EXTREME ULTRAVIOLET LITHOGRAPHY

1. Title:	Design of multilayer mirrors for metrology of EUV sources
2. Full names of all authors:	I. Kozhevnikov, A. Yakshin, S. Alonso v.d. Westen, E. Louis, and F. Bijkerk

3. Abstract body:

Development of EUV lithography tools demands characterization and comparison of available EUV sources with respect to the emitted radiation power. The emission spectrum of an EUV source is typically wide and extends generally from several nanometers to several tens of nanometers. At the same time, the total reflectivity of an optical system consisting of up to 11 Mo/Si multilayer mirrors is different from zero only within a narrow spectral interval of about 0.6 nm width centered around λ = 13.5 nm. Therefore, for metrology applications it is necessary to filter in-band radiation power out of the whole emission spectrum of a source.

We analyzed a possibility of designing a depth-graded multilayer structure for use in the metrology of broad band sources. The mirror operating together with a transmittance filter should provide the same shape of the reflectivity peak as the resulting one after reflection from 11 periodic Mo/Si multilayer mirrors and should have as small reflectance as possible outside the peak to guarantee the necessary spectral purity of a reflected beam. The efficiency of filtering is characterized by the ratio of the out-band radiation power to the in-band one:

$$\chi = \int\limits_{\text{out-band}} R(\lambda)d\lambda \Big/ \int\limits_{\text{in-band}} R(\lambda)d\lambda \cdot 100\%$$

which should be less than 1% for practical applications. For comparison, the parameter χ exceeds 20% in case of a periodic mirror.

We demonstrated that there are several factors leading to an enhanced efficiency of filtering in-band radiation from the whole emission spectrum. Among them: (a) the use of a multilayer structure with the reduced reflectance from upper and lower bi-layers, (b) the use of silicon containing transmittance filters (such as $ZrSi_2$ or $MoSi_2$) cutting effectively short-wavelength radiation at $\lambda < 12.4$ nm, (c) increase of the filter thickness, and (d) increase of the number of constituent bi-layers of a multilayer structure. Combining these factors we designed a multilayer mirror with an extremely small χ-ratio of 0.017% only. The total transmittance of the mirror and the filter is $RT \approx 3\%$, which is a quite practicable value. Increasing the parameter χ up to 0.15-0.25% allowed us to design multilayer structures providing the total transmittance RT of more than 10%.

We analyzed different physical and technological factors influencing the optical quality of the designed multilayer mirrors (impossibility of deposition of ultra-thin layers, inaccuracy in density and optical constants of materials constituent multilayer mirror, interfacial roughness, and so on) and demonstrated that the crucial factor is random layer fluctuations, which thereby should not exceed ± 0.02 nm.

Results of the first experiments on deposition of depth-graded multilayer mirrors are presented.