Maskless Si Nano-wall Formation by wet-etching process using a femtosecond laser irradiation

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Recently, ultrashort pulsed laser direct writing technique has been intensively investigated to develop a nanoscale fabrication enabling high aspect ratio. In the referred applications, laser induced nanostructures are formed with well manipulated laser beams in small area. On the other hand, Laser Induced Periodic Surface Structure (LIPSS) has attracted increasing attention for the possibility to generate periodic nanoscale structures in large area with relatively simple optical configurations. LIPSS is a self-organized one-dimensional periodic structure which is formed when multiple laser pulses with the laser fluence near ablation threshold are exposed. These self-induced nanostructures are often categorized into Long Spatial Frequency LIPSS(LSFL) and High Spatial Frequency LIPSS (HSFL) by their periodicity. The periodicity of LIPSS is varied by the wavelength of the laser and the material properties of the substrates. The orientation of the LIPSS is affected by the laser polarization. In case of the LSFL, the orientation is observed almost perpendicular with respect to the incident laser polarization. Therefore, LIPSS with direct-write scheme has been applied in rapid production of functional surfaces on large area such as superhydrophobic surfaces, enhanced absorption, cell adhesion, and tribological applications.

However, these demonstrations utilized the LIPSS property to increase the surface area by desirable surface roughening or enhancing surface properties. Relatively less attention was paid to the morphological changes of LIPSS followed by a chemical etching.

This presentation will introduce a new mask-free patterning technique of Si, which is combined with a conventional wet-etching process and direct-write LIPSS patterns of Si. The technique is a two-step process. First, a femtosecond laser irradiates a Si surface to generate one-dimensional LIPSS pattern on the surface. Conventional wet-etching solvents, such as KOH and TMAH (tetramethylammonium hydroxide), etch the LIPSS to form a periodic micro-cell surrounded by nanowalls with the height of a few hundred nanometers. The distance between the nanowalls was approximately one micrometer and the bottom surface of the cell was atomically flat which is sufficient to grow organic semiconducting thin films for organic devices. The bottoms of micro-cells surrounded by the nanowalls were considerably flat with a 3.10 nm surface roughness. A pentacene layer was deposited on the micro-cells of a Si surface to evaluate the film properties by grazing incidence wide angle x-ray scattering measurements. The pentacene film on the micro-cell Si surface showed a strong film phase, which was comparable to the film phase grown on the atomically flat Si surface.

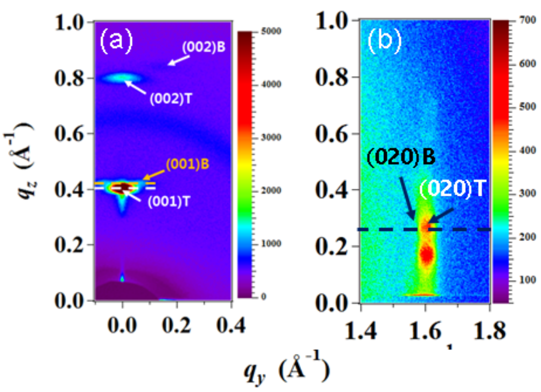

Figure 1. 2D GIWAXS images of 50 nm thick pentacene layer deposited on LIPSS-etched Si surface which was etched in TMAH solution.

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