Infrared antireflective coating for EUV mirrors based on a DLC/Si multilayer

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Future high power EUV tools in next generation lithography systems will be operated with CO_2 LPP sources. Some Kilowatts of laser pulse power at 10.6 µm wavelength are partially converted into EUV radiation but also into more than 95% out-of-band energy. Spectral filtering and transportation of unwanted radiation out of the EUV optical system is absolutely necessary for heat load reduction, especially for the thermally sensitive masks and projection optics.

Depending on required spectral purity and throughput various concepts of such filters are known, e.g. thin foils, transparent grids or reflective gratings. However, many of these systems are limited in heat load itself or are difficult to cool, what inhibits the integration in high power EUV tools. We present a new type of spectral EUV filter based on a DLC/Si multilayer mirror that is nearly transparent for infrared radiation (IR) but highly reflective at 13.5 nm (DLC - diamond-like carbon). Furthermore the multilayer coating can be subsequently incorporated as the top part of an IR antireflection coating designed to minimize reflection at 10.6 µm wavelength (fig. 1).

Model calculations for this DLC/Si system show an EUV reflectance of approximately 54 % (conventional Mo/Si ML have up to 70 %), whereas the reflectance for IR can be less than 1 % (Mo/Si 80-90 %). To realize this spectral response the diamond-like behaviour of the carbon as well as a smooth substrate surface and ML interfaces are important. Hence high energetic deposition techniques like ion beam sputter deposition (IBSD) are needed. In addition to the DLC/Si multilayer an IR antireflection coating has to be brought between the substrate and the EUV reflective multilayer. This antireflection coating typically has a considerably larger roughness than acceptable for EUV reflection coatings. To solve this problem ion beam sputtering can be used as well because of its outstanding potential to decrease surface roughnesses down to a level of some 0.1 nm rms.

We deposited DLC/Si multilayers by IBSD with 40 and 60 periods showing EUV reflectances of about 42 % and 50 %, respectively. Combining IR antireflective and EUV coatings, first prototype mirrors have been fabricated with an EUV reflectance of 42.5 % and IR reflectance of about 4.4 % at the same time.

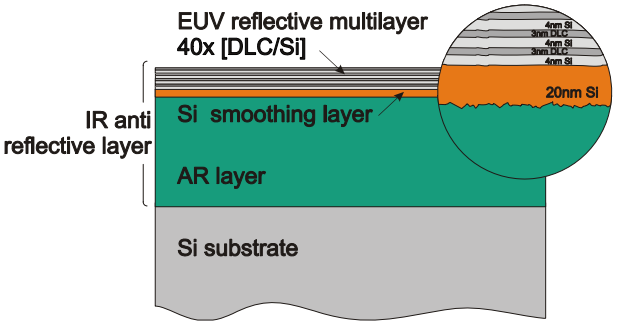

Fig. 1: Schematic design of the infrared-transparent EUV mirror