TAILORED SYNTHESIS OF NANOSTRUCTURED COATINGS WITH INTERESTING MECHANICAL AND TRIBOLOGICAL PROPERTIES.

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The design of nanocomposite coating materials, consisting of at least two phases (one or two that are nanocrystalline and one amorphous phase), is attracting an increasing interest due to the new possibilities of synthesis of applicable materials with superior physical, chemical and engineering properties [1]. The increasing demands on the mechanical performance of the hard coatings need new thin film materials with improved wear resistance in combination with low friction and high toughness. The knowledge of the structure of these nanocomposite coatings has been always considered of great importance not only for understanding the micromechanical mechanism behind their behaviour but also for the design of strategies to synthesize materials with controlled properties. In this work the results concerning the synthesis and characterization of three valuable systems (TiC/a-C; Ti-B-(N); Cr(Al)N) for practical applications are presented. Different coatings have been deposited by dc magnetron sputtering and characterized deeply in terms of structure, chemical bonding, composition and mechanical properties using a wide battery of experimental techniques. Interesting correlations between the conditions of synthesis and the structure and the mechanical behaviour of the coatings have been found.

In the case of TiC/a-C system, changes in coatings microstructure from quasipolycrystalline TiC to a nanocomposite formed by nanocrystals of TiC embedded in an amorphous matrix of carbon (nc-TiC/a-C) are observed depending on the synthesis conditions (Fig.1). The TiC content inside the nanocomposite has been monitored by chemical analysis and a percentage between 15% and 30% of TiC has been found as an optimum value to get the requirements of low friction an wear rates while TiC content above 45% are needed to increase the hardness of the coating [2]. A complete mapping of the mechanical and tribological properties of the nc-TiC/a-C system has been obtained for the synthesis conditions employed.

Regarding the Ti-B-(N) system, two different behaviours have been observed respect to the hardness of the coatings depending on whether or not nitrogen is used in the gas flow during the synthesis [3]. For samples prepared in the absence of N_2, polycrystalline TiB_2 coatings with grain size in the 6-20 nm range was obtained showing an improvement of hardness with increasing the crystallite size, typical of an Anti-Hall-Petch effect (Fig.2a). The use of N_2 during the synthesis yields to the softening of the coatings as nitrogen is incorporated in the form of an amorphous BN which acts as a matrix embedding small crystals (<5nm) of TiB_2. The progressively enrichment in BN at expense of the loss of TiB_2 phase as the percentage of N_2 is increased could account for the diminution of hardness observed (Fig.2b).

For Cr(Al)N system, the incorporation of Al in the composition of the films produces an increase in the mechanical properties (hardness and reduced Young´s modulus). The hardness behaviour can be attributed mainly to a reduction of the CrN crystallite size according to a Hall-Petch relationship. It is worth to mention the increased thermal resistance against oxidation observed in these coatings in comparison to the pure CrN composition. This improvement in thermal stability in air is explained by the formation of a nanocomposite structure of small CrN crystals embedded in an amorphous aluminium oxide or oxinitride matrix that prevents the CrN phase from crystal growth and further oxidation [4].

References:
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Figures:

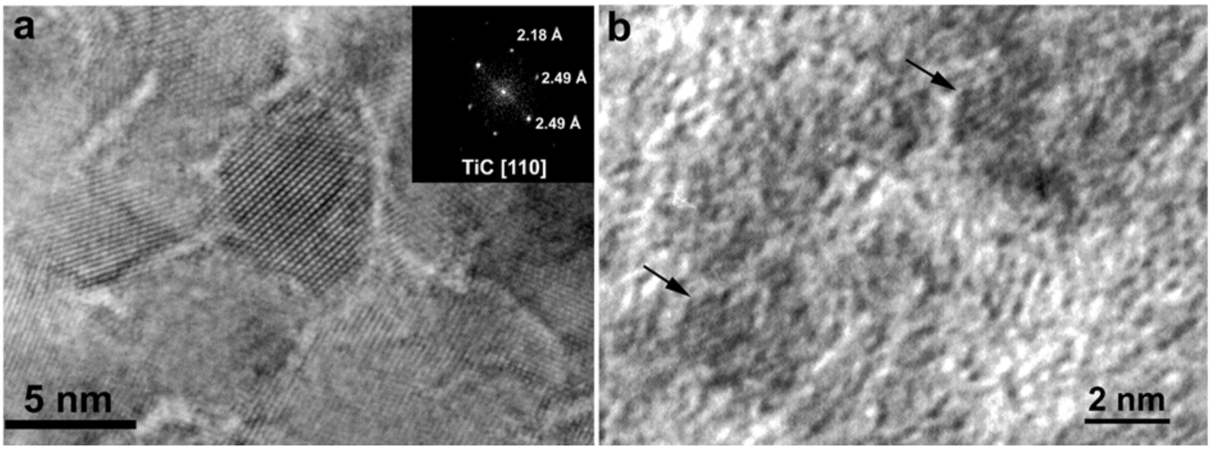

Figure 1. High Resolution Transmission Electron Microscopy (HRTEM) images of a quasipolycrystalline TiC (a) and nc-TiC/a-C (b) coatings. The digital diffraction pattern (DDP) obtained in the centered crystal is presented as inset in a). Two small crystallites of TiC are arrowed in b).

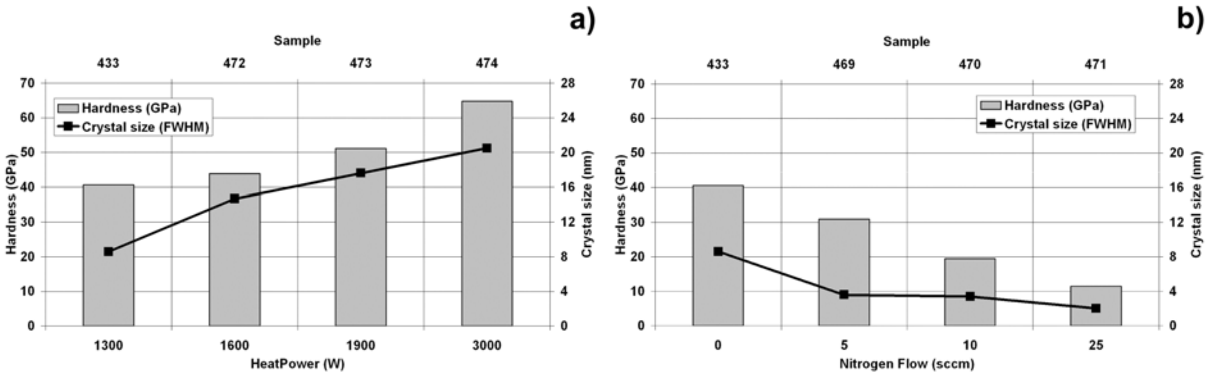

Figure 2. Graphical representation of hardness and TiB_2 crystallite size for Ti-B-(N) coatings prepared by using different heating power (a) and increasing nitrogen content in the gas flow (b).

Acknowledgements: Financial support from the Spanish MCYT (project nº MAT2001-1399/C02-01 and /C02-02), as well as from I3P program (CSIC) is acknowledged. We are especially grateful to Mrs. I. Rosa for technical support.