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Energy dependence of the ripple wavelength for ion-beam sputtering of silicon: experiments and theory

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Abstract— In spite of the efforts devoted for the last 20 years to elucidating ion-beam sputtering (IBS) as an instance of surface self-organization, the classic view on the main mechanism inducing the morphological instability has been recently challenged. We report on the verification of a recent theoretical description of this nanopattern formation process for semiconducting targets, as driven by stress-induced, viscous flow of a thin amorphous layer that develops at the surface [M. Cuerno and R. Cuerno, Appl. Surf. Sci. 258, 4171 (2012)]. Through experiments on silicon as a representative case, we study the dependence of the ripple wavelength with the average ion energy, finding a linear dependence in the 0.3-1 keV range. This is explained within the viscous flow framework, taking into account the energy dependence of the number of displaced atoms generated by collision cascades in the amorphous layer, as predicted by previous models of ion-generated stress. For our analysis, we provide a systematic criterion to guarantee actual linear dynamics behavior, not affected by the onset of nonlinear effects that may influence the value of the ripple wavelength.

Index Terms— Nanoscale pattern formation, ion-beam sputtering, ripples, viscous flow, surfaces, morphological instabilities, hydrodynamic models.

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