High aspect ratio etching of sub-300nm resolution oxide transmission gratings using design of experiment (DoE)

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Quality-demanding applications in the photonics field have pushed the nanofabrication industry towards better performance when it comes to resolution and stray light. Over the past decades, semiconductor technology has appeared and matured, offering manufacturing technologies applicable to transmission gratings, and bringing with it the high-volume low-cost benefits of semiconductor technology. By combining recent strides in production-oriented holographic patterning technology with semiconductor material and etching technologies, it is today possible to produce transmission gratings, etched into fused silica and other oxides exhibiting high refractive index and low absorption over a wide range of wavelengths that rival reflection gratings in all aspects[1]. The aforementioned requires state-of-the-art processes that ensure high uniformity in both etch rate and side-wall angle (SWA) as well as high mask selectivity towards the oxides to be etched, so that the procedure can be scaled into profitable industrial production.

In our research we optimize the reactive-ion etching (RIE) parameters for the fabrication of transmission gratings of various duty cycle (DC). A statistical method using design of experiment (DOE) is used to find the optimum values for the RF and ICP powers, the pressure and the gas mixtures for maximizing the etch rate, the uniformity and the selectivity. With a statistical approach, not only one gets closer to an optimized process for the given output variables, but also gets an insight on the working mechanisms of dry etching, as well as the many interactions that take place during the reaction. This complexity of interactions would be particularly difficult to quantified using the traditional One Factor At a Time (OFAT) method[2].

The preliminary results obtained through DoE show high selectivity (>20:1), suitable etch rate for mass production (>100 nm/min) whilst keeping the etch uniformity across the wafer over 90%. These tests have been performed on structures with lines width of 1500 nm and DC 61%, as well as structures with line width of 696nm and DC 32%.

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[1] Buchwald, Kristian. 2007. "Fused Silica Transmission Gratings." *Ibsen Photonics*
[2] TP, Ryan. 2007. *Modern Experimental Design.* New Jersey: John Wiley and Sons.

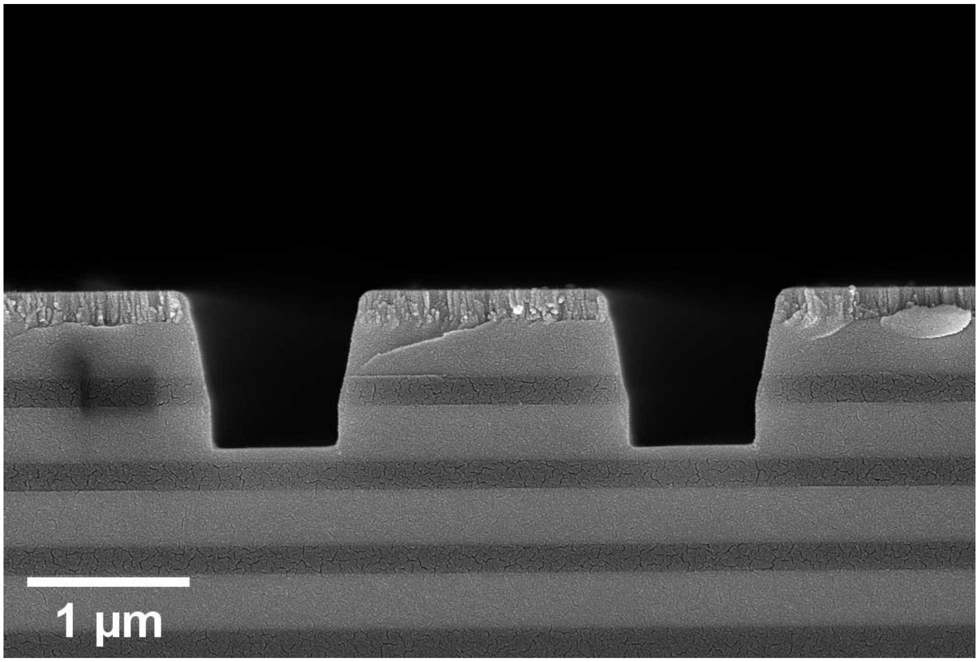

Figure 1: SEM cross-section of a multilayer oxide grating. The linewidth of this design is 1502nm with a 61% duty cycle.

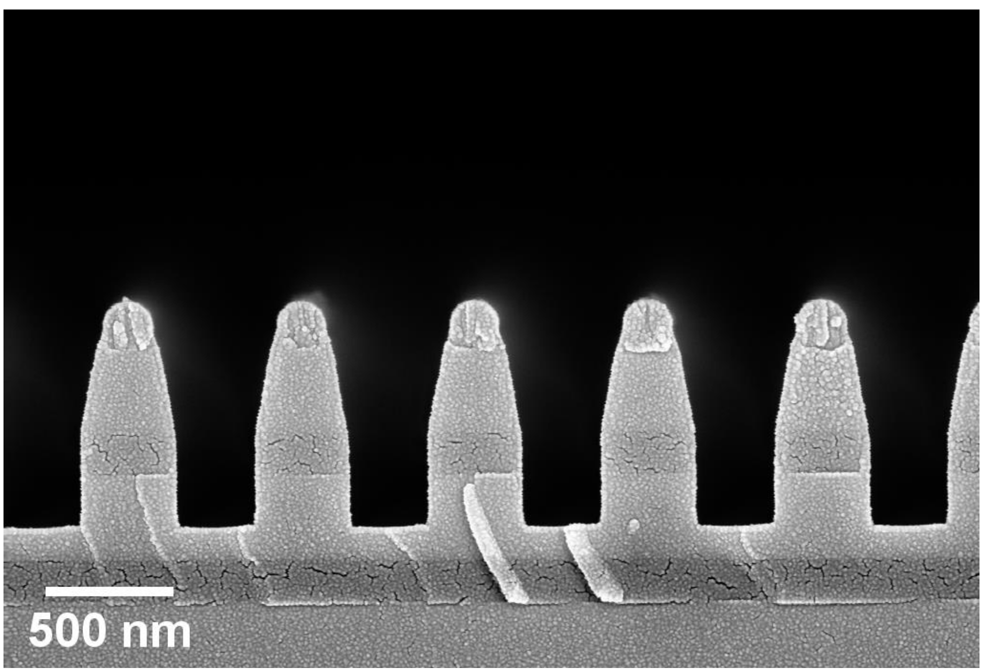

Figure 1: SEM cross-section of multilayer oxide grating The linewidth of this design is 230,7nm with a 32% duty cycle. Both shown gratings were confectioned on 6' wafers, patterned via DUV-Stepper Lithography and etched via dry chemistry.