CHAPTER 1

MAGNETRON SPUTTERED HARD AND YET TOUGH NANOCOMPOSITE COATINGS WITH CASE STUDIES: NANOCRYSTALLINE TiN EMBEDDED IN AMORPHOUS SiN_x

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1. Introduction

Nanocomposite thin films comprise at least two phases, a nanocrystalline phase and a matrix phase, where the matrix can be either nanocrystalline or amorphous phase. The general characteristics of nanocomposite coating are a host material with another material homogenously embedded in it, with one (or both) of these materials having a characteristic length scale of 1–100 nm as schematically illustrated in Fig. 1.1.

An example is given in Fig. 1.2 where 10∼20 nm (TiCr) C_xN_y crystals were embedded into a diamond-like carbon (DLC) matrix to reach a hardness of 40 GPa [1].

Nanocomposite thin films represent a new class of materials which exhibit special mechanical [2–4], electronic [5, 6] magnetic [7] and optical properties due to their size-dependent phenomena [8–10]. Recently it attracted increasing interest due to the endless possibilities of the synthesizing materials of unique properties. By convention, hard materials usually refer to materials with Vickers hardness less than 40 GPa, and superhard materials with Vickers hardness exceeding 40 GPa. Hard and superhard two- and multiphase thin films exhibit high hardness significantly exceeding that given by the rule of mixture, i.e.

$$H(A_aB_b) = \frac{aH(A) + bH(B)}{a+b}, \qquad (1.1)$$

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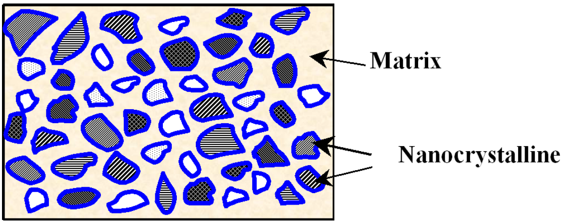

Fig. 1.1. Schematic diagram of nanocomposite coating microstructure, showing nanocrystalline phase embedded in matrix.

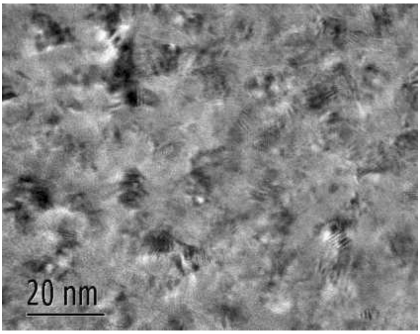

Fig. 1.2. Transmission electron microscopy (TEM) photo of TiCrCN nanocomposite film showing nanosize TiCrCN crystals embedded into the amorphous DLC matrix [1].

where $H(A)$ is the hardness of pure A, $H(B)$ the hardness of pure B. a is the composition of A in the mixture and b is the composition of B in the mixture. $H(A_aB_b)$ is the hardness of the mixture.

The use of coated materials in engines, machines, tools and other wear-resistant components is steadily increasing and has achieved a high level of commercial success, compared to the common non-coated materials such as steel [11]. Wear-resistant, superhard thin films for high speed dry machining would allow the industry to increase the productivity of expensive automated machines and to save on the high costs presently needed for environmentally hazardous coolants. Depending on the kind of machining, the recycling costs of these coolants amount to 10–40% of the total machining costs. For example, in Germany alone, these costs can be close to one billion US dollars per year [11, 12].