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COMPARATIVE REVIEW OF ILLUMINATORS FOR EUV PROJECTIVE OPTICAL SYSTEM

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Introduction. The extreme ultraviolet lithography illuminator is an important part of the extreme ultraviolet lithography. The illuminator provides uniform illumination for the mask and can realize various off-axis illumination modes. At present, commercial extreme ultraviolet lithography uses a compound eye relay system, but new design ideas for illuminator have also emerged. In this article, the design method and processing difficulty of these illuminators will be compared.

Main part. As lithography technology continues to upgrade, so does the illuminator. There are two main parts of an EUV illuminator namely, the relay system and double facets. The relay system images the mask and the entrance pupil of the projection objective to the position of the facet mirrors, and thus realizes the double conjugate relation in the Köhler illumination system. The double facet mirrors, also called double compound eye mirrors, consist of field facet mirrors and pupil facet mirrors. The field facet mirrors are conjugate to the mask plane, whereas a pupil facet mirror is located at the image plane of the entrance pupil. Since the projection objective lenses of extreme ultraviolet lithography have different numerical apertures, projection systems with different numerical apertures have different requirements for the illuminator. For high- NA (NA>0.5) projection systems, usually the imaging magnification in the scanning direction is 8, whereas that in the orthogonal direction is 4. Different imaging magnifications of an anamorphic high-NA objective will result in an elliptical entrance pupil with a circular aperture stop or an exit pupil. The design of the illuminator will bemore difficult. Double-row compound eyes need alignment matching.

In April 2022, researchers at RWTH Aachen University in Germany proposed a new approach to luminaire design. They used only one multilayer mirror. This illuminator is designed for a photolithography system for industrial resist qualification and large-area patterning. The designed illuminator consists of an off-axis parabolic multilayer mirror, which increases the intensity by a factor of 3.06 due to collection of a larger solid angle and an optimized layer system. Although the presented methods and obtained results are considered for a specific photo lithography system. This also provides us with a new design idea - to replace the existing illuminators with one or two multi-layer mirrors. As the number of reflections is reduced, the energy loss of the optical system is also reduced, thereby greatly improving productivity.

Conclusion. Analyze the design requirements and design methods of the illuminator used in the EUV projection optical system. Compared the commercially existing illuminator with a newly proposed one.

List of sources used:

1. Jiang J, Li Y, Shen S, et al. Design of a high-numerical-aperture extreme ultraviolet lithography illumination system[J]. Applied Optics, 2018, 57(20): 5673- 5679.
2. Mei Q, Li Y, Liu F. A reverse design method for EUV lithography illumination system[C]//Extreme Ultraviolet (EUV) Lithography IV. SPIE, 2013, 8679: 603-615.
3. 姜家华. 11nm 以下技术节点极紫外光刻照明系统设计研究[D]. 北京: 北京理工大

学, 2017. (In Chinese)

4. Mann H J. Anamorphically imaging projection lens system and related optical systems, projection exposure systems and methods: U.S. Patent 9,568,832[P]. 2017-2-14.

5. Lüttgenau B, Panitzek D, Danylyuk S, et al. Design of an efficient illuminator for partially coherent sources in the extreme ultraviolet[J]. Applied Optics, 2022, 61(11):3026-3033.