EUV optics lifetime – radiation damage, contamination, and oxidation

Creating high-reflectivity EUV (13.5 nm) multilayer mirrors is a significant challenge, requiring everything from optical design to atomic-level growth- and interface optimization. For application in EUV lithography an as-grown mirrors should not only have a high, ~70% initial reflectivity, but it should stay reflective over many years for economic viability. In this period the mirror is exposed to ionizing radiation and an ambient containing amongst others water, oxygen, and hydrocarbons. In this talk several lifetime-limiting effects are addressed.

First of all, direct radiation damage to the substrate and mirror materials is discussed. Upon EUV irradiation electronic bonds are broken by the absorption of high-energy photons. This can lead to photo-induced desorption of atoms or molecular groups, or to changes in material properties when the bonds 'heal' in a different configuration.

Practical EUV tools operate in imperfect vacuum conditions and the mirror surface thus is exposed to a flux of amongst others hydrocarbons, water, and oxygen. EUV irradiation causes cross-linking and dehydrogenation of adsorbed C_xH_y molecules, resulting in the possible build-up of a carbon contamination layer over time. When C_xH_y partial pressures are sufficiently low compared to O_2 and H_2O partial pressures, oxidation can occur. In this situation reactions with oxygen species produced by EUV-induced dissociation of e.g. H_2O are dominant. Oxidation, carbon growth and their mitigation will be discussed in the second half of the talk.