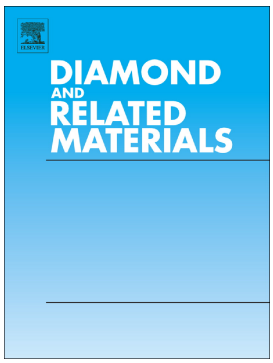

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Essential Causes for Tool Wear of Single Crystal Diamond in Ultra-precision Cutting of Ferrous Metals

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Abstract

This paper presents indepth theoretical analyses and experimental verifications involving the essential causes for diamond tool wear from aspects of crystal graphitization, carbon diffusion and oxidation reaction. The catalytic effect of transition metal iron on the structure transformation of diamond crystal to graphite was investigated using the molecular dynamics simulation technique. Mathematic prediction model of carbon atoms diffusing from the diamond tool surface into the iron lattice was established. Moreover, types and conditions of the complicated chemical reactions at the cutting interface were analyzed by chemical thermodynamic calculation method. Raman scattering analysis was performed to distinguish the structural change of diamond crystal, Energy dispersive X-ray analysis was used to detect the change in chemical compositions of the work material, and X-ray photoelectron spectroscopy was adopted to confirm the resultants of interfacial thermochemical reaction. The results indicated the essential causes for diamond tool wear could be summarized as initial rapid reduction of cutting edge strength caused by a series of tribochemistry transformations at localized high temperature and high pressure, and then was attributed to the cumulative mechanical wear of diamond metamorphic surface. This research work provides an important theoretical basis for exploring appropriate wear inhibition processes for diamond tool.

Key words

Diamond; Tool wear; Ferrous metals; Graphitization; Diffusion; Oxidation