Masked Ion Beam Lithography for Proximity Printing

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Optical and X-Ray proximity printing systems are resolution limited by diffraction and beam dispersion [1]. Parallel dispersion free ion beam systems are therefore ideal to transfer stencil mask patterns onto all sorts of nonideal substrates.

Fig. 1 shows the schematics of a 1:1 Masked Ion Beam Lithography (MIBL) system. Hydrogen or Helium ion beams are extracted from a suitable ion source and ExB mass separation unit. Using a proper electrostatic lens system a parallel broad ion beam can be obtained. Ion beam induced mask heating effects can be compensated by radiation cooling to a cold cylinder surrounding the mask exposure station [2]. The virtual source size can be as small as 10 µm and, implementing proper electrostatic systems, the divergence of the ion beams illuminating a point in the stencil mask can be as low as 30 µrad. Thus, there is a penumbrial blur of only 30 nm for a gap of 1 mm between stencil mask and wafer substrate.

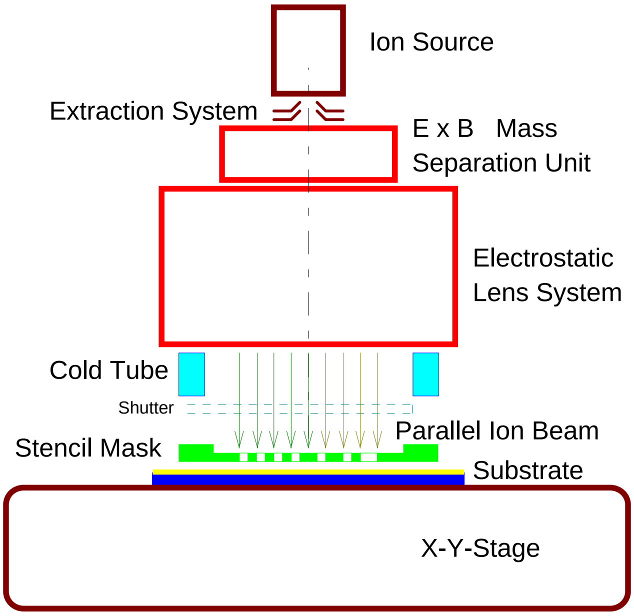

Fig. 1: Schematics of Masked Ion Beam Lithography system

Preliminary exposure results for a masked ion beam lithography system were obtained by using the existing Alpha ion projector of the Society for the Advancements of Microelectronics in Austria [3] in the MIBL mode (Fig. 2).

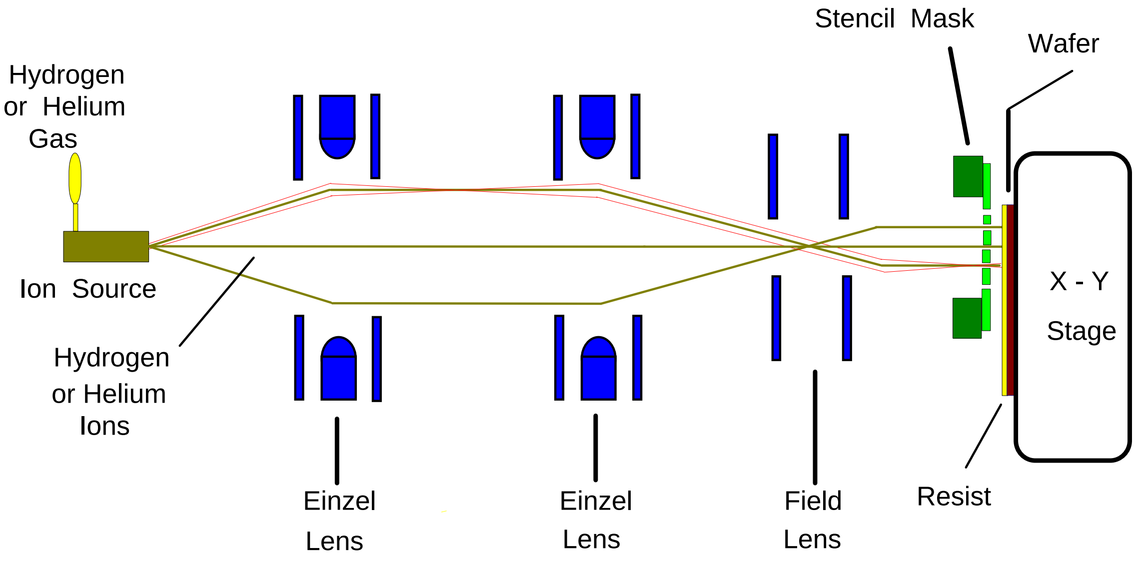

Fig. 2: Alpha ion projector of the Society for the Advancements of Microelectronics in Austria (GMe) as used in the MIBL mode.

