Quantitative characterization of angstrom-scale roughness via diffuse scatter at near-grazing geometry using a table-top 92eV HHG source

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Extreme ultraviolet (EUV) and soft X-ray radiation can be efficiently utilized for non-destructive characterization of nanostructures with nanometer accuracy. Conventional scatterometry enables structural characterization of periodic structures [1] while diffuse scatter measurements allow to characterize surface and interface roughness [2]. In this work we demonstrate results of the first time (to the best of our knowledge) angstrom-scale surface roughness characterization from diffuse scatter with a table-top EUV high harmonics generation (HHG) source.

Roughness characterization was performed on a Ru thin film generated by ion beam deposition (IBD). The schematic of the experimental setup is shown in Fig. 1. Direct registration of diffusely scattered 92eV light was realized by utilizing synthetic aperture and high-dynamic-range detection coupled with noise suppression techniques.

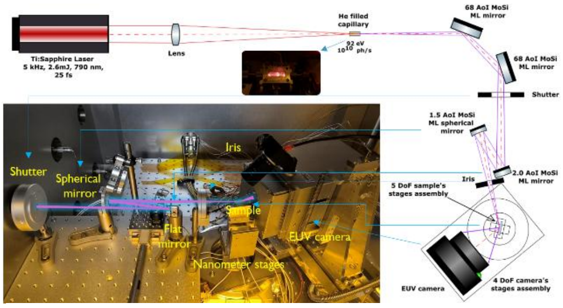

Fig. 1. Experimental setup

The experimentally obtained spatial intensity distribution of scattered EUV light was fitted with 3 Gaussians in order to extract the intensity and width of high-frequency scatter (Fig.2). From these parameters roughness and correlation length values were derived.

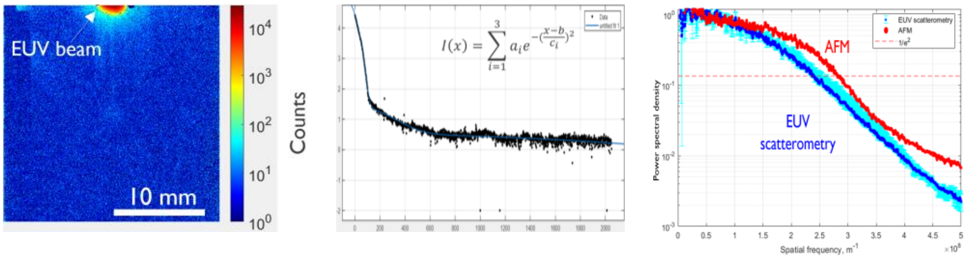

Fig. 2. HDR image of diffusely scattered EUV light (left), intensity distribution along vertical axis in log scale (center), and power spectral density curves (right)

We present promising results that demonstrate angstrom-scale precision and are in good agreement with AFM measurement (Table 1).

Table 1. Surface roughness measurement results

	Roughness (RMS Rq), nm	Correlation length (T), nm
EUV scatterometry	0.65 [0.57-0.74]	4.2 [3.9-4.3]
AFM	0.60	3.6

[1] L. M. Lohr, R. Ciesielski, S. Glabisch, et. al., 2023, Appl Opt **62(1)**, 117.

[2]. I. Busch and J. Stümpel, 2003, Appl Surf Sci **212–213**, 201–203.