Development of Multilayer Mirrors for BEUV Reflective Optics — Current Status of an Ongoing Project—

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The current state of the art in advanced semiconductor lithography relies on extreme ultraviolet (EUV) radiation at a wavelength of 13.5 nm, which succeeded deep-ultraviolet (DUV) wavelengths such as KrF and ArF excimer lasers to enable continued improvements in spatial resolution (Figure 1). This historical progression from i-line, through KrF and ArF, to EUV reflects the long-standing strategy of reducing the exposure wavelength to sustain device scaling in accordance with Moore's law.

While successive wavelength reductions have historically driven MOSFET scaling, EUV lithography differs fundamentally from earlier DUV systems in that it relies on reflective multilayer optics rather than refractive optics. As a result, further resolution enhancement in EUV systems depends primarily on increasing the numerical aperture (NA) of the projection optics, since the exposure wavelength is fixed at 13.5 nm. However, the use of reflective optics limits the NA to unity, the resolution is limited by NA. Beyond EUV, shorter-wavelength regimes such as beyond extreme ultraviolet (BEUV) near ~7 nm have been proposed as potential pathways to extend high-resolution patterning. In this wavelength range, advanced reflective X-ray optics based on periodic multilayer mirrors are essential for achieving sufficient reflectance [1].

In this presentation, we discuss key issues associated with BEUV reflective multilayer mirrors, including material selection, interface formation, and optical performance. We then present the current status of an ongoing BEUV multilayer mirror development project in our group, highlighting recent progress and remaining challenges toward practical BEUV reflective optics.

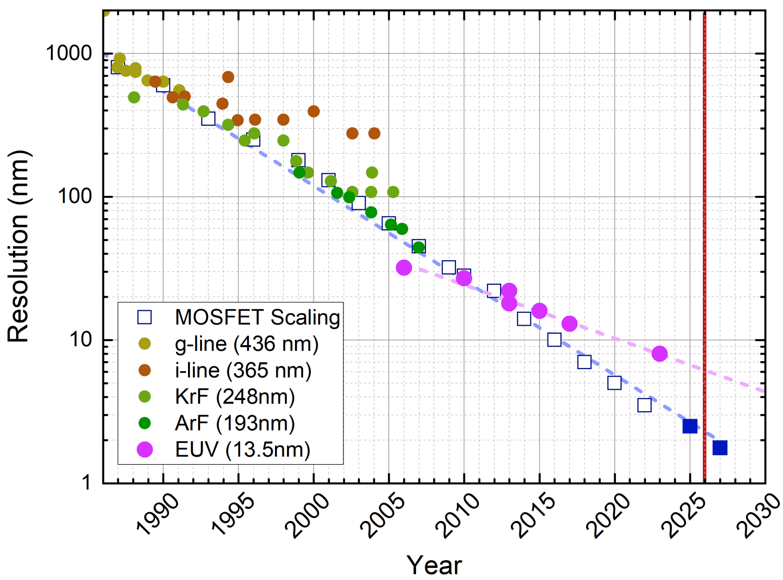

Fig. 1: Moore's law on MOSFET scaling and spatial resolution.

Reference:

[1] Uzoma, P. et al., *Nanomaterials* **11**(11), (2021) nano11112782. doi:10.3390/nano11112782.