Effect of substrate bias voltage on structure and mechanical properties of vacuum arc deposited W coatings

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Tungsten (W) and W-based alloyed thin films possess many attractive properties, such as high melting temperature, high mechanical strength and good metal barrier performance [1]. Ion sputtering methods (magnetron, triode, etc.) are most often used for the deposition of tungsten coatings [2]. Vacuum arc deposited coatings usually have better adhesion due to the high degree of plasma ionization. However, the influence of the vacuum arc deposition process parameters for W-coatings has not been studied.

The aim of these investigations was to determine the effect of the bias potential on the structure and mechanical properties of tungsten coatings, which were deposited from the plasma of a vacuum arc.

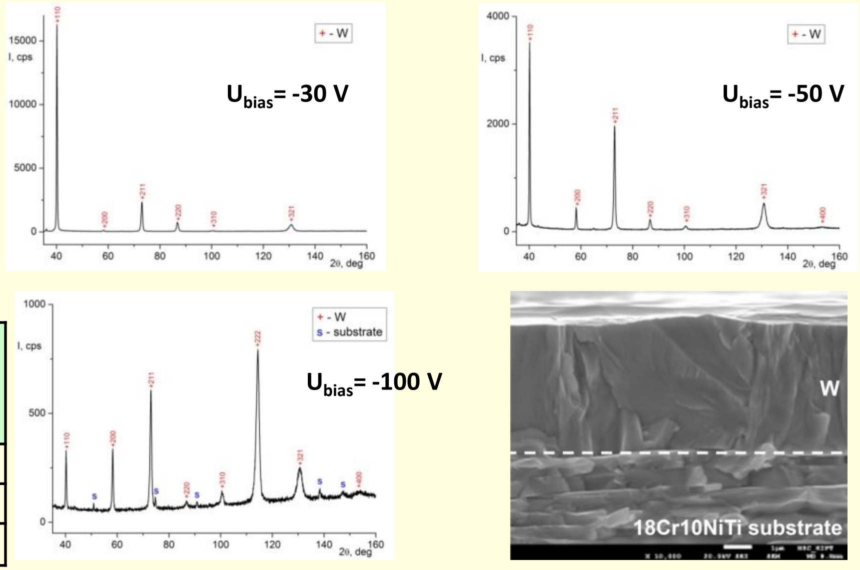
Coatings were deposited on the stainless steel Cr18Ni10Ti substrates (10×20×1.5 mm) without rotation at arc discharge current ~ 130 A, argon pressure of 1.5 Pa, negative substrate bias voltage ranging from -30 to -100 V and time of deposition - 60 min.

The coating thickness was ~ 5 μm. Diffractometric studies were carried out on a DRON-4-07 X-ray diffractometer in copper Cu-Kα radiation using a selectively absorbing nickel filter. The reflected rays were recorded with a scintillation detector.

The mechanical properties were measured by Nanoindenter G200 with Berkovich type indenter.

Table 1. Structural and substructural parameters of tungsten coatings

Substrate bias voltage, V	Lattice period a, Å	Macro stresses σ_{ϕ}, GPa	Crystallite size L, nm	Microstrain ε, × 10^{-3}
- 30	3,1730	-1,63	46,9	2,55
- 50	3,1731	-1,33	44,1	2,67
- 100	3,1746	-2,38	38,3	3,06



XRD patterns and SEM cross-section image of W film

According to X-ray diffraction analysis, an increase in the bias potential from -30 to -100 V leads to a change in the preferred orientation in W coatings (110)→(211)→(222), a decrease of crystallite size from 47 to 38 nm and an increase in microstrain from $2{,}55\cdot10^{-3}$ to $3{,}06\cdot10^{-3}$.

At the same time, regardless of the bias potential, the nanohardness and Young's modulus of W coatings are at the level of 9±1 and 400±10 GPa, respectively.

Coatings have a dense structure without delamination according to scanning electron microscopy. The obtained results indicate that the vacuum-arc method allows the deposition of nanostructured W-coatings with high mechanical properties.

References:

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2. *E. Vassallo, R. Caniello, M. Canetti, D. Dellasega, M. Passoni.* Microstructural characterisation of tungsten coatings deposited using plasma sputtering on Si substrates // Thin Solid Films.-2014.-**558**, -P. 189–193.