USE OF RAMAN SPECTROSCOPY TO STUDY FATIGUE TYPE PROCESSES IN POLYCRYSTALLINE DIAMOND (PCD)

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Abstract

Polycrystalline diamond (PCD) cylindrical cutters used in oil well drilling are susceptible to fracture due to the hostile environment of randomly occurring high impact loads. The fact that the cutters fail after repeated use gives rise to the possibility of fatigue type processes in diamond. Crack initiation in polycrystalline brittle material like diamond can emanate from nucleation sites at stress concentrations at boundaries caused by various flaws, such as small cavities or precipitates often introduced by sintering techniques. The study of stress fields and their relative geometries thus becomes crucial in the quest to have extended lives for these cutters. Since the diamond Raman line reveals both the nature and magnitude of the stress present in the material, this technique can be employed as a non destructive testing tool to investigate these stress fields. The 514.5 nm line of an Ar$^+$ ion laser was used as an excitation source with an 1800 grooves/mm grating in the single spectrograph mode of a Jobin-Yvon T64000 Raman spectrometer. Room temperature measurements show a general compressive stress field on the PCD before being fatigued which gradually deteriorates to a residual tensile stress field after the samples had been subjected to some fatiguing test. Whereas a general compressive stress is desirable in the PCD layer as it inhibits the propagation of cracks, on the contrary tensile stresses facilitate formation of cracks leading to catastrophic failure of the cutters.

Keywords: Polycrystalline diamond, fatigue, Raman spectrometer