Morphology dependent sputtering yield at grazing incident ion bombardment on Pt(111)

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Grazing incidence ion bombardment may be used for smoothing of surfaces and of growing films as well as for the formation of regular nanogrooves, ripple and dot patterns [1,2]. Measuring the reflected ion current or the related sample current during grazing incidence ion bombardment allows to obtain information on surface structure and even surface morphological evolution during epitaxial growth [3, 4]. The origin of all these applications is the selective interaction of the ion beam with the surface topology.

Focussing to the case of crystalline surfaces this statement specializes for most applications to a highly selective interaction of grazing incidence ions with steps. Due to the negligible perpendicular momentum of the grazing incident ions they are reflected from the atomically smooth terraces with a high degree of perfection. However, grazing incidence ions impinging on ascending steps are scattered at large angles, give rise to significant momentum and energy transfer to the substrate, and thus cause sputtering. As a consequence, unlike in normal incidence ion bombardment, at grazing incidence the spatially averaged sputtering yield is no more a nearly constant quantity: The variation of the step density with fluence and temperature makes this quantity a strong function of both parameters.

The surface morphology of Pt(111) was investigated by a variable temperature scanning tunneling microscopy (STM). The surface was exposed to a flux of 5 keV Ar^+ ions incident along the [-1,-1,2]-direction at an angle of 83^o to the surface normal at various temperatures and for various exposure times. After bombardment the sample was quenched to room temperature and imaged by STM.

The average erosion rate was found to be strongly dependent on the ion fluence and the substrate temperature during bombardment (Fig. 1). This dependence is traced back to the variation of step concentration with temperature and fluence. We develop a simple model allowing to determine separately the constant sputtering yields for terraces and for impact area stripes in front of ascending steps. The experimentally determined yield of these stripes - the step edge sputtering yield - is in excellent agreement with our molecular dynamics simulations performed for the experimental situation.

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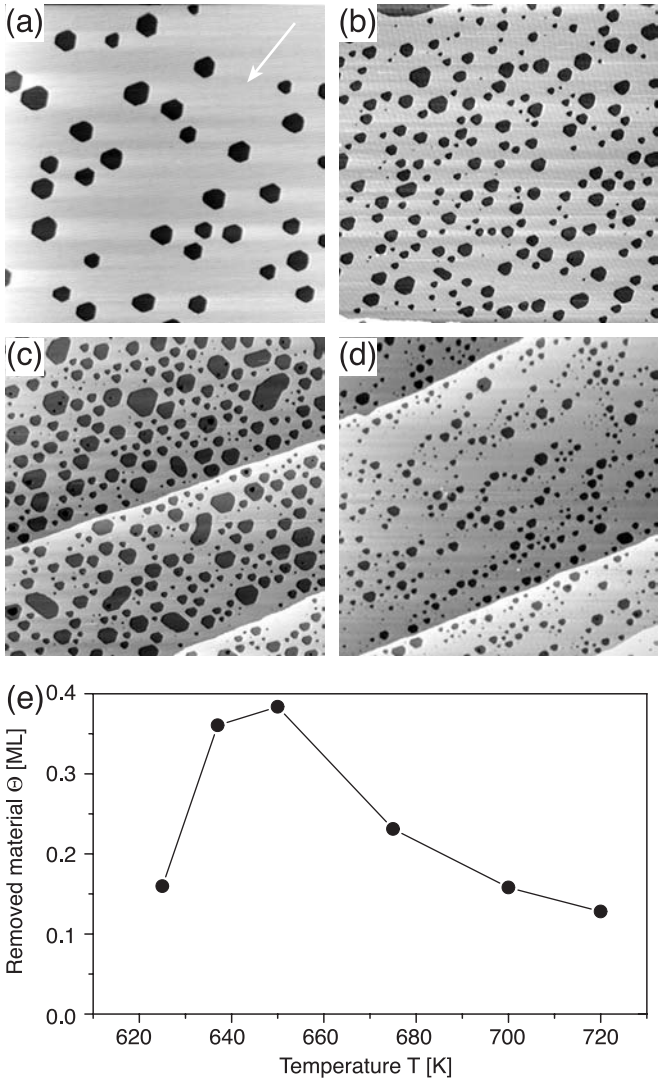

Fig. 1: (a)-(d) STM-topographs after the irradiation with a fluence of 0.5 ML at (a) 720 K, (b) 675 K, (c) 650 K, (d) 625 K respectively. The ion beam is incident along the direction indicated by the white arrow in (a). The topograph size is 2450 Å x 2450 Å. (e) Plot of the removed amount Θ versus the bombardment temperature T. Full circles represent the experimental data.

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