – Thermodynamics *[pr: CHEM 142, Math 126, PHYS 121]*
EE 215 (4cr) – Fund. of EE *[pr: PHYS 122 & MATH 126]*
IND E 250 (4cr) – Fundamentals of Engineering Economy
ME 123 (4cr) – Visualization and Computer Aided Design
ME 230 (4cr) – Kinematics & Dynamics *[pr: AA 210]*

MSE Core Courses (53 Credits)
MSE 310 (3cr) – Intro to Material Science & Engineering
MSE 311 (3cr) – Integrated Junior Lab I
MSE 312 (3cr) – Integrated Junior Lab II
MSE 313 (3cr) – Integrated Junior Lab III
MSE 321 (4cr) – Thermodynamics and Phase Equilibrium
MSE 322 (4cr) – Kinetics and Microstructural Evolution
MSE 331 (3cr) – Crystallography and Structure
MSE 333 (3cr) – Characterization of Materials
MSE 342 (3cr) – Materials Processing I
MSE 351 (3cr) – Electron Theory
MSE 352 (3cr) – Functional Properties of Materials I
MSE 362 (3cr) – Mechanical Behavior of Materials I
MSE 399 (1cr) – Undergraduate Research Seminar
MSE 431 (3cr) – Principles of Physical Materials
MSE 442 (3cr) – Materials Processing II
MSE 491 (2cr) – Materials Design and Failure
MSE 492 (2cr) – Design in Materials Engineering II
MSE 499 (4cr) – Senior Project

MSE Technical Electives (16 Credits)
16 credit minimum to include at least 8 MSE credits taken from the list of approved technical electives. Please see MSE Advisor for list of approved technical electives.

Total Credits Required for Graduation (180 Credits)

Early Admission Requirements
1. Early Admission is an option for Autumn Quarter only.
2. Students must be enrolled at UW-Seattle.
3. MATH 124, 125 & 126 or equivalent.
4. 10 credits of physical sciences courses plus the accompanying lab at the level of CHEM 142, 152; PHYS 121, 122, 123.
5. 5 credits of English Composition.
6. 15 credits must have been completed at UW.

Application Deadlines
Early Admission – July 1st
Upper Admission – July 1st (pending university approval)

Last revised August 2013

I.2 Assessment and Evaluation of Student Achievement

A process currently adopted for the assessment and evaluation of student achievement of our educational outcomes is carried out in a three-level curriculum review. This system was developed by the deparmental Accreditation and Continous Improvement (ACI) committee in 2006, and first implemented in 2007.

The first level is the review of all individual course offerings by the faculty intructors. Each faculty instructor evaluates the appropriateness of the outcomes they have assigned to their course, and assesses and evaluates the student achievement of the outcomes at least every other year. This data is submitted by the faculty member coordinating/instructing the course to the Departmental ACI committee. The ACI reviews each course and provides input individually. *The second level* is the evaluation of course groupings that occurs every three years by teams of the faculty. Courses are grouped by their sequencing, pre-requisites and content. A report is created and provided to the ACI committee from each group for evaluation and to identify needs and to recommend changes in the curriculum. The appropriateness of the outcomes for the set of courses is one issue addressed at this level of review. *The third level* of review is an overall review that is carried out by the faculty and the MSE Department's external curriculum review committee, consisting of three industrial participants all of who are alumni of our Department. This level of review provides recommendations from industry and the faculty that address the overall direction of the curriculum and methods for improving the student preparedness for their careers.

Another process currently adopted for the assessment of student achievement of our educational outcomes is through an interview study by asking seniors what kind of course contents presented to them have the greatest intellectual challenges to them, what made these activities challenging, what enabled students to meet those challenges, and what students learned from completing those challenging activities.

The department also pays special attention to recognize the achievements of the students. The faculty advisor and the academic counselor work with the students in helping them identify appropriate Fellowships and Scholarships to apply for and actively nominate students for awards and honors. As a result, a significant number of the students from the Department receive these awards and honors. Several Departmental awards also recognize the academic achievement and leadership potential of the students. Recognition of the awards are made through a congratulatory e-mail from the Chair, listing in the Department newsletter, announcement at the faculty meetings, the Department Graduation Ceremonies and the annual Faculty and Staff Retreats.

Appendix J
Direct Feedback from Graduating Students

We used the services of the Center for Instructional Development and Research (CIDR) to facilitate a group feedback session with the graduating seniors. The moderator broke the class in small groups (typically four students in each group) and asked the groups to consider a set of questions. They would then report back to the entire class and based on this discussion, the moderator generated a report that as shared with the UG committee.

The questions used in the session are: (a) What are the strengths of the program? (b) What changes you would recommend and how should these changes be made? (c) Other comments?, and (d) A few additional questions. These questions varied every year and where meant to seek specific input on issues that the Department considered to be important. These questions were developed in consultation with the Associate Chair and the UG committee.

