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Reactive ion-beam machining of aluminium

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Metal optics are of increasing interest, since refractive optical elements reach their physical limitations within the technological progress in EUV/XUV lithography, X-ray and synchrotron optics. The upcoming needs of most flexible shape adjustment and increasing surface quality demand improved deterministic tools in ultra-precision surface machining. Ion beam figuring (IBF) is an established method in high-end surface manufacturing. However, the direct processing of desired materials as standard aluminum alloys (e.g.Al6061) fails, since the surface roughness increases drastically as a result of inhomogeneous etching due to structural, crystallographic and chemical irregularities inside the material matrix. One technological solution is the coating of the aluminum device with an amorphous Ni(P) layer. Ni(P) is well-shapeable and reveals ultra-smooth surfaces after machining with IBF. But the additional process steps in fabrication of those optics are costly and time demanding. Moreover, the spectral reflection properties of Ni(P) are not as brilliant as pure aluminum surfaces.
We present an alternative figuring technology providing direct surface machining of aluminum alloys while preserving the surface roughness almost in its initial state. This promising route is based on reactive ion-beam etch (RIBE) processing. In addition to conventional IBF the process gas contains chemically active species as oxygen changing the etch mechanism from pure sputtering to a chemical-enhanced sputter etch process. Deterministic RIBE machining was performed on diamond-turned RSA Al6061 and Al905 aluminium alloy surfaces. The morphology and the chemical modification of the surface were analyzed by optical microscopy, atomic force microscopy, secondary ion mass spectroscopy, and energy dispersive X-ray measurements. The direct ion-beam machining process has been optimized for figure error correction of standard alloy aluminium surfaces with focus on superior optical surface quality.

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