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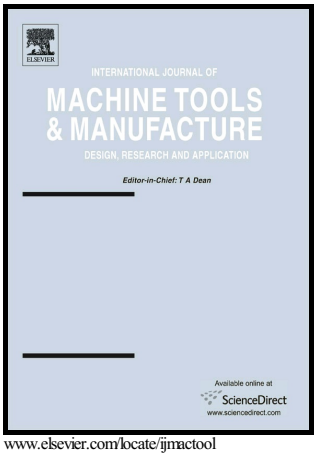

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Ductile machining of single-crystal silicon for microlens arrays by ultraprecision diamond turning using a slow tool servo

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Abstract

Microlens arrays of single-crystal silicon are required increasingly in advanced IR optics. In this study, we attempted to machine spherical concave microlens arrays on a single-crystal silicon wafer by slow tool servo diamond turning. The form error, surface topography, material phase transformation, and cutting force characteristics were investigated experimentally. It was found that brittle fracture occurred preferentially at one side (the exit side of tool feed) of the lens dimples when cutting direction is along <110> and tool feed rate is high. Amorphous silicon phase was generated significantly at one side (the exit side of tool feed) of the dimples as tool feed rate increased. The peak values and the direction angles of cutting forces changed with tool feed rate, crystal orientation, and the cutting direction. Two kinds of tool wear, namely, micro chippings and flank wear were observed in different regions of the tool edge where undeformed chip thickness is different. Spherical microlens arrays with a form error of ~300 nmPV and surface roughness of ~6 nmSa were successfully fabricated.

Keywords: Single-crystal silicon, Ultraprecision cutting, Diamond turning, Slow tool servo, Microlens array, Infrared optics