Surface engineering for ultra-precise optical surfaces on a large scale using RF-excited ion beam etching

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Abstract

The production of ultra-precision and functional optical surfaces has gained importance in recent years. Broad ion beam etching technologies are used to produce high-end spectroscopic diffraction gratings [1], telescope mirrors and optical elements for semiconductor lithography. These high-end applications require minimal mean square roughness in sub-nm range and ultra-precise shape or pattern to achieve the lowest possible stray light content and maximum efficiency [2]. Large area machining is becoming increasingly important and is leading to a significant increase in process time. A high ion density and, consequently, an increased volume etch rate is achieved by using RF-excited ion beam sources and long process times can be countered. The volume etch rate can be further increased by using reactive gas mixtures instead of inert gases such as argon. A change in the removal function and side effects such as a growth of carbon-fluorine compounds when using reactive gas mixtures such as e.g., CHF_3 and O_2, could influence the homogeneity during large area machining and are of particular interest.

The homogeneity of the etching process was investigated in a large area processing with a commercially available RF-excited broad beam ion source using a reactive gas mixture of CHF_3 and O_2. For this purpose, a relative movement between the broad beam ion source and the sample (SiO_2) was carried out in form of a meander. The motion algorithm was optimized for a diameter of 100 mm.

Recent research shows that when a reactive gas mixture is used, the removal function changes and affects large area machining. By adjusting the motion algorithm to the changed removal function, a homogeneity of ± 0.6 % (see Figure 1) could be achieved when using a reactive gas mixture and is comparable to etching results with argon (< 1 %). Scaling up to a sample diameter of 450 mm with comparable homogeneity < 1 % is part of the current research work at the IOM.

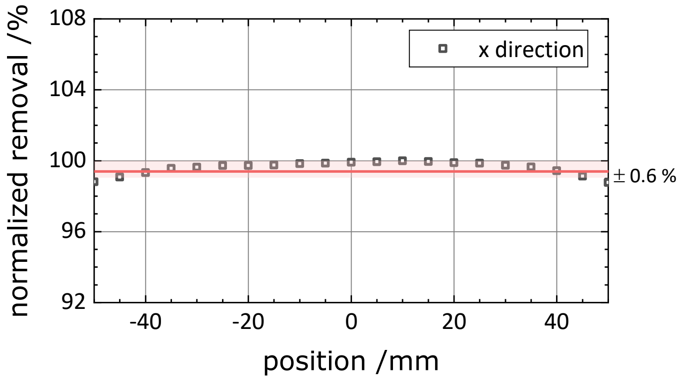

Figure 1: Normalized removal of a SiO_2 sample using an RF-excited broad beam ion source with a reactive gas mixture of CHF_3 and O_2 with meandering relative motion.

References

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