Isotropic and anisotropic behaviors in microstructured thin films

Asma Chargui*, Paulo Pedrosa, Sébastien Euphrasie, Alexis Mosset, Nicolas Martin, Pascal Vairac

Institut FEMTO-ST, UMR 6174, CNRS, Univ. Bourgogne Franche-Comté
15B, Av. des Montboucons, 25030 BESANCON, France

In thin film deposition, the GLAD approach is among the most attractive ways to produce original surface morphologies, especially to tune the surface anisotropy. The technique consists of deposing thin films at oblique deposition angles (defined as the angle α between the substrate normal and the trajectory of incident vapor), combined with a fixed or rotating substrate [1].
In this presentation, we study the correlation between the structural shape in columnar thin films and their anisotropic properties. To this aim, various metallic thin films (Au, Ag, Cu, W, Zr, Mo) are deposited by GLAD sputtering on silicon substrates with an inclination angle α of 80° and no rotate.
These samples are characterized with a heterodyne pump-probe set-up [2]. It allows the visualization of surface acoustic waves and the calculation of their celerity. The acoustic waves are generated by the absorption of the first laser (pump). The second laser (probe) measures the reflectivity variations of the sample's surface, which are linked to the temperature and acoustic changes.
Scanning electron microscopy (SEM) is used to view the surface and cross-section morphology of the films. It is shown that tilted columns exhibit a diverse array of columnar morphologies, depending on the nature of the sputtered metal. Thin films like Au, Ag and Cu give rise to a symmetric columnar growth with isotropic coefficient for the group velocities of the pseudo-Rayleigh wave (Table 1). Other thin films like W, Zr and Mo display asymmetric columns with elliptical patterns and void regions, created during the growth phase, which leads to important anisotropic behaviors of group velocities (Table 1). This directional dependence of acoustic properties is connected to the anisotropic columnar microstructures.

Material	v_x (m.s^{-1})	v_y (m.s^{-1})	Anisotropy
Au	1230 ± 50	1280 ± 50	1.04 ± 0.05
W	920 ± 50	1640 ± 50	1.78 ± 0.05

Table 1: Group velocities of pseudo-Rayleigh waves at $k/2\pi = 3\times10^5$ m^{-1} along x and y axes in Au and W thin films sputter-deposited by the GLAD technique (α = 80°).

[1] Robbie K, Sit J C and Brett M J 1998 Advanced techniques for glancing angle deposition J. Vac. Sci. Technol. 16 1115-22
[2] Coffy E, Dodane G, Euphrasie S, Mosset A, Vairac P, Martin N, Baida H, Rampnoux J.M, Dilhaire S, Anisotropic propagation imaging of elastic waves in oriented columnar thin films, J. Phys. D: Appl. Phys., 50 (2017) 484005-8.

* asma.chargui@femto-st.fr