Characterization and Optimization of a Locally Boron-Doped Diamond Tool for Self-Sensing of Cutting Temperature

Liu Shiquan, An Liang, Li Hui, Fu Xiang and Chen Yuan-Liu#
The State Key Lab of Fluid Power and Mechatronic Systems, Zhejiang University, 310027, Hangzhou, China
Corresponding Author / Email: yuanliuchen@zju.edu.cn, TEL: +86-571- 87952294

KEYWORDS: Cutting temperature monitoring, Self-sensing diamond tool, Ultra-precision machining

The high-sensitivity and accurate monitoring of micro-zone cutting temperature is crucial for the characterization and optimization of the machining states in ultra-precision cutting process. Using the cutting tools itself as cutting temperature sensors is an innovative method for in-process measurement of cutting temperature. In this work, optimized synthesis process and structure design for locally boron-doped diamond tools functional of temperature-sensing were proposed. The annealing treatment under high pressure conditions were conducted to promote the diffusion and ionization of boron multimers in the boron-doped diamond zone, thereby enhancing the crystal quality and semiconductor electrical properties of the locally boron-doped diamond. Various locally boron-doped diamonds with thin-layer temperature-sensing structure of different doping concentrations and thicknesses were synthesized. Through comparative analysis of temperature measurement capabilities and semiconductor properties, the optimal components and structures were identified as the temperature-sensing cutting tool. The selected tool was employed for in-process cutting temperature measurement in single-point diamond orthogonal turning of copper at different cutting parameters. Results indicate that the capability of the locally boron-doped diamond tool both to in-process accurately monitor cutting temperature during steady cutting process, and to identify the micro morphological features of machined surfaces based on the cutting temperature characteristics. These insights are pivotal for controlling cutting temperature and refining the ultra-precision cutting process.