The feedback on questions (a) and (b) from CIDR survey was used to enhance the quality of the program by focusing on aspects that needed to be changed. The results of these were shared with our faculty (typically at the annual retreat), with the Dean and with our Visiting Committee.

The feedback on questions (c) and (d) from the individual sessions was also made during CIDR interview to individually discuss the strengths and weaknesses of specific courses. This was used to enhance the quality of individual courses. Feedback from question (e) in the individual session and any related comments from the group session were used to gauze the relevance of courses outside the Department. This information was shared with the Counselor in order to better advise the students regarding these courses. The rest of the questions were mostly for information purpose.

In the summary below, the most frequent responses to questions (a) and (b) are presented. In each case, the area(s) identified for significant change is marked and the resultant changes made summarized.

Summary of Student Feedback from 2007-2008

Strengths of the Program

- Curriculum variety, breadth
- Hands-on labs and experience in student organizations
- Size of department
- Good faculty

Suggestion for Changes/Complaints

- Improvement of senior design project & senior research project
- Opportunity to go in-depth/specialize

Actions Taken

Improvement of the capstone courses (MSE 491 and 492) was initiated and made a plan to implement the proposed change. This was described in Criterion 4.

Summary of Student Feedback from 2008-2009

Strengths of the Program

- Variety/breadth of curriculum
- Lab and hands-on work
- Group activity and labs
- Small class/department size
- Good faculty, staff and TAs and their willingness to help

Suggestion for Changes/Complaints

- Senior project

- Laboratory facility
- More in-depth/focus

Actions Taken

The faculty focused on developing guidelines for the senior project and providing more departmental level oversight to MSE 499. To improve laboratory facility, a laboratory technician, Tuesday Kuykendall, took a lead to fix several major pieces of equipment during the summer. An internal proposal within the COE at the UW to purchase a new X-ray diffraction system was initiated, and a state-of-the art high quality XRD unit was installed in late 2008.

Summary of Student Feedback from 2009-2010

Strengths of the Program

- Labs and hands-on experience
- Senior project and research
- Faculty
- Size of department
- Good combination of science and engineering in elective courses

Suggestion for Changes/Complaints

- Junior lab facility and space
- Update courses and labs
- Career fair for MSE

Actions Taken

The focus this year was on continuous improvement of the undergraduate lab facility. A possibility to use the Student Technology Fund (STF) to purchase new equipment was explored, and obtained a fund to purchase several new laboratory equipment for UG laboratories. Student advisor worked with COE career fair personnel to improve information exchange.

Summary of Student Feedback from 2010-2011

Strengths of the Program

- The faculty are experts in their fields and are available/open to help us.
- The department is small and there's a strong sense of community.
- The program emphasizes research experience, e.g. senior project.
- The coursework teaches us the fundamentals.
- The program emphasizes working in teams.

Suggestion for Changes/Complaints

- Junior labs need to be improved. Possible ways to improve: restructuring the labs, reducing the number of experiments & make each lab more in-depth, and better training of students on the equipment.
- Junior labs should be worth more credits.
- Provide more opportunities for in-depth learning, e.g. more electives and/or sequences of electives; provide multiple pathways or tracks.

Actions Taken

Major revision of the Junior Lab course packs was made to improve the student's learning. The way the TAs were used in the Junior labs was changed, where one TA was assigned as the lead TA. This lead TA had the responsibility of making sure that the supplies and equipment for the lab were ready, train other TAs on that lab and grade that lab.

Summary of Student Feedback from 2011-2012

Strengths of the Program

- Variety/ diversity of topics, combines other fields.
- Small classes to know each other and the professors well; also work together collaboratively.
- Work in labs, on projects and get hands-on experience.

Suggestion for Changes/Complaints

- More chances for hands-on/lab experience.
- More electives, chance to specialize.
- More quantitative analysis/rigor.

Actions Taken

New elective courses were initiated by new faculty that had recently joined the department.

Summary of Student Feedback from 2012-2013

Strengths of the Program

- The program gives us a broad overview. Variety/ diversity of topics, combines other fields.
- Small classes. We get to know each other and the professors well; we work together collaboratively.
- Work in labs, on projects and get hands-on experience.

Suggestion for Changes/Complaints

- More chances for hands-on/lab experience.
- More electives, chance to specialize.
- More quantitative analysis/rigor.

