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Fabrication and Characterization of a Low Voltage Micro-Electron Column for Scan Field Size and Magnification†

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Fabrication and characterization of a low voltage micro-electron column are reviewed. Many optical technologies in fabrication of a micro-electron-column such as laser aid optical alignment and *in situ* laser bonding are introduced in assembling basic components of micro-electron column. The maximum field of view and scan field size were investigated as a function of biased voltage of deflectors and electron emission tip voltage. The magnification and the linearity of zooming current image dependant on the electron emission tip voltage are also discussed.

Key Words: Fabrication, Low voltage micro-electron column, Scan field size, Magnification.

INTRODUCTION

The micro-electron column is a miniaturized module composed of electron emitter and electron column as shown in Fig. 1. Its length is less than 10 mm, not excessive 1/100 of conventional electron column of 300-1,000 mm. The column is layered with source lens, Einzel lens and deflector. Each lens is made of silicone membrane of 2 µm thickness and has an aperture of several-hundreds mm in diameter. Insulator of pyrex was alternatively stacked to silicone lens and a deflector for bending electron beam was composed of polished molybdenum wires and a metal deflector.

In this study the laser assisted fabrication and characterization of a micro-electron column are introduced. In laser aid fabrication the diffraction method simultaneously applied for precise alignment with laser bonding method. The diffracted pattern was detected by a quadro-pole photodiode and captured voltages at each photodiode were amplified and calculated logically. Q-Switched Nd:YAG laser was used to bond silicone lens and pyrex[1]. Anodic bonding was also used for substantial bonding. Fabricated micro-column with assembled electron lenses was tested with a current image of sample. The optimum operation conditions for the best visibility and field of view without image distortion is also given. Though the largest scanning field width could be acquired with removal of Einzel lens, the visibility of current image became worse and the increasing working distance showed a growing barrel distortion of current image[2,3]. Therefore, the biasing voltages to double deflectors were switched with opposite sign to reduce the image distortion and the optimum operation condition was investigated in fully assembled environment.

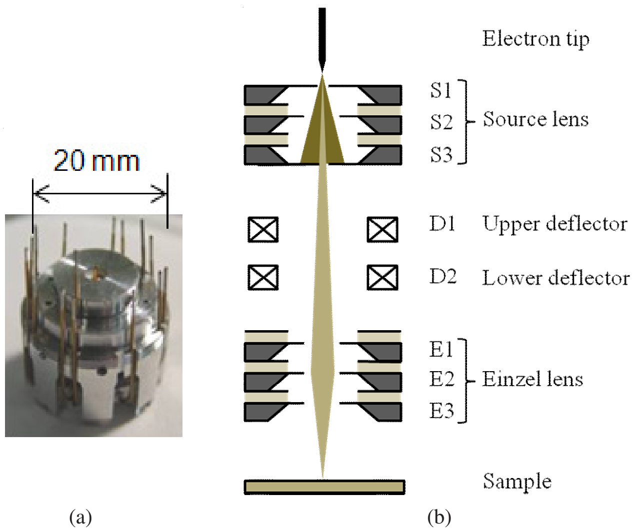

Fig. 1. (a) Outlook and (b) structure of a micro-electron column

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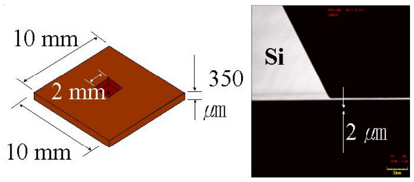
EXPERIMENTAL

Laser assisted fabrication: The appearance and cross sectional view of silicone lens are shown in Fig. 2. The size of silicone lens was 10 mm × 10 mm, the thickness was 350 μm, the aperture diameter was several tens to hundreds μm and the membrane size was 2 mm × 2 mm. SEM picture of silicone membrane (Fig. 2(b)) shows the thickness to be 2 μm. The insulator of pyrex has the same size of silicone membrane with thickness of 150 μm. It has an aperture of 2 mm in diameter at center position to provide the electron beam path.



(a) (b)

Fig. 2. (a) Appearance and (b) cross-section of membrane

Laser bonding is appropriate for short and non-physical contact operation. The high power density on a welding spot doesn't deform the alignment of stacked silicone membrane and pyrex in orderly fashion. The absorption of laser power into silicone is about 50 % at the wavelength of Nd:YAG laser. The pulse repetition rate and pulse energy should be controlled for bonding without cracking and excessive welding. At the optimum operation conditions, the laser power was 18.6 W, the pulse repetition rate was 20 kHz and the exposing time was 0.5 s. Higher laser power or lower pulse repetition rate could allow the increase of pulse energy and the generated optical shock cracked pyrex and formed a non-uniform bonding. Longer or shorter exposure showed over welding or short bonding, respectively.

