

## ELASTIC AND STRUCTURAL PROPERTIES OF SPUTTERED REFRACTORY METAL THIN FILMS

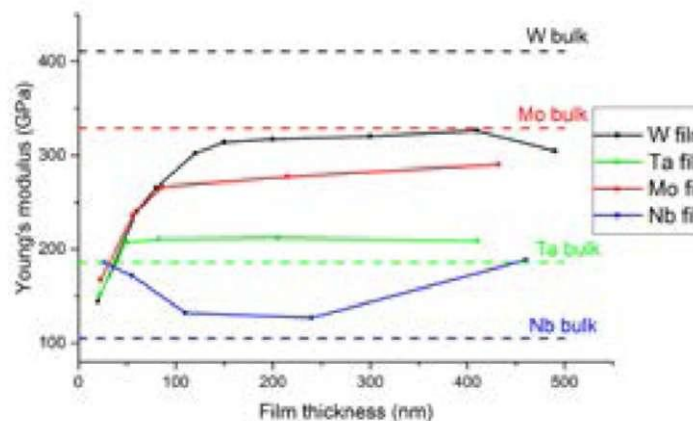
T. A. Yakupov<sup>1,2</sup>, Z. N. Utegulov<sup>1\*</sup>, T. Demirkan<sup>3</sup>, T. Karabacak<sup>2</sup>

1) School of Science and Technology, Nazarbayev University, Astana, Kazakhstan; \*[zhutegulov@nu.edu.kz](mailto:zhutegulov@nu.edu.kz); 2) Nazarbayev University Research and Innovation System, Astana, Kazakhstan; 3) University of Arkansas at Little Rock, Little Rock, AR, USA

**Introduction.** To fabricate optimal hard and wear-resistant coatings it is necessary to tailor their mechanical and structural properties for an optimal industrial application. We are exploring elastic and structural properties of refractory metal (Ta, Nb, Mo and W) thin films of different thicknesses fabricated by DC magnetron sputtering technique on single crystalline Si substrates.

**Fabrication.** We have fabricated refractory hard Ta, Nb, Mo and W thin films on Si (100) substrates with film thicknesses ranging from 20 to 500 nm using DC magnetron sputtering technique. Ar<sup>+</sup> gas was used for generating plasma and its working pressure was set at  $4 \times 10^{-3}$  mbar.

**Characterization.** Quartz crystal microbalance [1] attachment, placed next to the substrates, was used at every deposition to determine the film densities. Film thicknesses were determined by cross-sectional SEM. Young's moduli of these "slow" refractory films on "fast" Si substrate were obtained by measuring ultrasonic phase velocity of nanosecond laser pulse-induced surface acoustic waves as a function of wave frequency (phonon dispersion), and by taking into account measured film thicknesses and densities, as well as substrate density [2]. The films microstructure and orientation were deduced from 0-20 scan X-ray diffraction analysis.



**Results and discussion.** Measured Young's moduli presented in figure 1 show that for W, Ta and Mo films Young's moduli increase and approach their bulk values with the growth of films thicknesses. The thinnest and the thickest Nb films have Young's modulus values higher than the bulk values. For the thinnest Nb films this is probably due to the substrate effect on the measurements since Nb bulk Young's modulus is lower than that of Si substrate (165.3 GPa). With the increase of Nb film thickness effect reduces. But for the thickest Nb film, its effect probably appears again due to buckling/delamination or cracking within the film, which can be caused by high intrinsic stress generation as the film thickness grows.

**Conclusions.** For different refractory metals the results obtained on measured densities are in agreement with their elemental masses, but differ for film and bulk Young moduli of Ta and Mo. Optimum thickness and roughness of refractory sputtered films can be reached based on the highest values of Young's modulus.

### References.

1. C. Lu, O. Lewis, J Appl Phys, 43 (1972) 4385-4390.
2. D. Schneider, P. Siemroth, T. Schulke, J. Berthold, B. Schultrich, H. Schneider, R. Ohr, B. Petereit, H. Hillgers, Surface and Coatings Technology, 153 (2002) 252-260