Summary of Student Feedback from 2013-2014

Strengths of the Program

- Exposure to different areas of research

Suggestion for Changes/Complaints

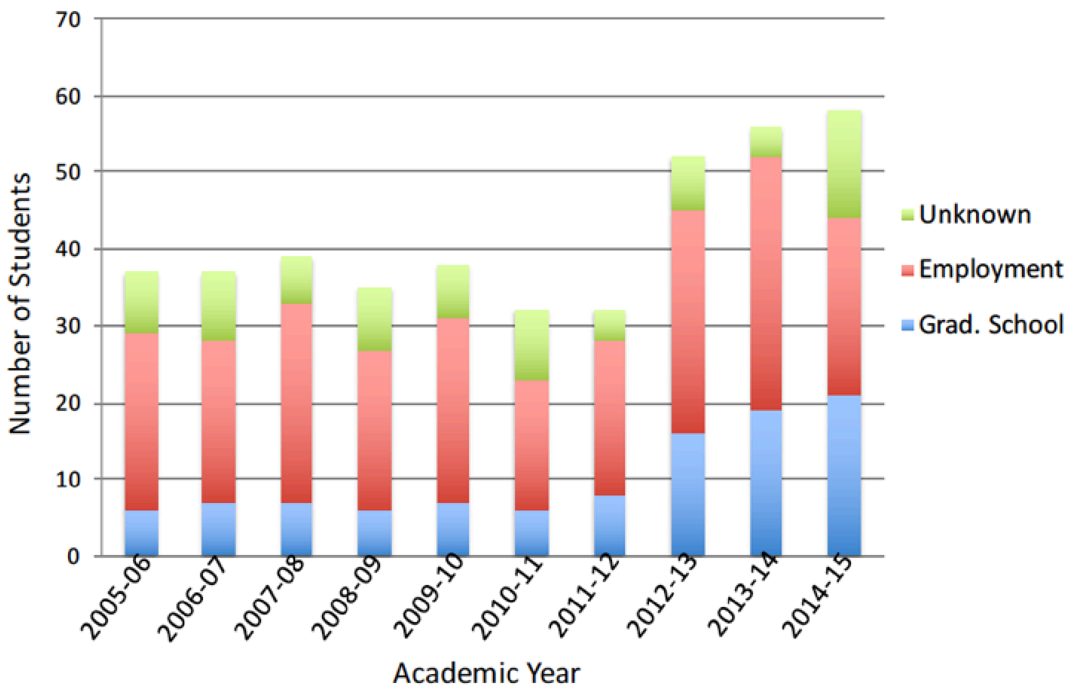
- Better organization of senior project courses
- More industrial, job-based, design-oriented group projects.

Actions taken

Reorganization of MSE 491 and MSE 492.

Appendix K

UG Career Placement



Appendix L

AMP Admissions and Enrollments

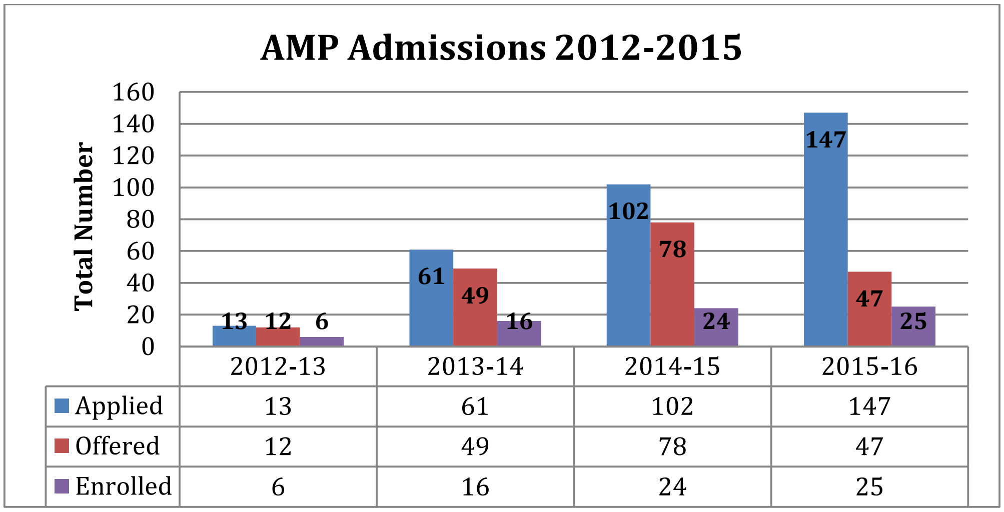


Figure L.1 Summary of AMP applicant pool and acceptance by year. The first year of the AMP program was 2012.

