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Roughness evolution in amorphous silicon films grown by (biased) DC magnetron sputtering

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Control over surface roughness (σ) is a critical issue in many physical, chemical, biological and technological processes. Regarding relevant systems, silicon is a model material that finds a wide range of applications in microelectronic and photovoltaic devices. Further, the growth of amorphous silicon (a-Si) could yield ultrasmoothness, a keystone for the production of ultrathin films, in analogy to amorphous diamond-like carbon [1]. Based on this motivation, we have studied the roughness evolution of a-Si films prepared by DC magnetron sputtering at low (LP) and high (HP) plasma pressures (10^{-3} and 3×10^{-3} mbar, respectively). The morphological analysis was carried out by atomic force microscopy and interpreted in the framework of dynamic scaling concepts [2]. The film thickness evolution was analyzed by ex-situ spectroscopic ellipsometry, providing also information on the disorder character of the films. Smooth ($\sigma<0.2$nm) films were produced at LP whereas rougher surfaces were grown at HP. The growth exponent [$\sigma(t)\sim t^{\beta}$] was close to 0.25 at LP, compatible with a morphology controlled by surface diffusion relaxation processes, whereas HP yielded considerably higher β characteristic of unstable growth. The distinct evolution should be related to the lower mean free path in the gas phase at HP, which alters the incidence angle and/or size of the particles condensing at the substrate and can result in shadowing effectsduring growth [3]. Finally, a negative DC bias voltage (-400V) applied to the substrate at HP changes drastically the surface morphology to ultrasmooth ($\sigma\sim0.12$ nm) during the whole temporal window sampled, resulting in $\beta\sim0$ (i.e. suppressing surface roughening). The latter could be consistent with the Edwards-Wilkinson interface equation [2]. This evident surface smoothing could be ascribed to ion-induced downhill currents that preferentially erode prominent features [1].
REFs.: [1] M. Moseler, P. Gumbsch, C. Casiraghi, A.C. Ferrari, and J. Robertson, Science 309, 1545 (2005); [2] A.L. Barabasi, and H.E. Stanley, Fractal Concepts in Surface Growth (Cambridge Univ. Press, 1995); [3] J.T. Drotar et al., Phys. Rev. B 62, 2118 (2000).

Keywords
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