DEVELOPMENT OF HARD AND WEAR-RESISTANT DENSITY MODULATED COATINGS BY MAGNETRON SPUTTERING

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INTRODUCTION.

A residual (or intrinsic) stress naturally evolves during growth of sputter deposited thin films. The control of this stress is essential for high mechanical quality coatings without cracking, buckling, or delimitation [1]. The method for stress reduction in sputter deposited film using a nanostructured compliant layer (NCL) sandwiched between the over-layer film and the substrate has been pursued using glancing angle deposition (GLAD) technique.

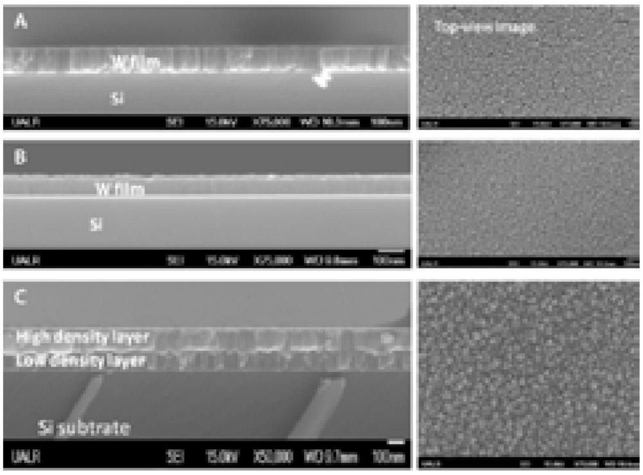

Figure 1. Cross-sectional and top view SEM mages of samples A (single-layer low density), B (single-layer high density), and C (density modulated high/low density) W films on Si substrates.

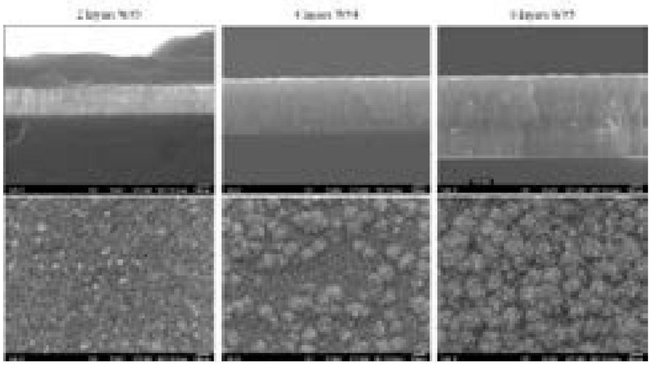

Figure 2. SEM images for multilayered W film samples, side, and top views

MATERIALS AND METHODS.

The major task of our project is to develop a density modulated tungsten-based films to achieve high adherence of the entire hard sandwiched film structure to the substrate. The density modulated thin films composed of low and high-density layers were made by DC sputtering at different Ar+ gas pressures. The low-density layer consisted of nano-columns deposited under high pressure is believed to be acting as compliant layer [2]. Additionally, we have made high density blanket W films of varying thickness.

RESULTS AND DISCUSSION.

SSEM images shown in Fig. 1 confirm that the low density films are more porous and rougher than high density films. Structure of the double-layered high/low-density film (sample C in Fig. 1) strongly resembles the overall quality of low-density underlying layer (sample A), which is also consistent with our expectations. The average density value of this sandwiched film was found to be 16.7 g/cm3, which is somewhat lower that that of the bulk tungsten (ρ=19.35 g/cm3). SEM images of multilayered samples consisting of 1 pair of low- and high- density layers (W#3), 2 pairs of low- and high- density layers (W#4) and 3 pairs of low- and high- density layers (W#5) are shown in Fig. 2. It can be seen that surface roughness increased significantly with increased number of pairs of alternating layers. In another set of samples consisting of single high density tungsten film of various thicknesses, it was observed that at the critical thickness of ~ 500 nm the tungsten film starts to buckle on the surface of the Si substrate. Currently the experiments on surface Brillouin light scattering (BLS) (Fig. 3) and laser-induced surface acoustic wave (SAW) spectrometry (Fig. 4) are underway to examine elastic and adhesion properties of fabricated film structures and as well as those to be fabricated using GLAD technique.

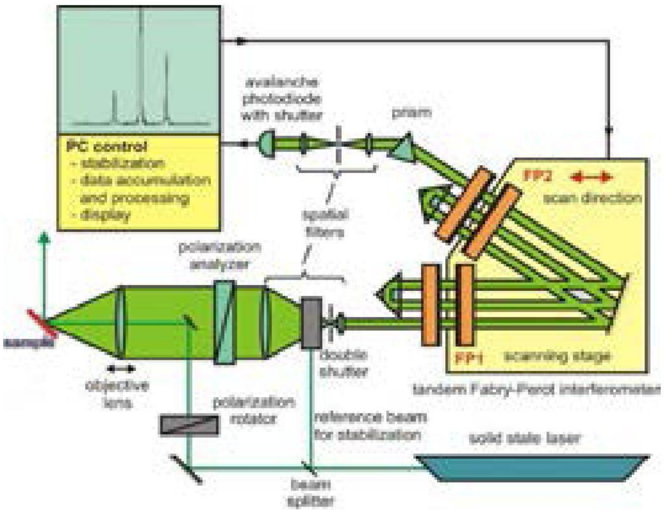

Figure 3. Schematic of Brillouin light scattering spectrometry setup

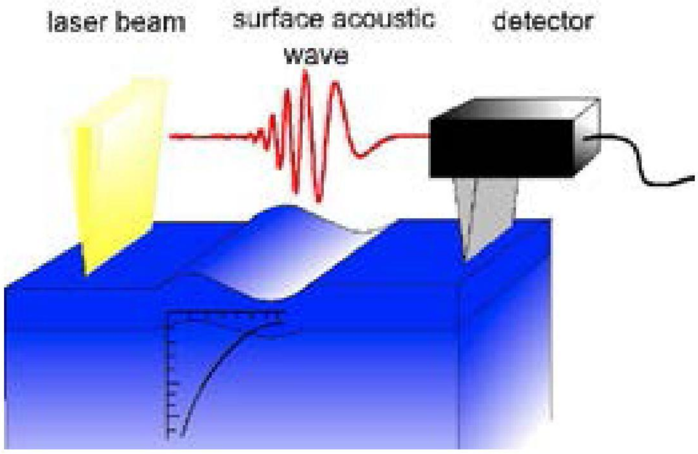

***Figure 4.** Schematic of laser-induced surface acoustic wave spectrometry setup.*

CONCLUSIONS.

Such laser-based materials characterization techniques as surface BLS and laser-induced SAW spectrometry coupled with SEM and XRD can provide comprehensive tools for measurement and analysis of elastic, adhesion and microstructural properties of fabricated thin film structures.

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