Analysis of Fabrication Misalignment Effects in a MEMS-based Electron-Optical System Design for Direct-Write Lithography

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Multiple-electron-beam–direct-write lithography is one of the promising candidates for next-generation lithography because of its high resolution and ability of maskless operation. In order to achieve the throughput requirement for high-volume manufacturing, miniaturized electro-optics elements are utilized in order to drive massively parallel beams simultaneously. Fabrication errors and uniformity of the elements can be serious issues in multiple-beam systems. Electron optical systems (EOSs) are assembled and tested directly after the elements are fabricated traditionally. The yield by this technique can degrade significantly with multiple beams. When they are fabricated separately on different substrates, misalignment between electron sources and electron-optical–objective-lenses[1-3] is inevitable. Previously, a new EOS design-to-manufacturing flow which takes fabrication errors into account before the final assembly and test processes has been proposed as shown in Fig. 1[4]. To achieve precise alignment and analyze the overlay results for an anodic bonding process, an image processing procedure in Fig. 2 and an overlay model[5-6] have been proposed and implemented. Fig. 3 shows the preliminary results that the overlay error is reduced to less than 2.5 μm by employing multiple alignment marks. Its effects on lens performance can be screened by rigorous electron trajectory simulation as presented in Fig. 4.

1 M. G. R. Thomson and T. H. P. Chang, J. Vac. Sci. Technol. B **13**, 2445 (1995).
2 J. Y. Park et al. J. Vac. Sci. Technol. B **15**, 2749 (1997).
3 M. J. van Bruggen, B. van Someren, and P. Kruit, J. Vac. Sci. Technol. B **27**, 139 (2009).
4 S. Y. Chen et al. in Proceedings of 22nd International Microprocesses and Nanotechnology Conference, 2009, p. 174. [submitted to Jpn. J. Appl. Phys.]
5 I. Fink et al. in Proceedings of SPIE **2196**, 1994, p. 389.
6 X. Chen et al. in Proceedings of SPIE **4344**, 2001, p.257

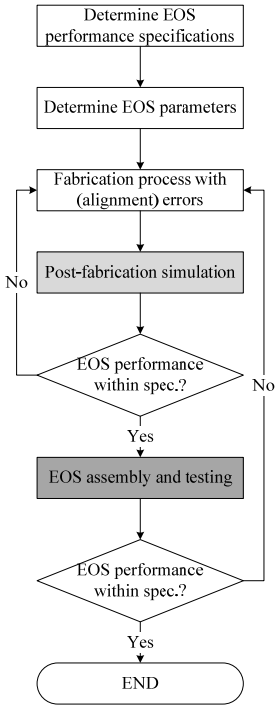

Fig 1: A new proposed EOS design-to-manufacturing flow with alignment errors

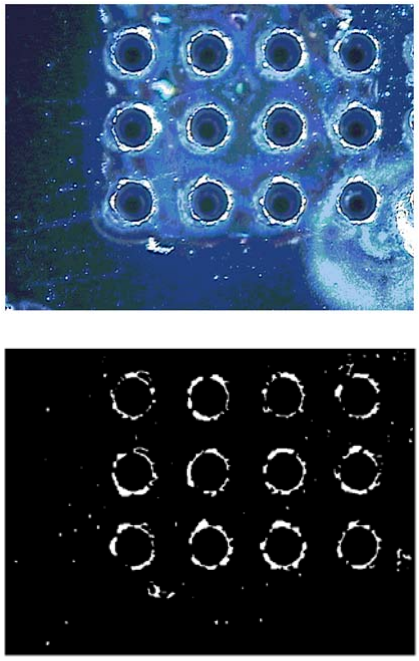

Fig 2: Optical microscope picture of assembled EOS (top), and the picture after image processing (bottom)

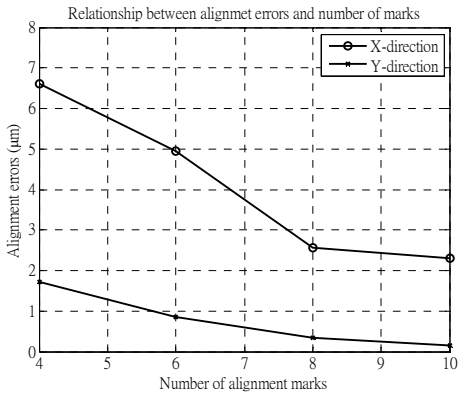

Fig 3: Relationship between alignment errors and number of marks in two axes

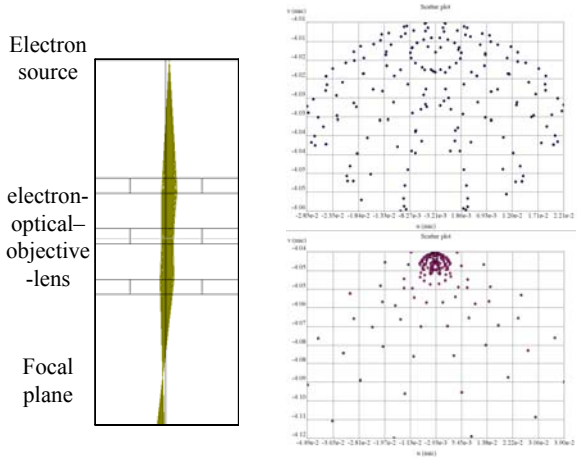

Fig 4: Misalignment between the electron source and the electron-optical–objective-lens (left), and the beam shape at two different focal planes (right)