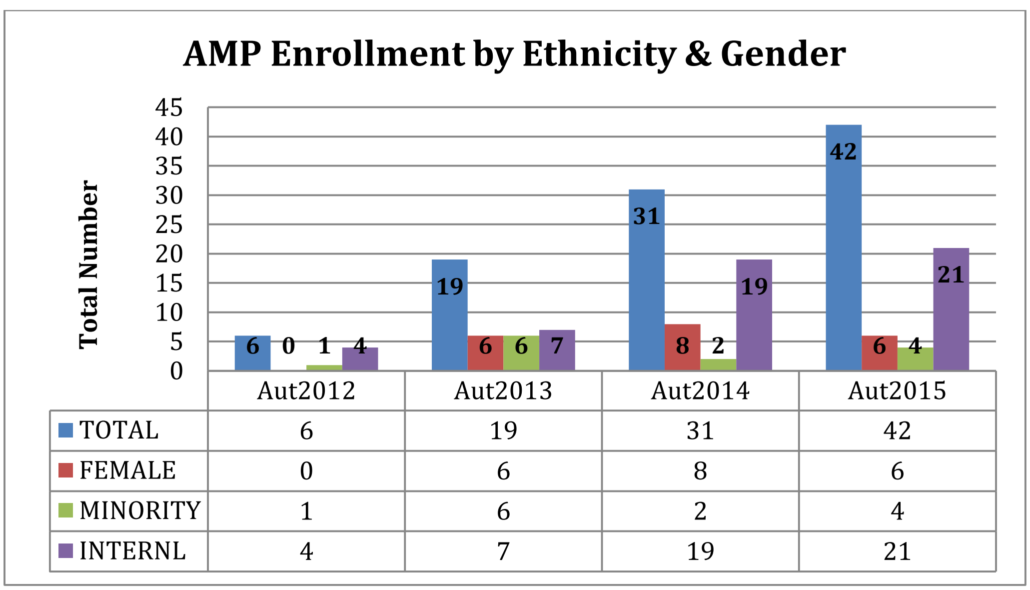


Figure L.2 Summary of AMP enrollments by year in terms of the ethnicity and gender. Note that enrollments for each year are greater than admission numbers (Figure L.1) due to students that elect to continue beyond 1 year.

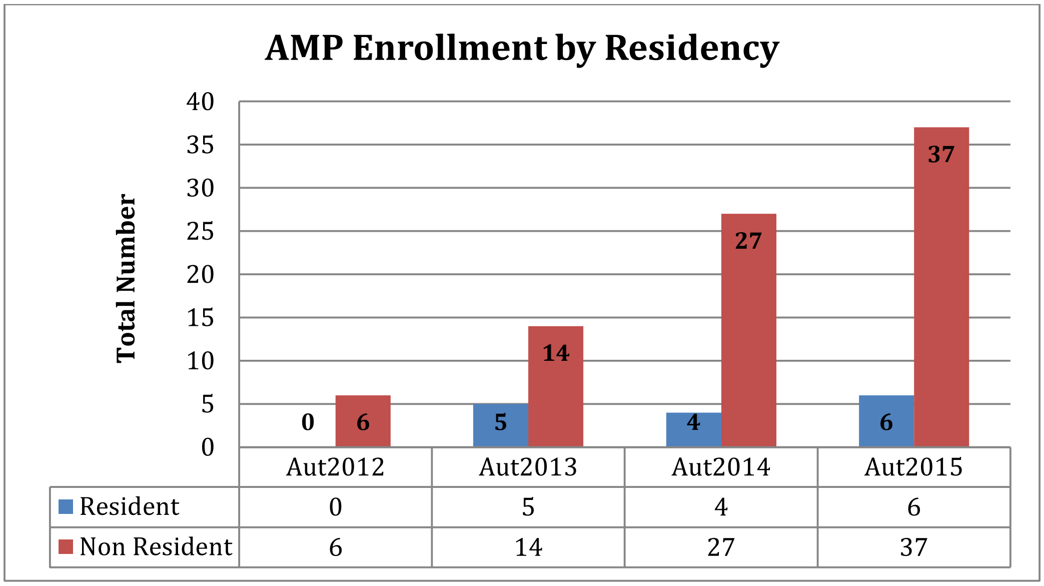
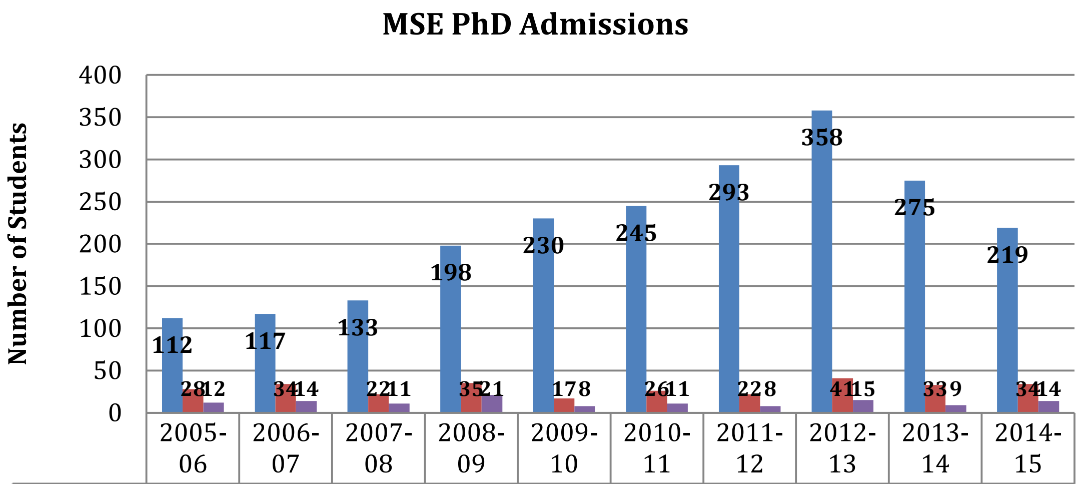


