FROM NANO TO MICROCRYSTALLINE HFCVD DIAMOND COATINGS ON CUTTING TOOLS

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CVD diamond coated materials possess outstanding tribological properties due to the diamond extreme hardness, high thermal conductivity and low friction coefficient against a wide range of materials. Hence, CVD diamond coatings are used for cutting tools in machining of abrasive and hard materials, such as MMC's, CFRC's and aluminum-silicon alloys. However, the surface roughness of conventional microcrystalline CVD diamond is a major problem when considering such purposes. Concerning other tribological applications, like mechanical seals, the large grain size of microcrystalline CVD diamond induces extremely long running-in polishing times before the full sealing condition is reached [1]. To overcome this drawback a solution is the development of diamond crystals with submicrometric or even nanometric size. One of the main advantages of these coatings is the almost constant crystallite size of the diamond through the entire film cross-section, contrarily to columnar growth observed in microcrystalline CVD diamond [2]. These diamond grades can be produced in a hot filament or microwave plasma CVD reactor from a variety of feed gas mixtures such as fullerenes/Ar, CH_4/Ar, CH_4/N_2, or just using higher ratios of CH_4/H_2 [2-6]. This way, the columnar structure that forms during the microcrystalline diamond growth, which is responsible for a high roughness of the free surface, is avoided.

Machining of hardmetal parts by chip removal is a challenge for a cutting tool but microcrystalline CVD diamond has already proved its adequacy [7,8]. However, there are no published works concerning the use of smoother CVD diamond in this application, although it has been reported for machining of Al–Si alloys and GFRP [9].

In the present work, diamond grain sizes from nano to micrometric grain sizes grades were produced in a hot filament reactor by adjusting deposition parameters, namely Ar/H_2 and CH_4/H_2 gas ratios, and substrate temperature. Also, conventional micrometric diamond coatings (5–12 µm) were grown for comparative purposes. Figure 1 presents AFM scans of the different diamond films.

The normalized coated inserts were tested for dry turning of tungsten carbide (WC–25 wt.% Co) hardmetal. All the CVD diamond grades endured the hardmetal turning showing slight cratering, having the flank wear as the main wear mode. Their turning performance was distinct, as a consequence of morphology and surface roughness characteristics. Among all the tested tools, the more even surface and the submicrometric grade presented the best behaviour regarding cutting forces, tool wear and workpiece surface finishing. For this coating, the depth-of-cut force attained the lowest value, 150 N, the best combination of wear types (KM=30 µm, KT=2 µm and VB=110 µm) and workpiece surface finishing (Ra=0.2 µm).

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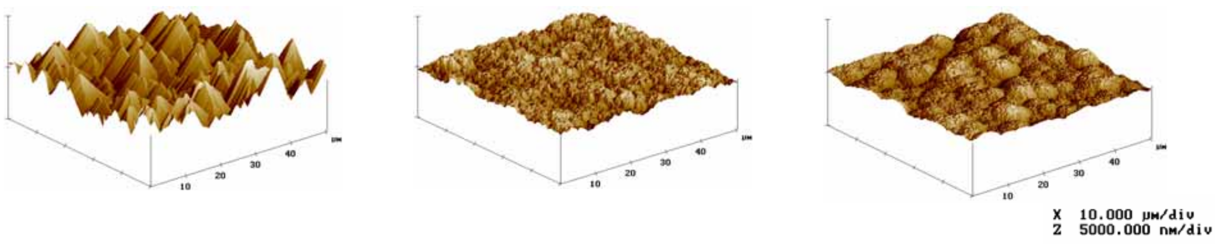
Figures:



(a) (b) (c)

Figure 1. 3D AFM scans of diamond film morphology of the: a) micro-; b) submicro- and c) nanometric diamond grain sized grades.