Evaluation of the impact by the electron collision on the silicon lens

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Microcolumn has been demonstrated as a next-generation technology with high resolution and high throughput capabilities for monitoring the small structures and it has the potential of detecting electrical troubles or repairing the defects in the metrology and inspection (MI) field for semiconductor and display device. The microcolumn has a stacked structure with silicon lens manufactured by microelectromechanical systems (MEMS) process. The silicone lens of microcolumn perform a different role depending on their position. The source lens located close to the emitter (tungsten tip) to help electron emission, the deflector takes care of beam scanning in the middle of microcolumn, and the einzel lens focuses the electron beam at the bottom. They produce performance with respect to probe beam size and deflection field size in previously our results. [1,2] Most of the emitted electrons from the field emission tip pass through the aperture of the source lens by applied potential, but some of the emitted electron's collision with the surface around the extractor of the source lens. Therefore, the surrounding of the aperture of the source lens is physically damaged by the continuous impact of the electron beam. Consequently, the life-time of the microcolumn is inevitably degraded. Additionally, the carbon remaining in the microcolumn is adsorbed around the aperture during the process causing contamination surrounding surface. In this study, we used the extractor of source lens with electron bombardment applied 300 eV for 6 months. We analyzed the correlation between intensity of electron bombardment and collision distance from aperture of extractor for evaluating the effect of the physical transition of the surface caused by the continuous collision of the electron beam by using Raman spectroscopy and electron probe micro analyzer (EPMA).

As the results, the emitted electrons from emitter pass through the aperture of the extractor and then the extractor was damaged by collision of sieved electrons in Figure 1. The degree of damage was stronger as it was closer to the aperture and decreased as it was further away from the aperture. Similarly, the carbon contamination was degraded to keep away from the aperture.

In conclusion, the life-time of the source lens could be expect from carbon

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[1] Ho Seob Kim et al, JPN. J. APPL. PHYS., vol. 56, 06GA02, 2017

[2] Tae-Sik Oh et al, Proceedings of SPIE., vol. 8923, 89234V, 2013

contamination. Therefore, we were able to predict the replacement cycle of the silicon lens and emitter (tip) in microcolumn through Raman spectroscopy such as a non-destructive analyze. And this analysis method is expected that the performance of electron beam can be improved.

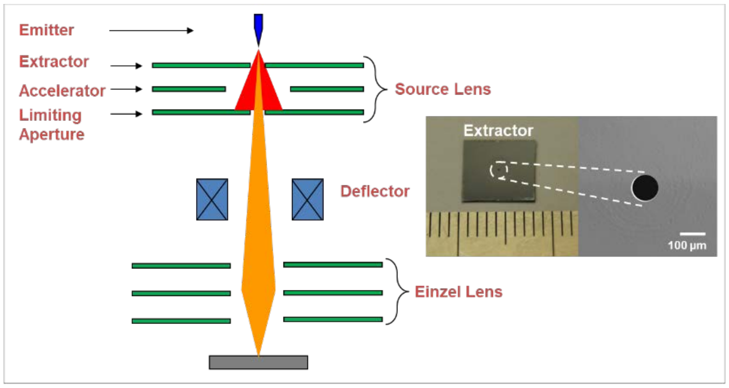

Figure 1: The illustrate of microcolumn structure that comprised source lens, deflector, and einzel lens (Red color: sieved electrons, Orange color: pass electrons). The optical image shows the dimension and shape of source lens and the SEM image shows magnified aperture of extractor (scale bar: 100 µm).

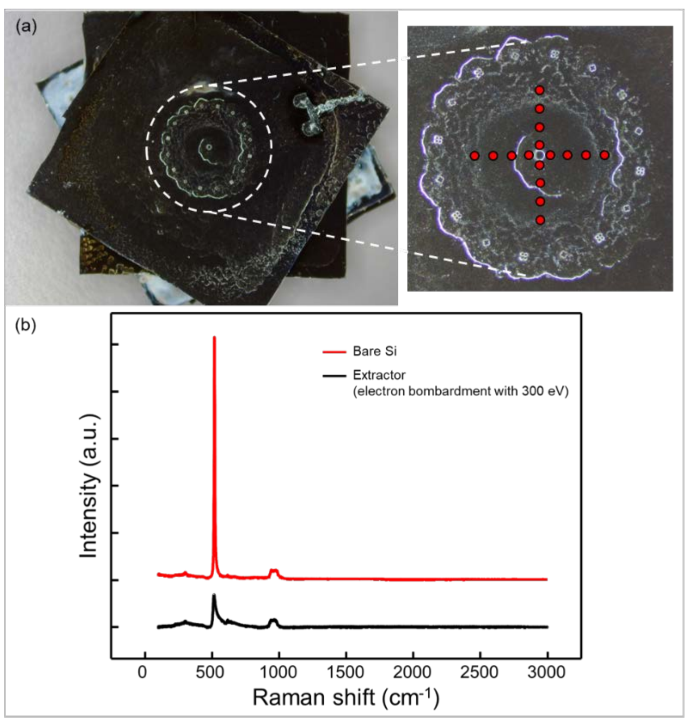

Figure 2: (a) The optical images indicate that the extractor of source lens collided with 300 eV (Red dots: measured position). (b) The plot shows the measured Raman shift of bare silicon and extractor by using Raman spectroscopy.