W FILMS BY DC MAGNETRON SPUTTERING

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Tungsten was designed as an armour material for the first wall of magnetic confinement thermonuclear fusion devices. Therefore it is necessary to identify an industrial scalable manufacturing method for W coatings with a thickness in the μm range on carbon based substrates. As reported in literature [1], direct deposition of W on Carbon Fibre Composite (CFC) was troublesome because of the poor adhesion: an intermediate molybdenum layer can solve the problem. The beneficial role of Mo seems to be in connection with the adjustment of the thermal expansion mismatch between CFC and W.
We are performing an investigation on the properties of Mo, W and Mo/W coatings deposited by DC magnetron sputtering.
The Mo films have been deposited on different substrates (titanium and silicon) and they have been analyzed using scanning electron microscopy and X-ray diffraction to verify their morphologies and grain structures.
The W coatings have been grown on glass, graphite, Si, Si/Mo, Ti and Ti/Mo changing progressively the sputtering parameters to optimize the process. The thermodynamically stable form of metallic tungsten is body-centered-cubic (α-W) but sputter-deposited tungsten thin films with an A15 metastable structure (β-W) have been commonly observed [2]. The tungsten coating final phase depends on substrate bias and temperature, deposition pressure, residual gas species (as an example O_2 and N_2 absorbed in the films promote the formation of β-W). The goal of this work is to find a correlation between W properties and a variety of deposition parameters. The XRD spectra show the α-W equilibrium phase dominates when a dc bias voltage is applied to the substrate. Moreover a series of SEM micrographs reveals that employing a DC bias it is possible to improve the surface morphology and compactness of the film. Hardness measurements were performed by the nano-indentation technique. The base pressure was reduced as much as possible (< level of impurities), the deposition temperature was increased or a post-annealing of the coatings was introduced. The substrate movement effect and the target-substrate distance role have been studied. The possible use of different materials is under investigation too: Mo/Re multilayer structures and a Mo-Re solid solution can improve the hardness and reduce the carbon diffusion from the substrate. Different sputtering gases (like Kr or Xe) have been employed to verify the film residual stress reduction.

References:

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