Optimization of diamond machined gratings for low light scattering and highest diffraction efficiencies

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Abstract

Optical instruments for Earth observation often rely on high performance spectroscopy. One key element in this technology is the dispersing element. Typically used grating designs in Littrow or Offner spectrometers are blazed or binary phase gratings. The diffraction efficiency of these elements is decisive for the radiometric accuracy of the instrument.

One highly effective and accurate technology for the manufacturing of optical gratings is diamond machining. It offers the opportunity to manufacture gratings even with curved base geometries. However, this is achieved by using more controlled axes than used in the classic mechanical approach of grating manufacturing by ruling. The accuracy of the diamond machined grating depends strongly on the accuracy of the geometric features. These features are controlled and corrected within the limitations represented by the geometry of the diamond tool and the machining technology. The correction of the geometric features is realized mostly based on white light interferometric measurements. But, besides of the geometric features set by the manufacturing technology, light scattering also originates from many more imperfections. Especially diamond machining with at least three simultaneous moving or rotating axis is an excellent source for straylight.

This publication discusses different ultraprecise machining processes and analyses the fundamental effects of light scattering on the grating performance. Further, the paper demonstrates how it is possible by varying the disturbing variables as machine feed or machine speed or changing the base material to enhance the performance of diamond machined gratings. It shows how classic feature analysis with white light interferometry combined with stray light analysis is able to enhance the optical performance of the element significantly.