Diffraction gratings embedded in bulk fused silica by laser ablation

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Diffraction gratings are one of the most used optical components [1], [2]. The gratings are normally amplitude or phase gratings [3], [4] although there exist some other possibilities such as polarization grating [5] or gratings formed by strips with different micro-topographic roughness [6]. In all this cases, the gratings are manufactured superficially, which can be problematic in some applications with dirty industrial environments.

In this work we develop a new kind of diffraction grating that is not engraved at the surface of the sample, but it is placed inside a bulk part of fused silica. Microtubes with a nano-size rough surface are formed (Fig. 1). We use a nanosecond Q-switched laser so that we can study, depending on the laser pulse width, not only the pure ablation regime, but also the thermal effects of radiation ([7], [8], [9]).

Moreover, we can study the differences between the gratings engraved in bulk and the gratings engraved in surfaces (front and rear), due the electronic process that appears in the ablation regime ([10], [11]), Fig. 2 and Fig. 3.

This kind of gratings can be employed in industrial environments since embedded gratings present several characteristics such as robustness, stability against surfaces flaws and easy cleaning process. Besides, the study of the diffraction due the nano-size roughness of the engraved cylinders is a quite new field of research in which meet two of the lasts advances of our group: the study of the diffraction by a cylinder with and without surface defects [12], [13], and the study of the effect of the roughness in a diffraction grating [14]. The theoretical analysis of this kind of diffraction gratings is not yet developed, according to our knowledge, Techniques based in statistical optics are required in order to analyze the optical behavior of this gratings. Therefore, we have experimentally analyzed the optical behaviour of this gratings, such as far field diffraction pattern and Talbot self-images (Fig. 4).

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Figures:

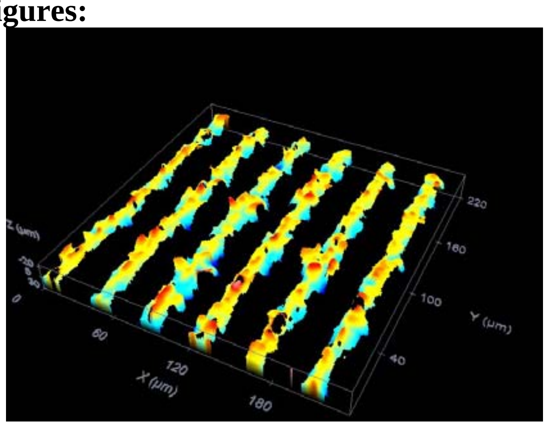

Fig. 1: Confocal image of an embedded diffraction grating with submicron roughness

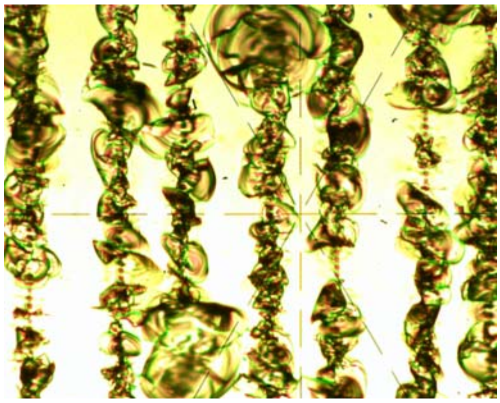

Fig. 2: Optical Microscopy Imaging of a diffraction grating engraved at the surface

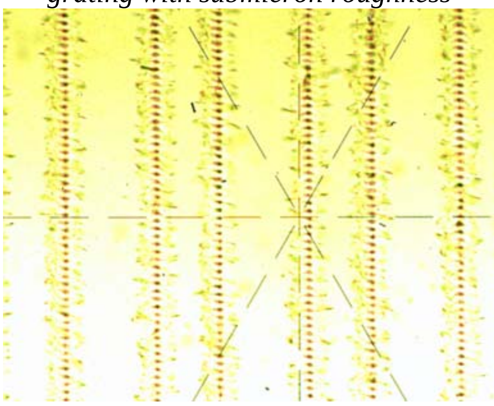

Fig. 3: Optical Microscopy Imaging of a diffraction grating engraved in bulk.

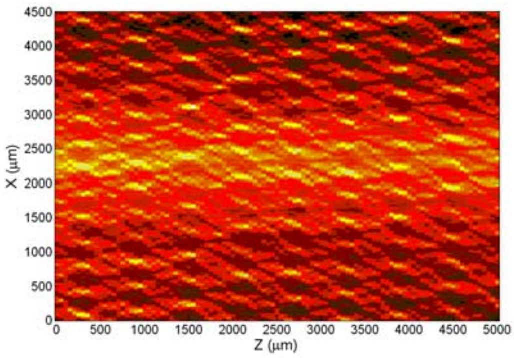

Fig. 4 : Talbot self-images of an embedded diffraction grating.