HIPIMS research at AFRL

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We rely on the exquisite control of composition and microstructure of thin film materials afforded by plasma-based processes for in order to develop novel, nanostructured materials for management of friction, wear, and high thermal loads in aerospace applications. HIPIMS offers advantages in terms of process control, in that the energy of the highly ionized fluxes can potentially be tailored to control re-nucleation and growth processes, and other kinetic phenomena that dictate surface physics occurring on growing films. This talk will describe our interest in using HIPIMS, and experiments performed to acquire a fundamental understanding of how the variable frequencies and pulse widths of our Trumpf/Huettinger/Advanced Converters power supply, as well as target substrate distance and background gas composition and pressure affect deposition rates, incident ion fluxes and ion energy distributions. Plasma characterization was performed with electrostatic probes and a Hiden EQP analyzer, and time-resolved potential and current measurements of the target were recorded. These results were then correlated to studies of thin film structures and properties at selected target pulse conditions of interest. One example of such a study is comparison of Ti and Hf metal films (both elements with equivalent ionization energies, but distinctly different masses and other physical properties) at fixed duty factors, but with variable frequency and pulse length. Plasma analysis was conducted duty factors of 1% and pulse widths of 20, 50, 100, 150 and 200 microseconds. The target IV characteristics, deposition rates, and relative ion fluxes were measured and compared to x-ray diffraction, electron microscopy and thermal conductivity measurement results. Fundamentally different trends were observed when Hf films grown with dc sputtering at the same deposition rate were compared to films grown with HIPIMS.