RESULTS AND DISCUSSION

The aligned and bonded silicone lens could be reviewed by optical microscope. Fig. 3 is the pictures of source lens composed of 50-100-20 μm apertures in diameter. The upper (50 μm)-middle (100 μm) lens and the middle (100 μm)-bottom (20 μm) lens pairs were pictured by focusing microscope. The alignment errors were 2 and 3 μm in upper-middle and middle-bottom pairs, respectively.

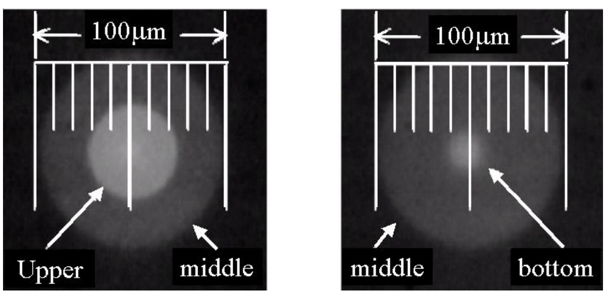
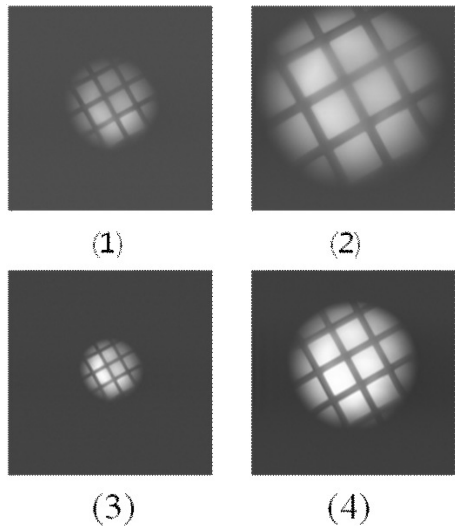


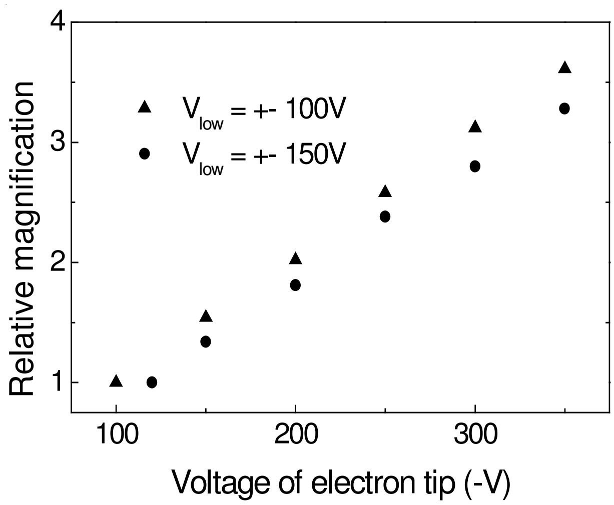
Fig. 3. Aligned source lens (50-100-20 μm)

Image magnification as a function of electron tip voltage: Fig. 4(a) shows current images when only one of two deflectors was biased condition. Images of (1) and (2) were obtained when only the lower deflector voltage was biased to ± 100 V. (1) and (2) are current images of -150 and -300 V of electron emission tip voltages, respectively. Images of (3) and (4) were also obtained when the upper deflector was biased to ± 150 V. (3) and (4) are current images of -150 and -300 V of electron emission tip voltages, respectively.

Though all images of Fig. 4 show the same field of view, the image was magnified in order of (3) → (1) → (4) → (2). Increasing V_{Tip} lessen scan field width y, but field of view is not affected by the voltage of deflector and follow the path C. This has a similar effect of magnification as that in optical microscope. Fig. 4(b) shows the magnification as a function of electron tip voltage, V_{Tip}. In Fig. 4(b), the graphs of lower deflector voltage of ± 100 and ± 150 V were valued basis on the image size of -100 and -120 V of electron emission tip voltage, respectively. The images of both cases were enlarged, which indicates that the zoom function of SEM can be realized by electron tip voltage.



(a)



(b)

Fig. 4. Magnification as a function of voltage of electron tip (a) current images, (b) relative magnification

Conclusion

A silicone lens and an insulator of pyrex, components of micro-electron column was assembled by aligning and stacking simultaneously. The scan field width and field of view also discussed theoretically. Expanding field of view and compensating lens aberration in micro-electron column are very important for substitution of conventional electron column. In this study, from fabrication of micro-electron column to theoretical view for scan field size and field of view were discussed and the current image magnification was also introduced.

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