Beyond-EUV multilayer coatings for next generation lithography

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Abstract

At present one promising technology, extreme ultraviolet lithography (EUVL) designed at the wavelength of 13.5 nm, has emerged as a likely successor to immerging DUV lithography and might be introduced to industry within the next years. At the same time the basics for next generation lithography with an even shorter wavelength of 6.X nm have to be investigated. This beyond-EUV lithography (BEUVL) at 6.X nm wavelength has a potential to extend EUVL beyond the 10 nm node [1], where high-reflective B-based multilayer mirrors are the key components of the BEUVL tools. La/B coatings provide the highest calculated peak reflectivity up to 80% near boron’s K absorption edge at $\lambda \approx 6.5$ nm. Currently, different labs [2, 3] apply various modern deposition approaches to minimize the gap between calculated and experimental reflectance. Currently, the highest reported measured reflectivity of 64% @ 6.65 nm was achieved with LaN/B multilayer mirrors [4]. For a later industrial use, an experimental reflectivity of at least 70% has to be achieved in near future. The insufficient reflectivity of the optics would be lowering the optical throughput of industrial lithography systems and thereby fundamentally obstructs a road for the possible application of this technology.

Today, the most promising approaches to enhance the optical performance of B-based multilayers seem to be the transition from conventional La/B to promising LaN/B multilayer coatings [2] as well as the application of ultrathin C-barriers [3]. The authors will present results on these approaches, where a maximum peak reflectivity of 58.1% at the wavelength of 6.65 nm could be experimentally shown with LaN/B_4C multilayer coatings. It will be also proven, that an utilization of C-barriers in the conventional La/B_4C multilayers improves the optical performance and leads to an increased reflection from 51.1% to 56.7% at $\lambda = 6.65$ nm. Furthermore, other materials have to be evaluated as proper diffusion barriers. Here, the authors will demonstrate theoretical calculations, thermodynamical considerations as well as corresponding experimental results. If applied on real optics, the coatings have to hold low residual stresses to avoid substrate deformation. The authors will show first results on the residual stress of B-based multilayer coatings and discuss different stress-reduction strategies in terms of minimum reflectivity losses.

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[3] Chkhalo N.I. et al., Appl. Phys. Lett. **102**(1), 011602 (2013).

[4] Kuznetsov D. et al., International Workshop on EUV and Soft X-Ray Sources, Dublin, Ireland, Nov. 3 - 6, 2014.