Reactive Ion Beam Figuring of Rapidly Solidified Aluminium (RSA) 501

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Abstract

Aluminium and aluminium alloys are widely used in the manufacture of optical elements for space telescopes, remote sensing and other applications. This is partly due to the excellent strength-to-weight ratio, but mainly due to the ease of manufacture and excellent optical properties of these alloys. The grain size of conventional aluminium alloys limits the surface roughness that can be achieved after machining. However, rapidly solidifying aluminium (RSA) alloys have grain sizes of less than 1 µm in diameter, allowing smoother surfaces to be produced in ultra-precision machining (UP) processes. However, UP processes are limited in the form accuracy that can be achieved due to mechanical influences during machining. Reactive ion beam etching (RIBE) is a finishing process that can produce ultra-precise surfaces in terms of both roughness and form accuracy. It enables in-situ surface passivation and amorphisation by bombardment with ions containing nitrogen or fluorine. This technique avoids the dependence of the etch rate on grain orientation that inevitably occurs when etching with inert ion beams. However, precipitates, which are common in aluminium alloys, can lead to selective etching and surface defects. In the preceding work for this research, such effects were investigated in detail using transmission electron microscopy, secondary ion mass spectroscopy and a number of topographic analysis techniques such as atomic force microscopy (AFM). Building on this, experiments have now been carried out to transfer our recently developed aluminium smoothing method to the ion beam figuration process, significantly reducing the figure error remaining after UP processing. To achieve this, single point diamond fly-cut samples of the alloy RSA 501 have been analysed topographically before and after the RIBE process to investigate the development of the topography as well as possibly developing surface defects due to etch rate selectivities.