Biaxial strain and texturing of TiCN thin films grown by ion beam assisted deposition

G.G. Fuentes[1], C. Quiros[2], P. Prieto[1], and J.M. Sanz[1]
[1] *Departamento de Fisica Aplicada. Universidad Autonoma de Madrid. Campus Universitario de Cantoblanco. E-28049 Madrid. (Spain)*
[2] *ESRF, BP 220, F-38043 Grenoble Cedex, France*
(February 18, 2003)

Titanium carbon nitride TiCN is a material of great interest due to its good physical properties such as wearing resistance, high hardness and melting point, and high thermal and electrical conductivity. In this study we have grown TiC_xN_y thin films in a dual ion beam sputtering system using a high purity TiC target, whereas the growing film is bombarded simultaneously with N_2^+ and Ar^+ ions from an independent ion source. The independence of both ion sources allows establishing a direct relationship between the deposition parameters and the physical properties of the films, such as the stoichiometry, hardness, structure and surface topography.

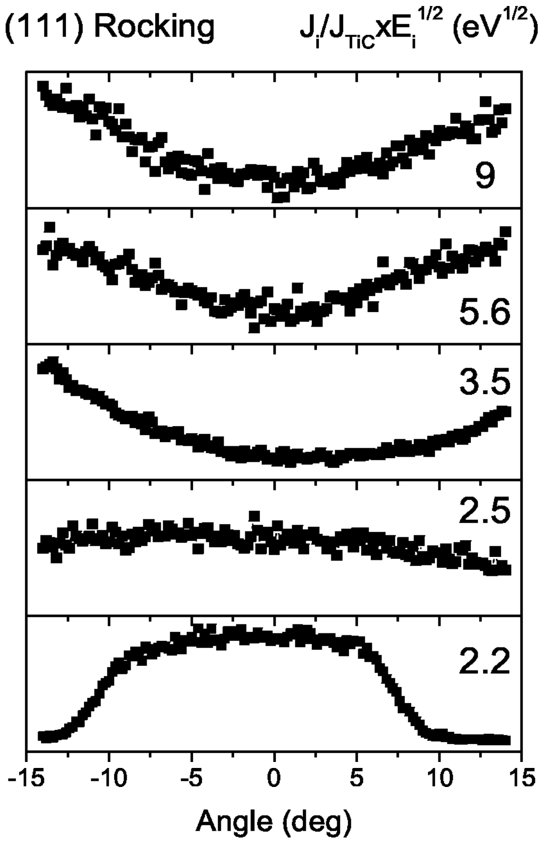

FIG. 1. Rocking scans around the diffraction plane (111) as a function of the growth parameter $J_i/J_{TiC}xE_i^{1/2}$.

The stoichiometry, structure and morphology of the films have been characterised as a function of the reduced energy density per arriving TiC moleculel ($J_i/J_{TiC}xE_i^{1/2}$). J_i is the current density of assisting ions, E_i is the energy of the assisting beam, and J_{TiC} is the current density of TiC deposited on the growing film.

We have focused our study on the structural properties of the coatings by analysing texture effects and biaxial stress as a function of $J_i/J_{TiC}xE_i^{1/2}$. In order to record information on texture of the principal diffraction planes, we have performed rocking curves of the planes (111) and (002) along an angular section of ±15 around the incidence plane. On the other hand, biaxial stresses of the films were measured using the well-known $\sin^2\psi$ method; in which θ-2θ scans around a given diffraction lines are recorded for different tilting angles ψ. In our case, we have selected the diffraction line (022).

The measurements have been performed in the experimental Hutch 1 of ID03 of the synchrotron radiation source ESRF, using a photon energy of 17.09 keV. A representative example of the evolution of the diffraction intensity of the plane (111) as a function of the rocking angle is shown in Figure 1 as a function of $J_i/J_{TiC}xE_i^{1/2}$. These curves show how this plane is preferentially oriented parallel to the plane of the film when $J_i/J_{TiC}xE_i^{1/2}$ is lower than 3 $eV^{1/2}$, whereas in the case $J_i/J_{TiC}xE_i^{1/2}>3$ $eV^{1/2}$, it grows preferentially out of the plane of the film.

The corresponding rocking curves of the plane (002) (not shown) seem to exhibit the opposite behaviour, although the transition between in-plane growth and out of plane growth is not as well defined as in the case of the plane (111). The results derived from the Δd/d versus $\sin^2\psi$ are represented in Figure 2 for $J_i/J_{TiC}xE_i^{1/2}$ = 3.5, 5.6, and 9 $eV^{1/2}$. Unfortunately, we could not extract reliable data from samples with low $J_i/J_{TiC}xE_i^{1/2}$ due to the low intensity of the plane (022). The biaxial strain is in all cases compressive as can be observed upon the positive slopes of the curves, and it is observed to decrease as $J_i/J_{TiC}xE_i^{1/2}$ increases. This compressive character of the biaxial strain indicates that the coating's texture is dense, and presumably do not develop columnar structures. The evolution of the strain upon the assistance suggest, on the other hand, that the films texture becomes denser when $J_i/J_{TiC}xE_i^{1/2}>3$ $eV^{1/2}$ decreases. This result is compatible with the behaviour of the preferential growth direction of the plane (111), since this plane grows preferentially parallel to the substrate under compressive stress.

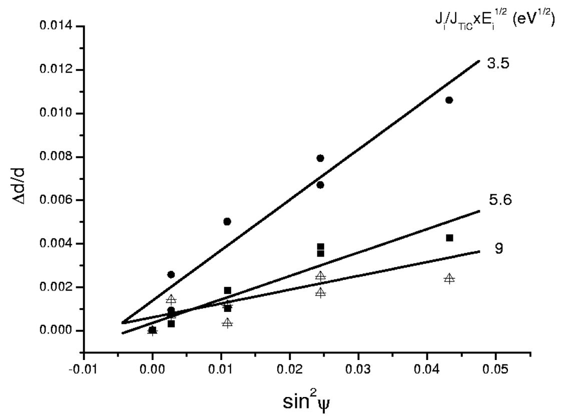

FIG. 2. Plot of Δd/d $\propto \sin^2\psi$ for three different values of $J_i/J_{TiC}xE_i{}^{1/2}$. The solid lines represent the result of a linear fitting.

We acknowledge the technical support of the beam line ID03 staff, and the funding from the ESRF under the project numbrer SI-733.