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Applied Surface Science 252 (2005) 57–60

www.elsevier.com/locate/apsusc

Laboratory LPP EUV reflectometer working with non-polarized radiation

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Available online 21 February 2005

Abstract

A laboratory extreme ultraviolet reflectometer (EUVR) for the wavelength range from 10 to 16 nm was built at IWS Dresden using a gold target laser pulse plasma (Au-LPP) source. The peak reflectance and the center wavelength are reproduced in relative standard deviation of 0.2 and 0.02%, respectively. In contrast to measurements using linearly polarized s-adjusted synchrotron radiation at PTB, measurements with non-polarized radiation at the EUVR yield systematically lower values for the reflectance due to the smaller reflectance of the p-component at higher angles of incidence.
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Keywords: Extreme ultraviolet; Metrology; Lithography; At-wavelength characterization; Reflectometry

PACS: 6.20; 42.82.C; 7.60.H

1. Introduction

For the development of high-reflection optical components (mirror, mask blanks) for extreme ultraviolet lithography (EUVL) corresponding metrology is required. In particular, the at-wavelength measurement of reflectance is very important. High-accuracy at-wavelength measurements of EUV optics are provided by Physikalische Technische Bundesanstalt (PTB) in Berlin using synchrotron radiation at BESSY II [1]. The rapid development of EUV optics, however, requires on-site metrology.

First developments of laboratory EUV reflectometers were started about 10 years ago by Windt and Waskiewicz [2], Gullikson et al. [3] and Heinemann [4]. In the last few years, IWS Dresden in cooperation with PTB Berlin and Carl Zeiss SMT AG, as well as Max-Born-Institute Berlin, Bestec GmbH, AIS Automation Dresden GmbH and a few other partners, developed and built a stand-alone laboratory EUV reflectometer (EUVR). In particular, large concave and convex optics can be qualified by using this EUVR.

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doi:10.1016/j.apsusc.2005.01.113

A detailed description of the EUVR is given elsewhere [5]. Here, we present the results of reflectance measurements in dependence on the angle of incidence, in comparison with results obtained by PTB using synchrotron radiation.

2. Instrumentation

The EUVR consists of an EUV radiation source, a monochromator and a goniometer chamber. Figs. 1 and 2 show a photograph and the optical design of the EUVR, respectively.

The non-polarized EUV radiation is generated by a gold target laser pulse plasma source (Au-LPP) using a commercial Nd:YAG laser working at a wavelength of 532 nm with pulse durations of 10 ns and a repetition rate of 10 Hz. The laser beam is focused to a point of ∅10 μm. A detailed characterization of the EUV source was presented in [6].

The monochromator provides tunable monochromatic EUV radiation in the wavelength range between 10 and 16 nm and focuses the EUV beam into the exit slit and onto the sample surface in the goniometer chamber, respectively.

The manipulation systems for samples up to 500 mm in diameter, up to 200 mm thick and weighting up to 30 kg as well as for the measuring detector are located in the goniometer chamber. The angle of incidence can be varied from 3° to 60° relative to the surface normal. The measuring detector can be moved from 0° to 180°. The EUV spot size on the sample is 1.2 and 0.5 mm (FWHM), horizontally and vertically, respectively.

3. Results

3.1. Reflectance of Mo/Si multilayers—near-normal incidence measurements

Fig. 3 shows the reflectance of a Mo/Si multilayer with 60 periods measured with the EUVR and by PTB. The peak reflectance was measured as 69.88% with a relative standard deviation of 0.2%. The center wavelength was measured as 13.327 nm with a relative standard deviation of 0.02%. The results of peak reflectance and center wavelength of the EUVR are in agreement with the results of PTB (69.81 ± 0.10)% and (13.328 ± 0.002) nm, respectively.

3.2. Reflectance of Mo/Si multilayers in dependence on the angle of incidence

Fig. 4 shows the reflectance measured at different angles of incidence of the same Mo/Si multilayer in

Fig. 1. Photograph of the IWS EUV reflectometer.

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