Beam Drift Detection Using a Two-Dimensional Electron Beam Position Monitor System for Multiple-Electron-Beam–Direct-Write Lithography

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One of the promising candidates for next-generation lithography is multiple-electron-beam–direct-write lithography because of its high resolution and ability of maskless operation. Miniaturized electro-optics elements are utilized in order to drive massively parallel beams simultaneously to achieve the throughput for high-volume manufacturing. Electron beam drift problems can become quite serious in multiple-beam systems. Periodic recalibration with reference markers on the wafer has been utilized in single-beam systems to achieve beam placement accuracy. This technique becomes impractical with multiple beams. Architecture of a two dimensional beam position monitor system for multiple-electron-beam lithography has been proposed[1] as shown in Fig. 1. It consists of an array of miniaturized electron detectors placed above the wafer to detect backscattered electrons. Fig. 2 shows the relation between beam drift and distribution of backscattered electrons on different detector elements which is simulated by an in-house Monte Carlo electron-scattering simulator. Single-beam drift of (10 nm, 10 nm) from lens axis in the left part of Fig. 3 is estimated by using cross-correlation as shown in the right part of Fig. 3. Cross-coupling between beams are shown in Fig. 4. The multi-beam drift can be effectively estimated from output signals of detector array with some array signal processing to account for cross-coupling effects between beams. How to optimize detector array parameters to improve the measured SNR is another important issue[2] in the design of electron beam position monitor system. These are currently ongoing.

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1 S. Y. Chen et al. in Proceedings of SPIE **7520**, 2009, p. 7520-91.
2 H Alves et al. in Proceedings of SPIE **7271**, 2009, p. 72712O-1.

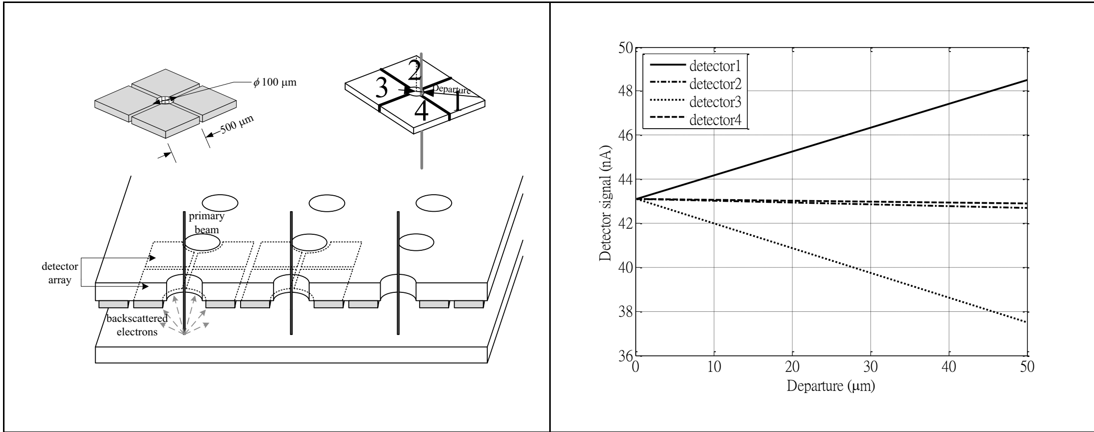

Fig 1: One BPMS sensor design based on a two-dimensional array of quadrant detectors (bottom), and an electron beam deviates from the original beam axis and drift toward detector 1 (top-right).

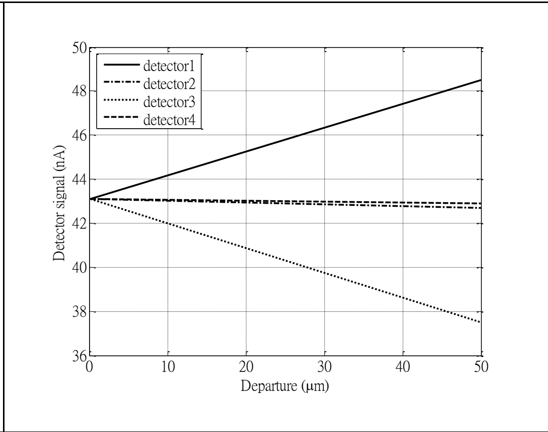

Fig 2: Signal variation simulation of the detectors as the 10 nA electron beam depart the original beam axis from 0 to 50 µm.

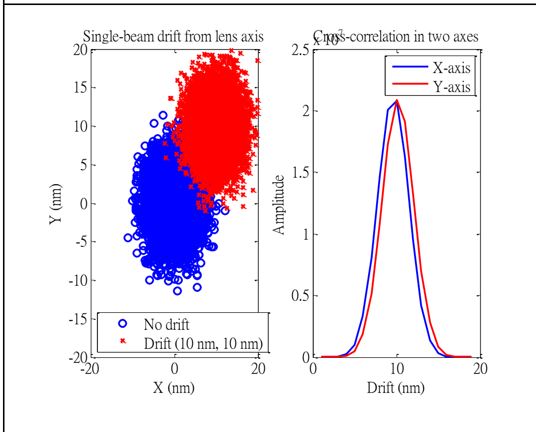

Fig 3: Single-beam drift of (10 nm, 10 nm) from lens axis (left), and the cross-correlation analysis in two axes (right)

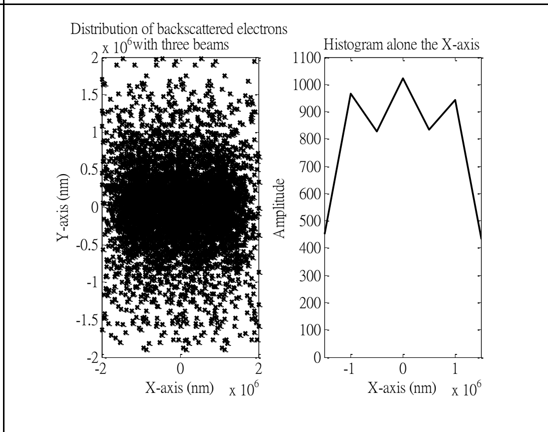

Fig 4: Distribution of backscattered electrons with three beams (left), and the histogram alone the X-axis for collected backscattered electrons by the detector array (right)