DEVELOPMENT OF CVD MICRO / NANOCRYSTALLINE DIAMOND TOOLS FOR ALUMINUM ALLOY MILLING

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1. Introduction

The need for better performance carbide tooling at a reasonable value in a short time, coupled with industrial competition boosted technological advances in the field of precision machining. The use of high-speed machining led to the search for new and advanced materials with improved wear characteristics [1].
The increase in cutting speed implies an increase in the removal rate, reducing the cost of material removed, but also implies an increase in the use of coolant and reduction of the life of the tool, raising labor costs. The replacement of the necessary tools and care with refrigerant maintenance is sometimes greater than the value of the tool [2,3].
CVD diamond-coated tungsten carbide cutting tools obtained by the HFCVD technique would be an excellent choice for machining, with an interesting cost-benefit ratio [4, 5, 6, 7]. However, the machining performance of diamond-coated tools is not robust due to the non-optimized adhesion between the carbide tool and the deposited diamond film [2].
Aiming to study the performance of 7075 aluminum alloy machining with WC-Co cutting tools with deposition of CVD diamond films, we set out to study and obtain such coated substrates.

2. Theory

The cobalt is a transition metal and during deposition of CVD diamond negatively influences the adhesion of the film [8]. One of the reasons is the catalytic effect that the cobalt exhibits during the initial phases of deposition promoting the nucleation and growth of the graphite phase with greater density of sp2 hybridizations.
Different authors have studied substrate surface preparation processes to improve the nucleation and growth of the diamond film. Surface preparation plays a key role in nucleation control and is important in obtaining high quality, high tack diamond films. The increase in nucleation density may improve the homogeneity of the films, increasing the adhesion between film and substrate [9].
Due to the deposition process of CVD diamond films on WC-Co substrates being dependent on critical factors preceding deposition, the experiments will be conducted in steps to ensure optimal growth parameters and conditions.
The surface preparation will be carried out by polishing with silicon carbide sandpaper in the granulations from 220 to 1200, and for finishing the cloth with diamond solution (6 - 0.25 μm) as an abrasive. The composition and surface evaluation studies will be through FEG-MEV, AFM, XRD and EDX. An evaluation of chemical methods of surface modification by selective removal of Cobalt using a two step chemical treatment of the first step in Murakami solution (K3 [Fe (CN) 6] + KOH + H2O), and in the second step using royal water (HNO 3 / HCl = 1: 3) [10].
The substrates are submerged in a polymer solution of cationic character, PDDA (Poly (DiallylDimethylAmmonium chloride)) for 30 minutes to ensure efficient functionalization and then immersed in the anionic solution nano diamond particles on PSS (Poly Sodium Styrenesulfonate) to occur on the surface, and were washed in D.I water after each step, so that the excess of polymer and particles were removed.
The study of CVD diamond nucleation on WC-Co substrates will be conducted by exposing the ready-made substrates to the growth conditions for short periods of time. The evaluation by FEG-MEV will aim to identify the growth morphology obtained and the correlation between nucleation density and growth parameters.
The depositions are performed in hot filament reactor (HFCVD) varying the following parameters: the diluted concentration of methane in hydrogen ([CH4]), the system pressure (P), the temperature of the tungsten filament and the temperature of (NCD), ultra-nano-crystalline (UNCD), mono-layer and multi-layer diamond films were used to obtain microcrystalline diamond (MCD) films. The results used for the tools will be with growth of two hours in atmosphere of 2% of CH4 in Hydrogen in the pressure of 50 torr at 850ºC.

3. Results and Discussions

Using the grown films will be carried out machining tests of the aluminum 7075 in various conditions, aiming to improve the cost benefit of these tools of important use in various branches of industry.

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4. References

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