NC-AFM Observation of Ultra Precision Machined Fluorite Surfaces

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Next generation laser lithography requires special lens materials exhibiting high transparency in the deep ultraviolet (DUV) spectral range. Due to its very wide band gap, CaF_2 is the material of choice for DUV applications. However, this brittle, single crystalline material is a severe challenge for lens makers and, therefore, novel manufacturing and testing procedures have to be applied for surface shaping, finishing and analysis. Highest purity calciumdifluoride crystals having a roughness below 1 nm over large areas were prepared by ultra-precision grinding and float polishing. High resolution dynamic scanning force microscopy was applied to investigate six equivalently machined (111) surfaces. While the surface roughness has similar values on all samples, small inclinations of the machining plane with respect to the (111) crystal plane lead to the creation of vicinal surfaces exhibiting terraces with a step height of 0.3nm, corresponding to the F-Ca-F triple layer height. Inclination angles were found to be less than 0.1°, resulting in terraces of 200nm in width. If the polishing tool is exactly aligned no terraces are observed, but small islands or pits with a triple layer height dominate the topography. Only very few remainder of the polishing process of up to several nm height randomly cover the surface. We explore the resolution limits in imaging as determined by surface degradation due to air exposure of the surfaces and the tip properties. Furthermore we investigated surfaces directly after the ultra-precision grinding process, taking special care of the effects of the grinding direction with respect to the [1-10] direction of the crystal surface.