Stability of Mo/Si and Mo/Be multilayer coatings for extreme ultraviolet lithography

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Abstract

Extreme Ultraviolet Lithography (EUVL) is a candidate for future application by the semiconductor industry in the production of sub-100 nm feature sizes in integrated circuits. Using multilayer reflective coatings optimized at wavelengths ranging from 11 to 14 nm, EUVL represents a potential successor to currently existing optical lithography techniques. In order to assess lifetimes of the multilayer coatings under realistic conditions, a series of radiation stability tests has been performed. In each run a dose of EUV radiation equivalent to several months of lithographic operation was applied to Mo/Si and Mo/Be multilayer coatings within a few days. Depending on the residual gas concentration in the vacuum environment, surface deposition of carbon during the exposure lead to losses in the multilayer reflectivity. However, in none of the experimental runs was structural damage within the bulk of the multilayers observed. Mo/Si multilayer coatings recovered their full original reflectivity after removal of the carbon layer by an ozone cleaning method. Auger depth profiling on Mo/Be multilayers indicate that carbon penetrated into the Be top layer during illumination with high doses of EUV radiation. Subsequent ozone cleaning fully removed the carbon, but revealed enhanced oxidation of the area illuminated, which led to an irreversible loss in reflectance on the order of 1%.

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