Creation of X-ray multi-scale microfabrication system

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Recent three dimensional (3D) modeling technology has progressed very rapidly. 3D printers using two-photon absorption can draw 3D structures in an area of about 4 inches with a resolution of several tens of nm. Although there is a tradeoff between throughput, cost, and resolution, respectively, unprecedented processing technology has been realized.[1, 2] Accordingly, it is being actively deployed in fields such as optical elements and metamaterials with significant results. On the other hand, although processing using X-rays is not common due to the use of synchrotron radiation facilities, it is characterized by surface processing accuracy and the ability to process high-aspect structures over large areas, which cannot be achieved by machining. Although the development of Lithographite-Galvanoformug-Abformung (LIGA) process that fabricates molds from electroformed masters machined using X-ray microfabrication and then performs molding and processing, has been underway, it has been difficult to implement submicron-level processing.[3, 4)]

Therefore, in this study, a mechanism to change the X-ray energy according to the processing dimensions was implemented in the beamline, and both submicron-scale processing and high-aspect-ratio processing of several tens of microns were successfully realized. Figure 1 shows an overview of the beamline and Scanning electron microscope (SEM) images of the processed acrylic plate. In the X-ray processing system installed in the synchrotron radiation facility NEWSUBARU beamline 2[4)], we succeeded in simultaneously incorporating a high pass line that extracts high energy (2ke to 20keV) and a low pass line that

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extracts low energy (2keV or lower) by combining a plane mirror and a cylindrical mirror. By using an exposure system consisting of a 5-axis drive stage, we were able to achieve high aspect ratio microfabrication with High Pass Processing and submicron pattern formation with Low Pass Processing, as shown in Figure 1. This system is expected to be applied to surface processing accuracy and material systems that cannot be realized with commercially available 3D printers, and in combination with the liquid-phase synchrotron radiation light process[5-8], it is expected to be used to create microstructures composed of composite materials such as metals, oxides, and organic materials.

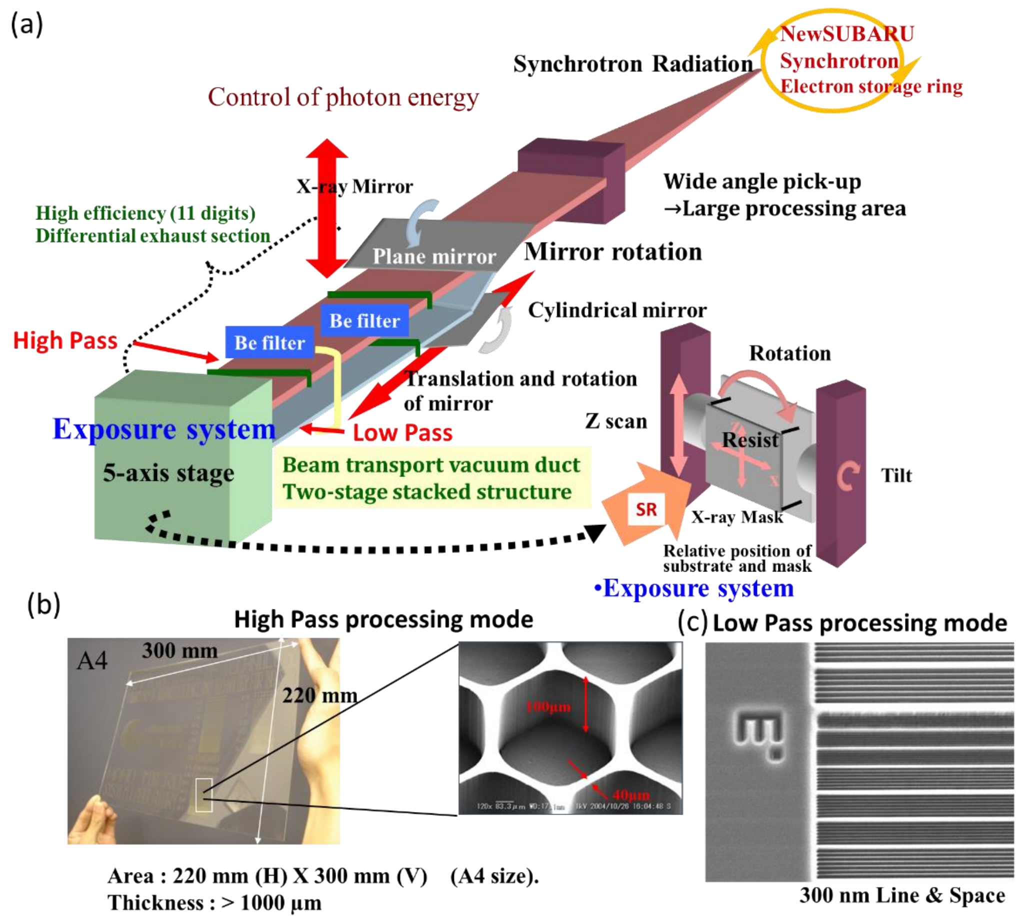

Figure 1: (a) Beamline configuration for multi-scale X-ray microfabrication. (b) SEM image of a large-area, high-aspect-ratio structure processed in High Pass Processing mode. (c) SEM image of sub-micron 300 nm line & space processed in Low Pass Processing mode. Simultaneous processing is possible by using different energies in a single system.