Optimization of Large-area Uniformity for Angled Ion Beam Etch Processes

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Ion beam etch (IBE or RIBE) processes (using broad beam techniques) are widely used for the formation of off-normal features in various materials. One of the many advantages of IBE techniques over RIE is the ability to tilt the substrate relative to the etch ion beam which, amongst other things, allows angled features to be created on the substrate for devices such as diffraction gratings used as optical combiners in AR/VR applications (see Figure 1) and angled facets for solid-state laser applications (e.g. HCSELs). The independence of the etch beam energy (beam voltage) and ion flux (beam current) controls is also advantageous, as is the possibility of introducing reactive gases either into the chamber or into the ion source itself (CAIBE, RIBE), allowing both physical and chemical "fine-tuning" of the process for optimization of certain features required in optical applications (e.g. improving sidewall roughness, angle parallelism and reducing footing).

However, achieving high uniformity of angled etch depth over large-area substrates still remains challenging. This is because the static, off-normal tilt of the substrate relative to the ion source would naturally (due to grid beamlet divergence[1]) lead to a significant "near-side" to "far-side" disparity in local ion current density, and hence local etch rate, depending on the tilt angle, as shown schematically in Figure 2.

In this paper, we present a combination of both grid design and beam shuttering techniques used to overcome this problem and demonstrate excellent etch uniformity performance on both blanket and patterned 200mm substrates relating to angled diffraction gratings for a range of grating angles.

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[1] V. Norkus, G. Gerlach, T. Reichard, R. Teichmann, Surface and Coatings Technology **174–175**, (2003), p.922

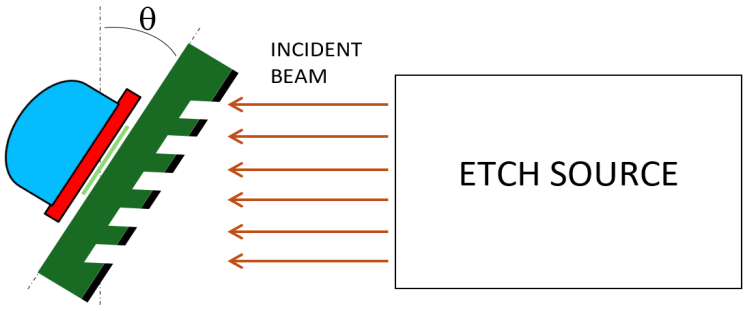

Figure 1: Typical angled (θ) diffraction grating etch configuration by IBE or RIBE

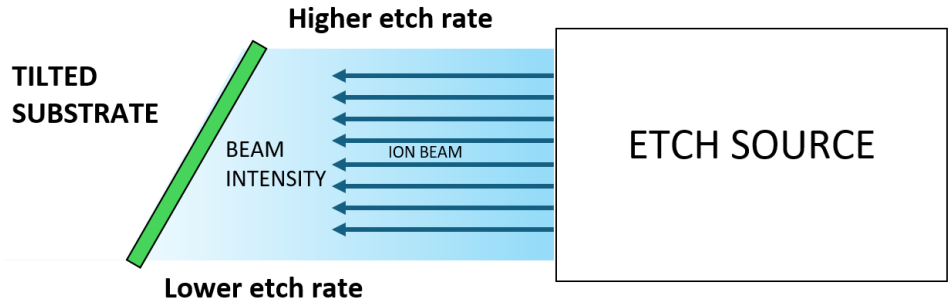

Figure 2: Ion beam etch configuration for angled substrate etch showing the natural tendency for a higher local beam current density at the top than the bottom