Irradiation of EUV-mirrors with multiple FEL pulses below the single shot damage threshold

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A free-electron laser (FEL) is an intense sources of near monochromatic light. The FEL principle is mentioned as source for lithography. As FEL output comes in ultra-short pulses, optics and coatings are needed that withstand short, and intense light pulses. It was shown that a single light pulse of 13.5 nm wavelength does not damage typical reflective coatings until extremely high pulse energies per unit irradiated area. Critical single shot damage threshold (SSDT) levels have been reported to be 45 mJ/cm^2 for normal incidence reflective Mo/Si multilayer coatings (Ref. 1) and 80 mJ/cm^2 at 4° grazing incidence for amorphous carbon (Ref. 2). In practice, in a lithography application optics are subject to large number of pulses. (Ref. 3). This paper/poster describes experimental determination of the multi shot damage threshold (MSDT) of grazing and normal incidence EUV coatings for 13.5 nm wavelength. The experiments have been executed at the Free-electron LASer in Hamburg (FLASH). The exposures were performed for various fluence rates up to 10 % of SSDT values for corresponding materials and for various number of pulses up to 16M. After exposures the change of reflectivity of 13.5 nm EUV light was measured in exposed spots. The measurements showed that reflectivity of coatings exposed to 10% of SSDT 16M pulses was slightly changed. These small observed changes are ascribed to non-optimum vacuum conditions of the experiment resulting in EUV induced surface modifications.

References

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