Modeling of XUV-induced electron emission in ultrathin semiconductor films

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Absorption of extreme ultraviolet (EUV) and X-ray photons by thin-film optical devices results in the excitation of electrons from various energetic levels, either core shells or valence band of film material. These electrons initiate various processes leading to the degradation of film sensitives. One of such processes is electron emission, which occurs at the initial stage of the electron system response to photon absorption. Emitted electrons reduce the amount of absorbed energy decreasing the heating of a film. However, they may ionize an environment gas that can cause chemical reactions of gas ions with the surface leading to surface degradation [1].

The intensity of surface-related processes is determined by the number of emitted electrons. This number depends on many factors, such as the energy of an absorbed photon, thickness of a film, and its electron structure. Having the information about the distribution of emitted electrons, one can extract parameters of electron cascade, which is the number of secondary electrons excited by one primary photoelectron.

In the present work, we study the electron emission caused by 92 eV EUV photon irradiation as a function of film thickness for Si, a-C, and graphite films. We provide a theoretical analysis of emission spectra using Monte Carlo code TREKIS [2]. In the Monte Carlo scheme, we simulate the electron cascade formation in a film and treat emitted electrons as particles that can overcome potential barrier at the film surface. Our simulations predict an increase of the number of secondary electrons with increasing film thickness until a critical thickness value when saturation is reached. For graphite films, we demonstrate that the saturation thickness and saturation value correspond to experimentally measured values [3].

[1] T. E. Madey, N. S. Faradzhev, B. V. Yakshinskiy, and N. V. Edwards, *Surface Phenomena Related to Mirror Degradation in Extreme Ultraviolet (EUV) Lithography*, Appl. Surf. Sci. **253**, 1691 (2006).

[2] N. A. Medvedev, R. A. Rymzhanov, and A. E. Volkov, *Time-Resolved Electron Kinetics in Swift Heavy Ion Irradiated Solids*, J. Phys. D. Appl. Phys. **48**, 355303 (2015).

[3] J. T. Hollenshead and L. E. Klebanoff, *Modeling Carbon Contamination of Extreme Ultraviolet (EUV) Optics*, Emerg. Lithogr. Technol. VIII **5374**, 675 (2004).