Development of MEMS electron-optics bonded on nc-Si electron emitter array for Massively Parallel EB Lithography System

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Our prototyped device of MEMS (Micro Electro Mechanical System) lens array bonded on nc-Si (nanocrystalline silicon) surface electron emitter array for massively parallel direct writing electron beam system is demonstrated in this report. We showed that the EB stepper which is a surface electron emission lithography system exposed deep submicron pattern over full-field for practical use as shown in EIPBN 2011. The surface electron emission lithography system had nc-Si electron emitter array as massive electron beam sources. Each element of array was a micro surface electron emitter which had rectangle shape of 360 nm x 180 nm. The exposure results indicated that the deep-submicron patterns were well reproduced in the area corresponding to full-field. The uniform reproduction in large area was due to properties of nc-Si electron emitter. In addition, chromatic aberration on projected electron image became small because the energy dispersion of emitted electrons from nc-Si electron emitter was small. The focus of the electron image was obtained with magnetic field vertical to the surface of the electron emitter array. Even if the electron beam spread in every direction, they were focused by Lorentz Force to the distance correspoding to cyclotron cycle. In this study, we employed MEMS lenses instead of the vertical magnetic field to obtain the focused massively parallel electron beamlets as shown in Fig.1, because the direct writing system needs to scan beamlets in directions parallel to the surface of the electron emitter. The lenses were designed so as to collimate the electron beams. In order to provide high resolution and high throughput for direct writing system, the lenses made the beam size reduced (1/10), and increased the beam current density (x100) as shown in a calculated result of Fig. 2. It was demonstrated that the prototyped device of electron emitter array with MEMS lenses provided massively electron beams, and then the electron image of beams on a target was indicated.

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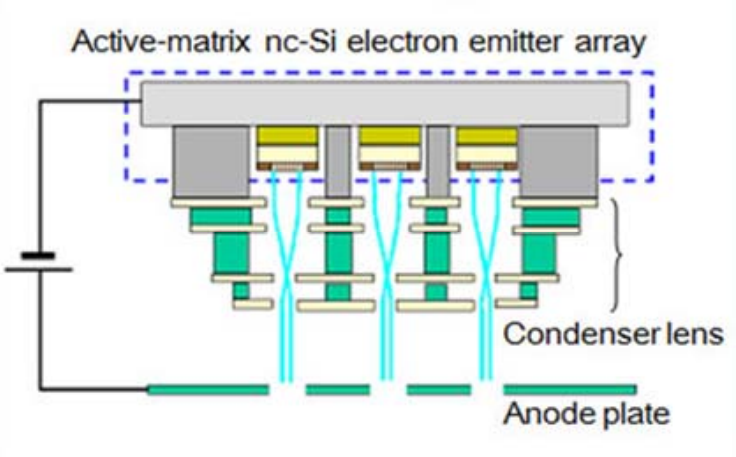

Fig. 1. Prototyped device of electron emitter array integrated with MEMS lenses for massively parallel direct writing electron beam system

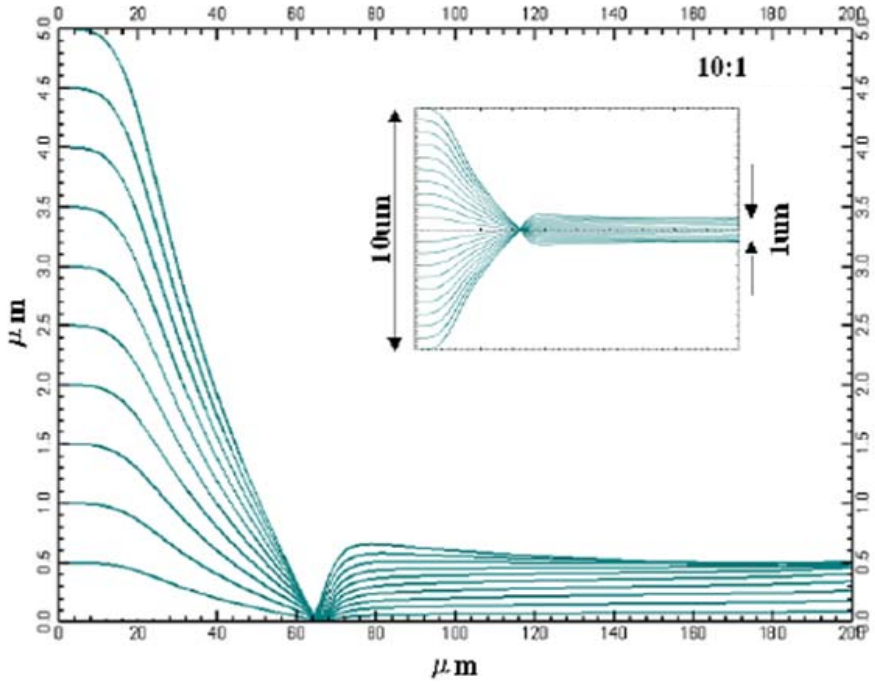

Fig. 2. Calculated result of beam collimation with MEMS lenses. The beam size reduced (1/10) and increased current density (x100).