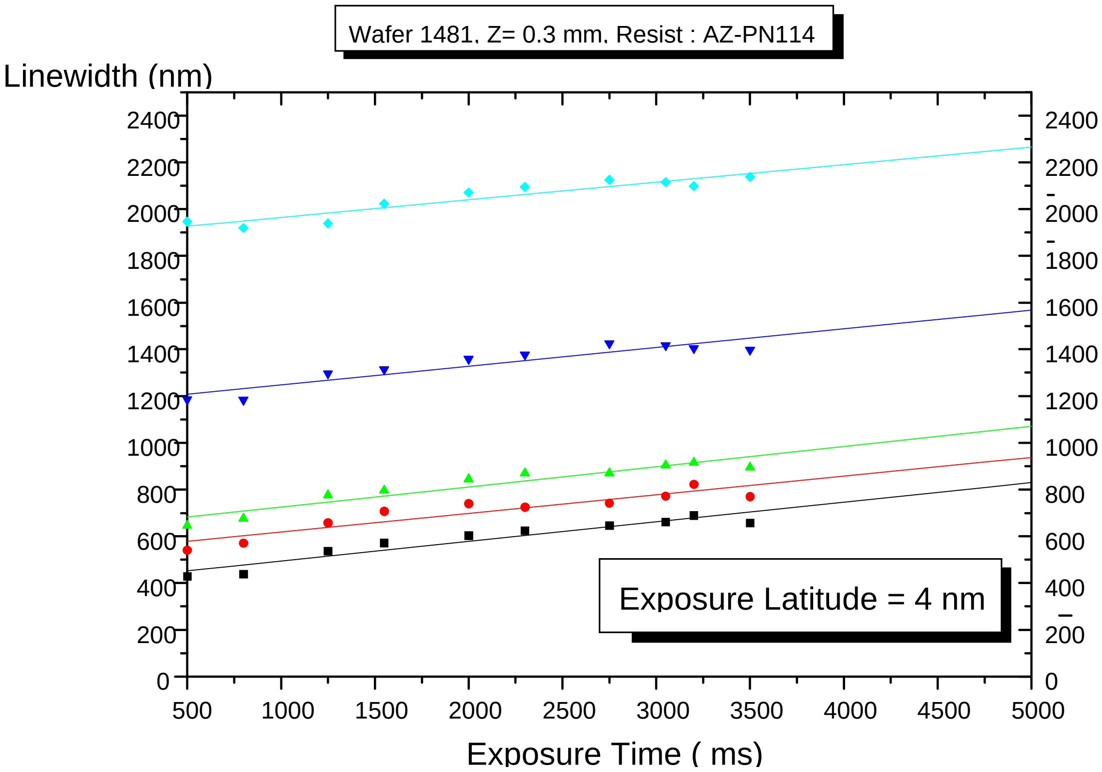

Fig. 3: MIBL exposure results obtained with the Alpha ion projector of the Society for the Advancements of Microelectronics in Austria (GMe) for a gap of 0.3 mm between a Nickel stencil mask and a resist coated Silicon wafer substrate. MIBL exposure with 55 keV He^+-ions into 0.4 µm thick negative AZ-PN114 resist. Shown is the dependence of the linewidth of developed resist patterns vs. exposure time for 5 different stencil mask line patterns. The stencil mask opening width correspond to the resist linewidth for 500 msec exposure time.

Recently the pattern transfer of ≈ 0.2 µm stencil mask patterns into AZ-PN114 negative resist for a gap of 1 mm between stencil mask and wafer substrate could be demonstrated. Even for a mask to wafer gap of 2.8 mm the widening of resist lines with 10% overexposure was found to be only 14 nm. For a gap of 0.3 mm the resist widening with 10% overexposure is reduced to 4 nm (Fig. 3).

This excellent exposure latitude value favorably compares with synchrotron based X-ray lithography, where a widening of 20 nm with 10% overexposure has been reported for a 40 µm gap [4],which only was improved to 10 nm widening of resist patterns when the gap between X-ray mask and wafer substrate was reduced to 10 µm [5].

Promising applications of the MIBL technique include the fabrication of flat panel displays based on vacuum electronics (field emitter displays) and - in combination with reactive ion etching - the fabrication of micro electro-mechanical systems (MEMS).

References

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