CHEMICAL ENGINEERING

DISTINGUISHED YOUNG SCHOLARS SERIES

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A two-pronged approach for engineering luminescent defects in nanomaterials

ABSTRACT: Engineering materials with precise atomic structure over large length scales represents one of the major challenges in chemistry and materials science. Our successes designing and manipulating doped nanomaterials via colloidal syntheses has yielded materials with unique optoelectronic properties and has enabled wide ranging applications, including biologically inert fluorescent labeling, photothermal therapies, low-energy light emitting diodes, next-generation photovoltaics, etc. While colloidal syntheses can produce nanomaterials with remarkable control over composition and structure, their synthetic space is typically limited to thermodynamically stable dopants and crystal hosts. If the desired dopant or crystal host are unstable, the structure must instead be kinetically trapped. Moreover, colloidal syntheses produce dispersed nanomaterials, and translating these materials into practical devices—such as single-particle devices—remains an outstanding challenge. The development of methods to deterministically synthesize and manipulate doped nanomaterials bring us closer to realizing the promises of nanoscience.

In my presentation, I will discuss two examples of forming defects in nanomaterials and translating the functionality of these defects into large-scale devices. First, I'll discuss the formation of luminescent dopants in diamond, known as color centers, which have emerged as a promising platform for quantum computing, sensing, and cryptography. Because diamond is metastable at atmospheric conditions and has a low diffusion coefficient, traditional doping methods fail to form color centers. I will present a new methodology to deterministically synthesize doped nanodiamond by first incorporating small molecules into a thermodynamically stable, amorphous carbon precursor. Rapid laser heating of this precursor at high pressure drives the formation of nanodiamond and kinetically traps small molecules in the diamond lattice, which define luminescent color centers. Second, I will present studies on the formation of thermodynamically

stable Yb3+-doped inorganic perovskites, which exhibit near-infrared photoluminescence quantum yields approaching 200% via a mechanism known as quantum- cutting. The tunable absorption and strong near-infrared photoluminescence of these materials makes them ideal downconversion layers to boost the efficiency of silicon photovoltaic devices. Unlike dopants in diamond, I will demonstrate how the thermodynamic stability of Yb3+-doped perovskites facilitates new, scalable synthetic methods, including mechanochemical synthesis and rapid thermal processing. Leveraging these processes, I will present initial results from Yb3+- doped, perovskite-based devices. I'll conclude the talk with future work to further bridge the gap between doped nanomaterials and nanostructured devices.

BIOGRAPHY: Matthew Crane received his bachelor's degree in Chemical Engineering from the Georgia Institute of Technology. He then moved to the University of Washington to study Chemical Engineering, conducting research under the guidance of Prof. Samson Jenekhe for his M.S. and Prof. Peter Pauzauskie for his Ph.D. Currently, Matthew is a Washington Research Foundation Postdoctoral Fellow in the Chemistry department in the Gamelin Laboratory at the University of Washington where he investigates the optical and electronic properties of doped, nanostructured perovskites. He is also a co-founder of BlueDot Photonics, a startup working to enhance the efficiency of solar cells. During his studies, Matthew was awarded a National Defense Science and Engineering Graduate Research Fellowship as well as a Joseph Goldstein Fellowship. In his free time, Matthew enjoys playing music with his band, Better Off Ed, and enjoys being distracted by his cats, David Bowie and Bean.

LECTURE 4:00 – 5:00 (PAA) A118
Happy Hour in Benson Hall Lobby Following

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