Figure L.3. Summary of AMP enrollments by year in terms of residency. Currently the program admits applicants according to their strength of their application.

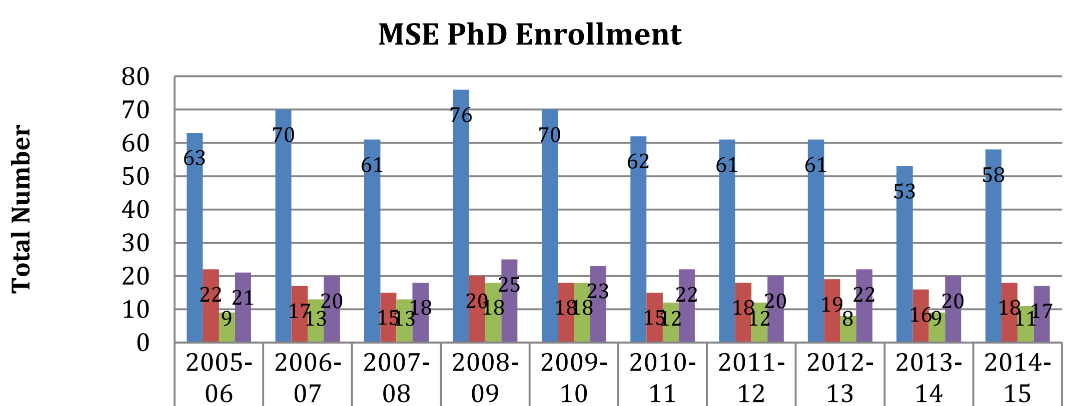
Appendix M

PhD Admissions and Enrollments



	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15
Applied	112	117	133	198	230	245	293	358	275	219
Offered	28	34	22	35	17	26	22	41	33	34
Enrolled	12	14	11	21	8	11	8	15	9	14

Figure M.1 Summary of PhD applicant pool and acceptance by year.



	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15
TOTAL	63	70	61	76	70	62	61	61	53	58
FEMALE	22	17	15	20	18	15	18	19	16	18
MINORITY	9	13	13	18	18	12	12	8	9	11
INTERNL	21	20	18	25	23	22	20	22	20	17

Figure M.2 Summary of PhD enrollments by year in terms of the ethnicity and gender.

