Carbon film growth and mitigation on model electron-irradiated EUVL mirror capping layers: TiO_2 and Ru

Theodore E. Madey, B. V. Yakshinskiy, M. N. Hedhili, S. Zalkind
Dept. of Physics and Astronomy, and Laboratory for Surface Modification
Rutgers, The State University of New Jersey, Piscataway NJ 08854 USA

We focus on surface processes that affect the reflectivity of TiO_2- and Ru-capped multilayer mirrors used in EUV lithography; low-energy electron beams mimic excitations initiated by EUV radiation. Carbon film growth is measured on both TiO_2 and Ru crystalline surfaces during 20 to 100 eV electron bombardment in methyl methacrylate ($C_5H_8O_2$, MMA) or benzene (C_6H_6), over a wide range of pressures, and temperatures near 300K. Films grow more slowly in benzene than MMA, due to differences in the surface chemistry of the two molecules. For MMA, the initial C-growth rates on the clean surfaces are very different: a C film grows more rapidly on TiO_2 than on Ru. However, the limiting growth rates are the same for C thicknesses greater than ~ 1 to 1.5 nm, when gaseous MMA interacts with a C film. Irradiation of the C films in O_2 gas has a mitigating effect, as does irradiation of TiO_2 in MMA + O_2 mixtures (also benzene + O_2) containing high relative O_2 concentrations. We find evidence both for direct radiation damage by EUV photons (O-vacancy formation on TiO_2 surfaces) and indirect damage by low energy secondary electrons (carbon film growth caused by secondary-electron-induced reactions).

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