Wavelength-dependence of near-field etching

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Realization of an ultraflat surface is highly important in future electrical and/or optical devices because of carrier-scattering losses caused by surface roughness. To overcome the problem, we have developed a near-field etching technique, which can realize an atomic-scale flat surface [1]. According to theory, the etching effect originates from radical atoms. To realize selective dissociation of ambient O_2 molecules, we need to choose the photon energy of the light source less than the dissociation energy of O_2 molecules at 5.12 eV [2], and these radical O atoms react with the surface protrusion selectively. In order to achieve finer control, we examine the wavelength dependence of the near-field etching light source. Using light sources (λ = 325 and 405 nm), which are longer than the absorption edge of the photoresist (λ_{ab} = 310 nm), we compare the etching volumes from the cross-sectional profiles using atomic force microscope (AFM). We obtained bigger etching volumes for 325 nm light (see Fig. 1(a)), which is closer to λ_{ab}. Although 405 nm light did not cause structural change in the photoresist (see Fig. 1(b)), a higher reduction of the surface roughness was observed as compared to the 325 nm light, implying that even wavelengths above 325 nm can cause surface roughness improvements in the atomic scale.

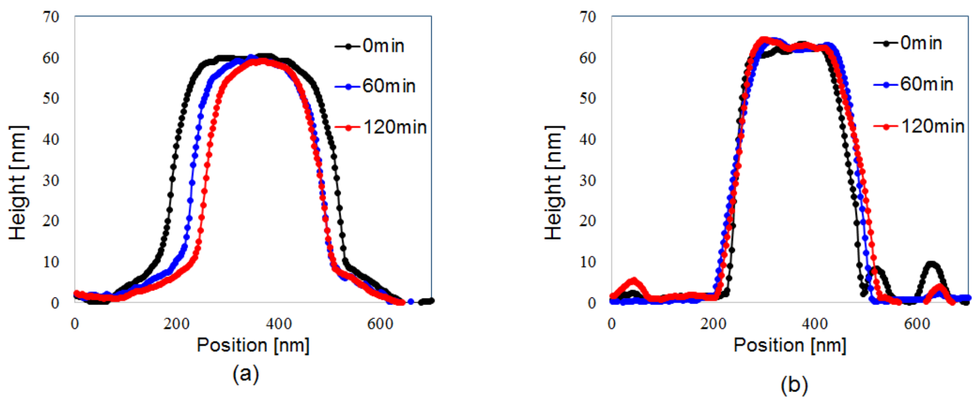

Figure 1: (a) Photoresist profile before (black) and after 60min (blue) and 120min (red) of 325 nm laser illumination under room conditions. (b) Same as (a) but with 405 nm laser illumination.

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Reference: [1] T. Yatsui, et al., Beilstein Journal of Nanotechnology 2013, **4**, 875-885. [2] D. Keilin, et al.. Nature 1950, **165**, 543-544.