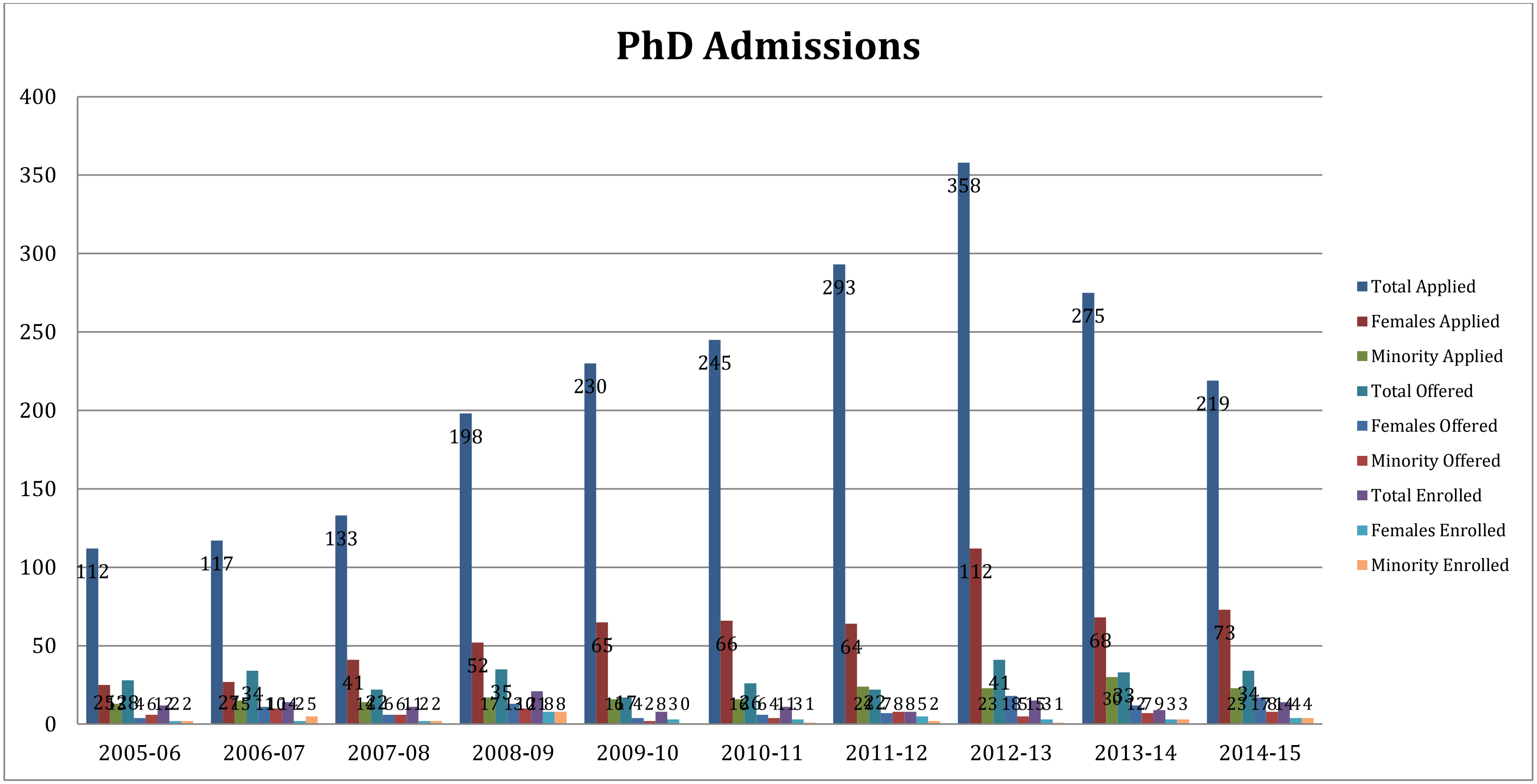
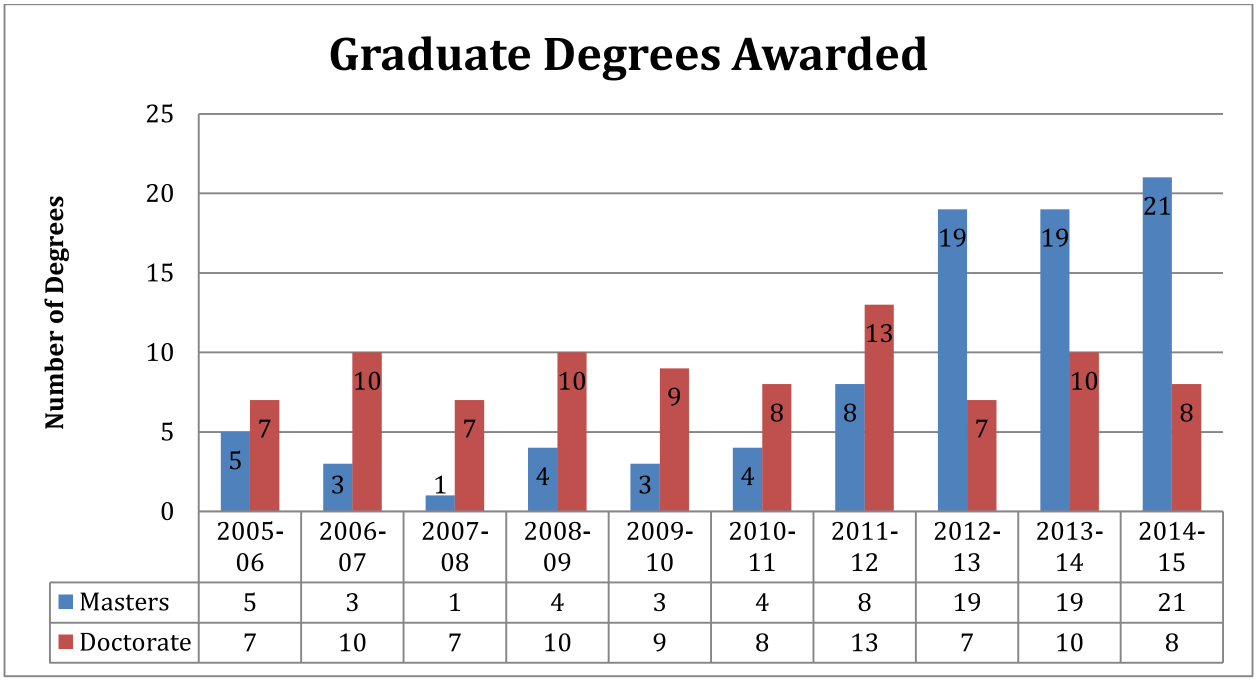


