Degradation of Mirror Reflectivity in EUV Lithography: Surface Science Aspects

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This work is motivated by the need to understand the stability of Ru and TiO_2 capping layers on reflective optics used for extreme ultraviolet lithography (EUVL), in the presence of residual gases in vacuum. Using sensitive surface science methods, we study the interaction of water vapor and other molecules with surfaces of hcp Ru and rutile TiO_2. We characterize adsorption/desorption processes of water, oxygen, and hydrocarbons on clean surfaces, as well as on contaminated surfaces. The surface chemistry depends strongly on the substrate preparation. Electron-induced dissociation of water and hydrocarbons adsorbed on these surfaces leads to dissociation, O and carbon accumulation, and even polymerization (e.g., of methyl methacrylate, MMA). We also report on electron-induced defect production on oxide surfaces (e.g., atomically-resolved electron-stimulated desorption of substrate O atoms from TiO_2, which affects subsequent reactivity). The role of radiation damage due to EUV-induced secondary electron emission, and the use of synchrotron radiation to measure secondary electron yields, are discussed.