Ultra-shallow large area EUV-diffraction gratings for near normal incidence

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Multi-layer coated grating structures with heights of a few nanometres can be used as diffraction gratings for EUV radiation at near normal incidence. This promotes the future development of benchtop fabrication and metrology facilities. We present a method based on the small volume changes caused by the formation of defects during the irradiation with ions. Previous methods utilizing similar effects have been limited to areas in the μm^2 range [1]. The method presented here incorporates a broad beam ion source so that elements with areas of several cm^2 and grating pitches of about 200 nm can be achieved.

Irradiations were performed through a mask of photoresist attached directly to the sample. It was fabricated utilizing character projection electron beam lithography [2]. The resist shields parts of the sample from the impinging ions and allows the use of a broad ion beam. This reduces the writing time by at least two orders of magnitude in comparison to direct write processes.

First systematic studies have been carried out on the irradiation of silicon with a broad beam of helium ions accelerated to an energy of 30 keV. The investigated fluences range from 10^{16} to 10^{17} ions per cm^2. The resulting structure heights and shapes were measured via atomic force microscopy (AFM; see fig. 1 and 2). With this, a reproducible and easily controllable method to fabricate structures with heights in the range of 0 to 20 nm is presented. Further research will aim to better control the resulting structure shapes.

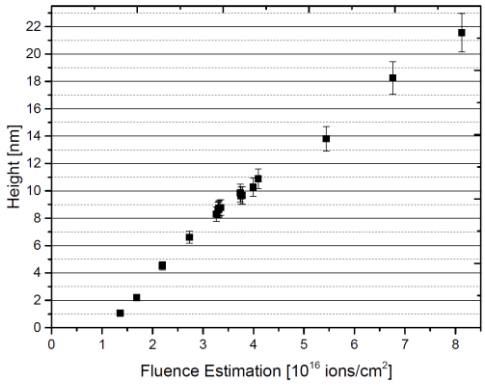

Fig. 1 Increase of structure height with fluence of helium ions.

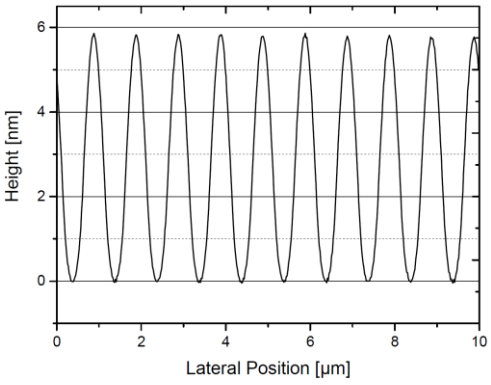

Fig. 2 Example of the resulting profile shape as measured by AFM.

[1] G. García., M. Martin, M.D. Ynsa, V. Torres-Costa, M.L. Crespillo, M. Tardío, J. Olivares, F. Bosia, O. Peña-Rodríguez, J. Nicolas, M. Tallarida, 2022, The European Physical Journal Plus **137**, 1157.

[2] M. Hädrich, T. Siefke, M. Banasch, and U. D. Zeitner, 2022, PhotonicsViews, 19, 28-31