Figure M.3 Summary of PhD admission by year in terms of the demography



	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15
Masters	5	3	1	4	3	4	8	19	19	21
Doctorate	7	10	7	10	9	8	13	7	10	8

Figure M4 MS and PhD degrees awarded in the past 10 years

Current Job Areas of MSE PhD Graduates
Between 2003 and 2015

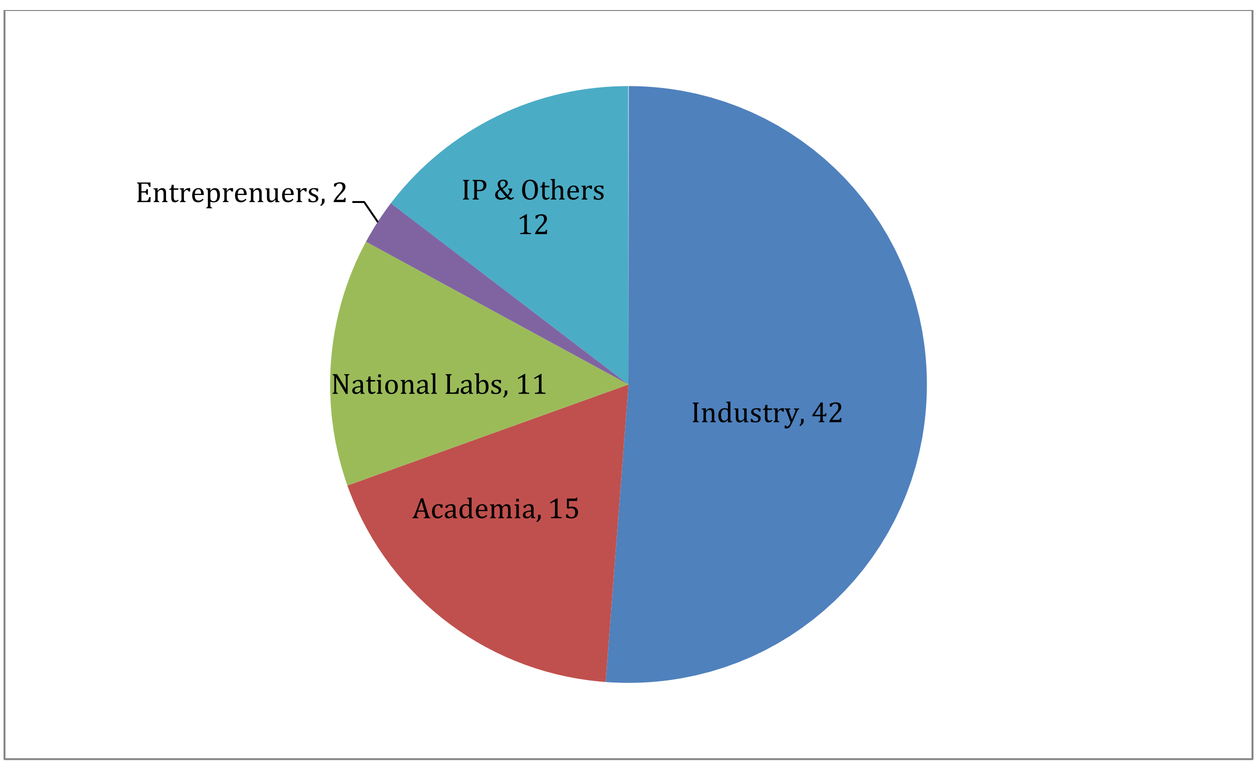


Figure M5. Current job areas of MSE PhD graduates in the past 10 years

Academia: 15

Angus Yip	(Professor, South China University of Technology)
Yadong Yin	(Associate Professor, UC, Riverside)
Yuping Bao	(Associate Professor, The University of Alabama)
Cody Youngbull	(Assistant Professor, Arizona State University)
Ying Wang	(Assistant Professor, Tulane University)
Dawei Liu	(Assistant Professor, Alfred University, 2012)
Chingyi Chen	(Assistant Professor, National Chung-Jeng University, Taiwan)
Taedong Kim	(Associate Professor, Hannam University, Korea)
Hassan Ramay	(Assistant Professor, Ghulam Ishaq Kahn Inst. of Sci. and Tech.)
Patrick Shamberger	(Assistant Professor, Texas A&M)
Cheng-Chun Lee	(Lecturer, Teessdie University, UK)
Saghar Sepehri	(Lecturer, Shoreline Community College)
Karen Hinkley	(Teacher, Forest Ridge HS, Bellevue, WA)
Tucker Howie	(Instructor, Edmonds Community College)
Peter Kazarinoff	(Instructor, North Seattle Community College)

