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Directionally Resolved Characterization of Sputter Processes with Force Probes and Quartz Crystal Microbalances

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In today's technology, sputtering is a well-established method to etch semiconductors or to deposit thin films. The optimization of the sputter and coating process requires a detailed understanding of the physical phenomena. The particles released by sputtering a target do not distribute uniformly in all possible directions. Deposition rates can be measured by quartz crystal microbalances, while charged particles in the sputter plume can be characterized by Faraday cups or retarding field analyzers. The diagnostic of the neutral particles requires more complex diagnostics, such as optical emission fluorescence, laser-induced fluorescence [1], or mass spectrometry [2]. Interferometric force probes allow for a more direct measurement of all particles in the sputter plume by measuring their momentum transferred onto the probe surface. Previously, these probes have been used to determine the thrust of ion engines, forces exerted by a low-temperature plasma onto a solid boundary [3], or the recoil of reflected and sputtered particles at a sputter target [4]. In this study, force measurements were combined with measurements of deposition rates. Sputter plumes are generated by an ion beam directed onto a rotatable copper or aluminum target, respectively. A directionally resolved momentum profile and the deposition rate are obtained by circling a force probe and a quartz crystal microbalance about the target at a fixed distance. The profiles are compared with numerical simulations using SRIM [5]. Measurements and simulations are carried out for different angles of incidence, ion energies, gases and target materials.

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