Anisotropic propagation of surface elastic waves in inclined columnar thin films

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In thin film deposition, some specific techniques allow producing anisotropic structures. The GLancing Angle Deposition (GLAD) approach is among the most attractive ways to produce original surface morphologies, especially for designing anisotropic architectures [1]. The technique consists of depositing thin films using oblique incidence of the sputtered particles flux and on a fixed or mobile substrate. This leads to the creation of thin films presenting a columnar architecture with different angles to the normal.

A femtosecond heterodyne pump probe setup [2] is used for the acoustic characterization of the GLAD films. This technique allows the visualization of surface acoustic waves and the calculation of their dispersions. The elastic 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. Thanks to a lens mounted on a 2D translation stage, the pump-probe distance can also be scanned.

Two kinds of metallic films (W, Au) are deposited by GLAD sputtering using a constant inclination angle of 80°. The choice of these metals is motivated by their propensity to create morphological columnar features, which is connected to their film growth process. Scanning electron microscopy (SEM) are used to view the surface and the structural morphologies of the films. It is shown that W GLAD growth gives rise to asymmetric columns with elliptical sections linked by void regions that is especially favored by the atomic shadowing effect occurring during the growth of the inclined columns. Such architecture leads to important anisotropic behaviors for the group velocities of the pseudo-Rayleigh waves (fig.1). Au GLAD films produce a rather circular and more symmetric columnar growth with an isotropic propagation [3].

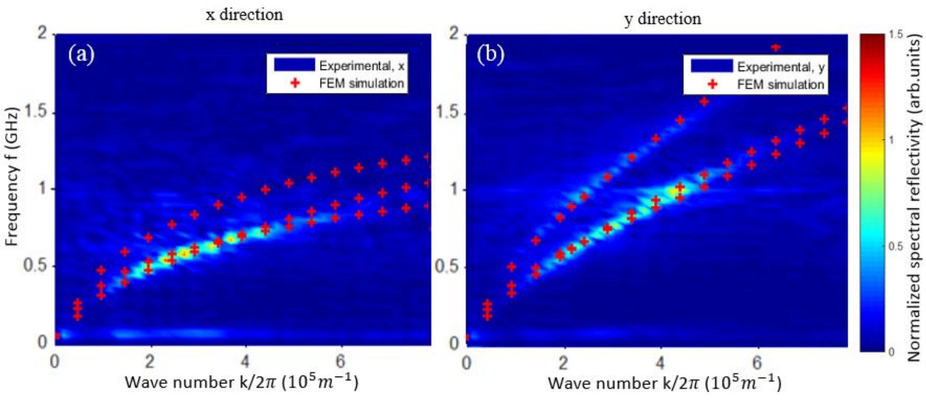

Fig. 1. Dispersion curves for x (a) and y (b) directions obtained from the variation of relative reflectivity versus spatial and time frequencies, compared with FEM simulation for W GLAD.

Numerical simulations of the surface acoustic wave propagation are performed with the finite element method. It is proved that acoustic anisotropy is related to the structural anisotropy of the film's architecture.

A systematic change of the W films thickness allows tuning the morphology of the columnar microstructure: from nearly circular shape to elongated as the thickness increases. The same phenomenon is noticed with a change of the argon sputtering pressure from 15×10^{-3} up to 2.5×10^{-3} mbar. This leads to tunable column angles and more interestingly significant changes of the columnar microstructure. Here again, some anisotropic behaviors are investigated and discussed.

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