

A mathematical analysis carried out on the study of compatibility, de-lamination and load-bearing capacity of synthetic diamond coatings deposited on tungsten carbide composites

N. A. Sheikh*, M. Mursaleen Butt and Kaleem Ahmad Najar

Mechanical Engineering Department, National Institute of Technology Srinagar-190006, India.

E-mail: nazirahmads@yahoo.com

Abstract: Experiments were conducted here for the fabrication of thin films of nanocrystalline diamond (NCD) and microcrystalline diamond (MCD) on tungsten carbide composite (WC–6%Co) materials using hot filament chemical vapor deposition (HFCVD) method, under pre-determined process parameters. The crystalline quality, microstructure, compositional analysis and grain size of these synthetic diamond coatings were compared using X-ray diffraction (XRD), Raman spectroscopy and Scanning electron microscopy (SEM) techniques. The general parameters affecting the integrity of NCD and MCD coatings on WC–6%Co substrates were studied and mathematical analysis was carried out for calculating the force of de-lamination and load-bearing capacity of these coatings. Thus, a comparison has been documented between two fundamental types of synthetic diamond coatings for the purpose of specifying their significance during Machining and Tribological applications.

Calculation of Load-bearing Capacity for WC–Co/NCD System:

$$F \text{ (Newton/cm)} = Z_{\text{NCD}} \text{ (mm)} \times E_s \left(\frac{\text{Newton}}{\text{cm}^2} \right) \times t \text{ (\mu m)} \times A \text{ (\mu m)} \times [10^{-9}]$$

$$= 0.75 \text{ (mm)} \times \{550 \times 10^5 \left(\frac{\text{Newton}}{\text{cm}^2} \right)\} \times 3 \text{ (\mu m)} \times \{16 \times 0.35 \text{ (\mu m)}\} \times [10^{-9}] = 6930 \times 10^{-4} = 0.6930.$$

Calculation of Load-bearing Capacity for WC–Co/MCD System:

$$\text{Similarly, } F \text{ (Newton/cm)} = Z_{\text{MCD}} \text{ (mm)} \times E_s \left(\frac{\text{Newton}}{\text{cm}^2} \right) \times t \text{ (\mu m)} \times A \text{ (\mu m)} \times [10^{-9}]$$

$$= 1.57 \text{ (mm)} \times \{550 \times 10^5 \left(\frac{\text{Newton}}{\text{cm}^2} \right)\} \times 3 \text{ (\mu m)} \times \{16 \times 0.57 \text{ (\mu m)}\} \times [10^{-9}] = 23625 \times 10^{-4} = 2.3625.$$

Hence, based on the above calculations, the load-bearing capacity of MCD coating is more than NCD coating on WC-Co substrate, due to its high hardness and more grain size

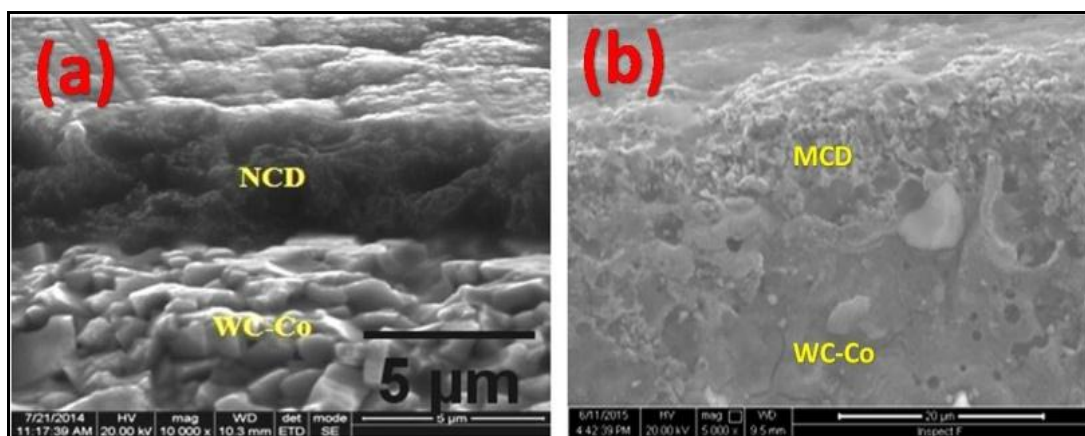


Figure 1: Overall cross-sectional SEM images of (a) WC-Co/NCD and (b) WC-Co/MCD.

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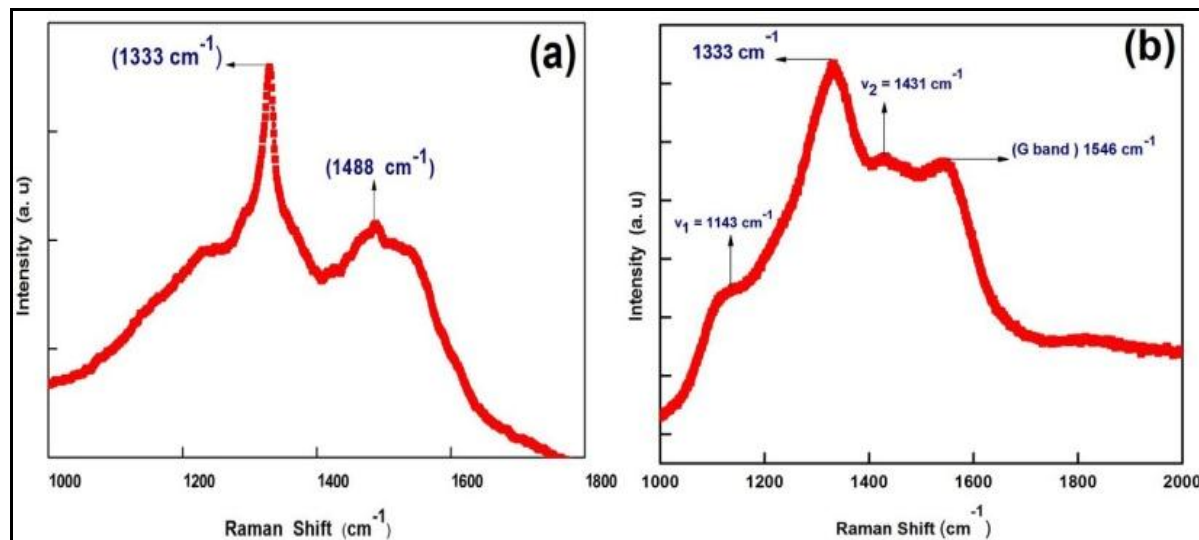


Figure 2: Raman Spectra of (a) MCD coating and (b) NCD coating.

Biography: N. A. Sheikh has completed his PhD in mechanical engineering from IITKanpur, India and was working on “Smart Materials and Smart Structures”. His research work is based on Health Monitoring of Smart Cantilever Beam and is now presently working as Professor in Mechanical Engineering Department at NIT Srinagar. N. A. Sheikh has 20 international publications in reputed journals and his work is based on physical, mechanical and Tribological properties of composite materials and coatings.