Industry: 42

Zheng Li	(Apple)
Pinyi Yang	(Aries App. Inc.)
Sen Liu	(IBM)
Matthew Leung	(Basel Action Network)
Travis Sherwood	(Boeing)
Sharon Wong	(Boeing)
Todd Morton	(Boeing)
John Aubin	(Boeing)
Kelsi Hurley	(Boeing)
Molly Moench	(Boeing)
Ashley Tracey	(Boeing)
Yufeng Hou	(Consumer Electronics)
Evan Uchacher	(Du Pont)
Jeff Satterwhite	(Torray Composites)
Dmitriy Khatayevich	(Impossible Foods Inc.)
Marnie Haller	(Intel)
Julie Bardecker	(Intel)
Orb Acton	(Intel)
Pegah Hassanzadeh	(Intel)
Joel Horwitz	(Intel)
Clair Lu	(Intel)
Paden Roder	(Intel)
Melvin Zin	(3M)
John Smythe	(Micron Technology, Inc.)
Xiaosong Ji	(Applied Materials)
Jingyu Zou	(Microsoft)
Jonathan Eck	(Envision Technology)
Aaron Feaver	(VP, EnerG2)

Noriaki Suzuki	(EnerG2)
Neil Tucker	(BAE Systems)
Lixin Zheng	(Nth Degree Technologies Worldwide, Inc)
Tricia Bull	(Nth Degree Technologies Worldwide, Inc)
Betzaida Batalla Garcia	(Nanostructured & Amorphous Materials)
Aydin Tankut	(Maxim Integrated Technologies)
Shane Boyd	(Maxim Integrated Technologies)
Zhensheng Li	(W. L Gore & Associate Inc.)
Ashleigh Cooper	(RTI Biologics)
Tracy Lovejoy	(Nion Corporation)
Yi-Cheng Lee	(Industrial Technology Research Institute)
Turgay Kacar	(Pharmaceutical Company in Istanbul)
Brian Clark	(Intec)
Zhengwei Shi	(Unipixel)

National Labs: 11

Kirsty Leung	(Lawrence Livermore National Laboratory)
Taisuke Ohta	(Sandia National Laboratory)
Kevin Strong	(Sandia National Laboratory)
Nam Nguyen	(National Institute for Materials Science, NIMS, Japan)
Nik Hrabe	(NRC Research Associate, NIST)
Cliff Leslie	(NRC Research Associate, Wright-Patterson Labs)
Esmeralda Yitamben	(Postdoc, Argonne National Lab)
Wei Zhang	(Postdoc, Argonne National Lab)
Chris So	(Postdoc, NASA)
Marcela Weyhmiller	(Children's Hospital Oakland Research Institute)
Yoonsoo Chun	(Korea Institute of Science and Technology)

Postdocs: 18

Kwangsuk Park	(Postdoc, Univ. of Wisconsin)
Shiho Iwanaga	(Postdoc, Caltech)
Kelli Roberts	(Postdoc, Cornell University)
Shelly Arreguin	(Postdoc, Empa, Switzerland)
Mustafa Gungormus	(Postdoc, UW)
Urartu Seker	(Postdoc, MIT)
Tianlong Wen	(Postdoc, Carnegie Mellon University)
Natalia Doubina	(Postdoc, Georgia Tech)
Omid Veiseh	(Postdoc, Harvard University)
Katherine Mazzio	(Postdoc, Helmholz Zentrum, Berlin)
Stephanie Candelaria	(Postdoc, National Institute of Standards and Technology)
Conroy Sun	(Postdoc, Stanford University)
R. Ferguson	(Postdoc, Commercialization, UW)
Matt Durban	BASF
Kaishi Wang	(Postdoc, BASF)
Yingxin Deng	(Postdoc, California Institute of Technology)

Ryan Toivola	(Postdoc, University of Washington)
Chen Fang	(Postdoc, Fred Hutchinson Cancer Research Institute)

Entreprenuers: 2

Amit Khanhar	(Lodespin Labs)
Nathan Kohler	(Co-founder of Yellow Dot Innovations)

IP & Others: 12

Michelle Liu	(Han IP Law, PLLC)
Steve Hau	(Intellectual Ventures)
Nathan Kohler	(CMO & MD at Florida Hospital)
Yanyi Liu	(AMPACC Law Group)
Mike Beerman	(Intellectual Ventures)
Jonathan Gunn	(JD Student, Law School, Northwestern University)
Fareid Asphahani	(Perkins Coie LLP)
Brad Roberts	(Intellectual Ventures)
Dan Hutchins	(JD Student, Santa Clara University)
Alex Turner	(Pursuing PhD at Kyoto University)
Isaiah Gatuna	(Activist in Kenya)
Andrew Rice	(eWorld Editing)