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Surface ripple formation during plasma etching of silicon
KOUICHI ONO, NOBUYA NAKAZAKI, HIROTAKA TSUDA, YOSHINORI TAKAO, KOJI ERIGUCHI, Kyoto University — Atomic- or nanometer-scale roughness on feature surfaces has become an important issue to be resolved in the fabrication of nanoscale devices. Control of the surface roughening during plasma etching might be possible, given a deeper understanding of plasma-surface interactions concerned with it. We have investigated the surface morphology evolution in response to ion incidence angle onto substrate surfaces during silicon etching in chlorine-based plasmas, through Monte Carlo simulations and experiments using sheath control plates. The simulations showed randomly roughened surfaces at normal incidence, while ripple structures at off-normal angles of incidence, traveling laterally across the surface in the direction of ion incidence. Correspondingly, the experiments demonstrated sawtooth-like ripples whose crests/troughs are elongated perpendicularly to the direction of ion incidence at intermediate off-normal angles, while small ripples or slit-like grooves whose crests/toughs are parallel to the direction of ion incidence at high off-normal angles, as predicted by simulations. These results are discussed in terms of the effects of ion reflection from feature surfaces and those of geometrical shadowing of the feature.

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