A cutting strategy with continuously varying stepover to suppress the diffraction effect of ultra-precision machined surfaces

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Diffraction effect has been troubling optical elements fabricated by ultra-precision machining for decades, which results in energy loss and imaging quality degradation. Such effect is assumed to result from the periodic micro textures similar to diffraction gratings which are generated during machining. To provide a possible solution, a continuously varying stepover cutting method is designed to disrupt the periodic tool marks during slow tool servo turning. Tiny harmonic vibration is integrated into the spiral cutting motion. The influence of amplitude and period of the vibration on the resultant surface texture is investigated both theoretically and experimentally. A theoretical model is established to predict the periodic micro textures fabricated by the proposed method. Machining experiments with various vibration magnitudes and periods are designed and conducted on a plane surface. Measurement results coincide well with theoretical surface textures. Power spectral density analysis is performed to compare the spatial frequency of fabricated surfaces. Diffraction effect is evaluated and some parameters are chosen for characterization. It is indicated by the results that vibration with relatively small amplitude is conducive to suppressing the diffraction effect of ultra-precision machined optical elements while maintaining surface finish.