Surface Processing by RFI PECVD and RFI PSII

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Abstract

An RFI plasma enhanced chemical vapor deposition (PECVD) system and a large-scale RF plasma source immersion ion implantation (PSII) system were designed and built to study two forms of 3-D surface processing, PECVD and PSII. Using the RFI PECVD system, Ti-6Al-4V substrates were coated with diamond-like carbon films with excellent tribological and optical properties. As an innovation, variable angle spectroscopic ellipsometry (VASE) was successfully applied for non-destructive, 3-D, large-area tribological coatings quality investigation.

Based on the experience with the RFI/PECVD system, a large-scale RFICP source was designed and built for the PSII. Langmuir probe and optical emission spectroscopy studies indicated that the RFI source produced stable, uniform, and clean plasma. MAGIC code was for the first time used to model PSII process, addressing different target geometries and boundaries, materials, plasma parameters, illustrated sheath formation and evolution, field distribution, ion and electron trajectories, ion incident angles, and dose distributions, which are critical for PSII design and understanding.

The RF PSII system was developed into a versatile large-area, uniform, 3-D surface processing apparatus, capable of PSII, PVD, PECVD, and in situ surface cleaning and interface properties modification, for multilayer, multi-step, and high performance surface engineering. Using the RFI/PSII system, for the first time, PSII was studied as a mask-based surface layer conversion technique, for pattern writing by implantation as an alternative to current deposition-based and ink-based direct write technologies. It operates at low substrate temperature, keeps the original surface finish and dimensions, and avoids adhesion problem. A different operating mode of the RF source was discovered to perform biased sputtering of high purity quartz, which turned the RFI/PSII system into a novel integrated RF PSII/PVD system for large-area, uniform, nitrogen-doped, and hydrogen-free SiO2 films deposition at low substrate temperatures. Nitrogen-doped SiO2 films with excellent optical properties were deposited on semiconductor, metal, and polymer substrates with excellent adhesion. Ellipsometry was used again for non-destructive SiO2 coatings investigation. FEL test electrodes processed by SII/PVD

showed suppressed field emission. A group of transition metals and an FEL test electrode were also implanted by nitrogen using the PSII mode and analyzed.