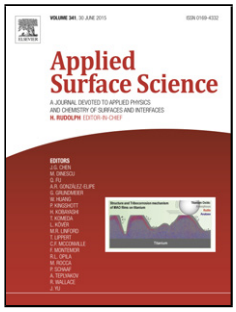

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Molecular Dynamics Simulation of Subnanometric Tool-Workpiece Contact on a Force Sensor-Integrated Fast Tool Servo for Ultra-Precision Microcutting

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Abstract

This paper investigates the contact characteristics between a copper workpiece and a diamond tool in a force sensor-integrated fast tool servo (FS-FTS) for single point diamond microcutting and in-process measurement of ultra-precision surface forms of the workpiece. Molecular dynamics (MD) simulations are carried out to identify the subnanometric elastic-plastic transition contact depth, at which the plastic deformation in the workpiece is initiated. This critical depth can be used to optimize the FS-FTS as well as the cutting/measurement process. It is clarified that the vibrations of the copper atoms in the MD model have a great influence on the subnanometric MD simulation results. A multi-relaxation time method is then proposed to reduce the influence of the atom vibrations based on the fact that the dominant vibration component has a certain period determined by the size of the MD model. It is also identified that for a subnanometric contact depth, the position of the tool tip for the contact force to be zero during the retracting operation of the tool does not correspond to the final depth of the permanent contact impression on the workpiece surface. The accuracy for identification of the transition contact depth is then improved by observing the residual defects on the workpiece surface after the tool retracting.

Keywords: molecular dynamics, microcutting, measurement, contact depth, elastic-plastic transition, fast tool servo, surface damage

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