Experimental study of 4H-SiC electromagnetic fiel d-assisted ultra-precision grinding

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Single-crystal silicon carbide (SiC) is a third-generation semiconductor material utilized in high-performance power electronics. However, due to its inherent hardness and brittleness, cutting it presents a significant challenge. Ultra-precision grinding (UPG) is a machining technology that enables the production of surfaces with nanometer-scale roughness and submicron shape accuracy in difficult-to-cut materials, obviating the need for subsequent machining. However, when machining SiC using UPG, several machining and material-intrinsic factors, including grinding temperature, grinding wheel vibration, tool wear, tool shank material, material removal rate, material expansion, and rebound, have the potential to significantly impact the machining of SiC surfaces. To achieve superior surface integrity for SiC, this paper puts forth a novel machining approach that incorporates a electromagnetic field within the UPG process. The impact of the magnetic field on a range of machining and intrinsic material factors during grinding of 4H-SiC was investigated through an experimental approach based on magneto-plasticity and electromagnetic induction theories. Additionally, the material removal mechanism of magneto-plasticity in 4H-SiC and the application of magneto-plasticity in 4H-SiC machining are investigated using scratch experiments, which demonstrate the positive potential of magnetic field-enhanced plasticity (i.e., magneto-plasticity) in improving plastic-brittle transition and machinability.