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Pattern evolution on rippled Au(001) by oblique angle ion-beam-sputtering

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Pattern formation by low energy ion beam sputtering has been widely studied, because it induces versatile nano-structures such as periodic ripples, nano-dots and nano-pores. Nevertheless, few subjects on methods of sputtering other than single ion (beam) sputtering have been studied except the simulation of multiple ion beam sputtering and the experimental of dual ion beam sputtering. In this work, we show firstly the result of pattern formation by sequential ion beam sputtering. We formed ripples by 2 keV ion-beam-sputtering (erosive regime) that are straight along ion beam direction and its coherence length is longer than 1μm with a wavelength λ~29 nm. Then, we study the topographic evolution of the Au(001) induced by ion-beam-sputtering at oblique angle (θ=72°), perpendicular to the pre-patterned ripples. We observe both decay of pre-patterned ripples and growth of new ripples at the same time in early stage of cross ion beam sputtering. New ripples are, however, not superposed over pre-patterned ripples. Pre-patterned ripples decay exponentially and wavelength increases according to power law. In contrast, the roughness of new ripple follows power law behavior, while wavelength of new ripple increases a little from ~25nm to ~28nm. We study the dependence to pattern evolution on ion beam energy and flux. For that purpose, we also investigate the topography evolution by cross ion beam with 0.5 keV ion beam energy (diffusive regime). In the diffusive regime, pre-patterned ripples are not so straight and its coherence length shorter than 1μm with a wavelength λ~30 nm. As for the case of the erosive regime, there are observed no superposition of two ripples formed by crossing ion beams. But we can observe rectangle patterns which do not exist in erosive regime. The formation of this rectangular patterns can not be explained with linear continuum theory. In the diffusive regime, pre-patterned ripples also decay exponentially and coarsening of wavelength follows logarithm behavior, not the power law as observed in the erosive regime. Both the roughness and the wavelength of new ripples, however, shows quite complicated behaviors.