GEMSEC SRD SEMINAR

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Milnor-Roberts Room, Wilcox 243, MSE Department

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Mechanical properties of polymer-derived ceramics constituted from Si-C-O-N and their tribological behavior for microsystem applications

Ceramics produced via the polymer synthesis route can be tailored to exhibit unique functionality. So-called polymer derived ceramics (PDC's) are processed from liquid organometallic precursors by cross-linking the polymers into an infusible solid followed by controlled pyrolysis that yields a ceramic. PDC's can remain inert and highly stable, both mechanically and chemically in harsh environments. The resilience of PDC's in aggressive environments combined with the capability to be fabricated into thin fims, and free-standing micron size parts through lithographic and micromolding techniques makes PDC's ideally suited for unique micro electromechanical systems (MEMS) applications. In addition, PDC's are capable of taking on high surface area porous structures that can be functionalized for sensing, catalysis, and filtration. Silicon carbonitride (SiCN) and silicon oxycarbide (SiOC) are two well-known examples of this class of materials. Their microstructures typically comprise of nanodomains of ceramics and free carbon, which is highly dependent on precursor synthesis, polymerization, degree of crosslinking, and pyrolysis temperature and environment.

Polymer derived SiCN typically contains phases of silicon atoms bonded to carbon and nitrogen in sp^3 configurations, as well as phases of carbon in aromatic sp^2 configurations within an amorphous microstructure. The presence of large amounts of carbon in the PDC's, up to one third molar, motivated the study of the tribological properties of the PDC's.

Surface coatings are often required to combat friction and wear (tribological) problems in MEMS, and can be difficult to tribological materials that can survive high temperature and corrosive environments. In the current study, we have evaluated the friction and wear behavior of bulk polymer derived SiCN coupons fabricated by vinyl group photopolymerization and pyrolysis under hot isostatic pressure, along with thin films. The friction coefficient of these samples was measured with a ball-on-flat linear wear tester in dry nitrogen and humid environments, and various loading environments. Wear behavior was evaluated with profilometry, SEM, and EDS. The carbon rich regimes were characterized with Raman spectroscopy, while silicon bonding was investigated with FTIR and compositional analysis. The results yield promising implications for extending microsystems applications to harsh environments, and provide insight into the nature between the nanostructure and its mechanical properties.