Sub-micron period grating structures in Ta_2O_5 and InO_x thin oxide films, fabricated using 248nm interferometric excimer laser ablation

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Abstract: High quality relief gratings of period 500nm have been patterned in InO_x and Ta_2O_5 thin films using interferometric 248nm excimer laser ablation. Details of the ablation process and the morphology of the gratings are presented.

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Thin oxide films have proven to be useful materials for the realisation of versatile and functional optoelectronic devices, since they can be fabricated using well-characterised and cost-effective methods and they often offer a unique combination of good optical and electrical properties. Thin oxide films are used in optical communications, imaging and waveguide sensing. The micro-patterning of thin oxide films may play a key-role in the application of this kind of films to useful optoelectronic devices. High resolution features are required, if thin oxide films are used as waveguide overlayered Bragg gratings, or photonic band-gaps located in the 1.5μm or visible band.

The interferometric ablation [1] of 500nm period relief gratings in InO_x and Ta_2O_5 thin films, using 248nm excimer laser radiation is presented in this paper. The fabrication of relief grating structures in oxide thin films using interferometric excimer laser ablation can be proven advantageous, due to the simplicity and repeatability of the method, the quality of the patterning and the resolution obtained. Significant advantage of the above method is the easy adjustability of the recorded grating period, and the capability of producing different kind of gratings (relief, photorefractive or volume damage) by simply tuning the exposure conditions.

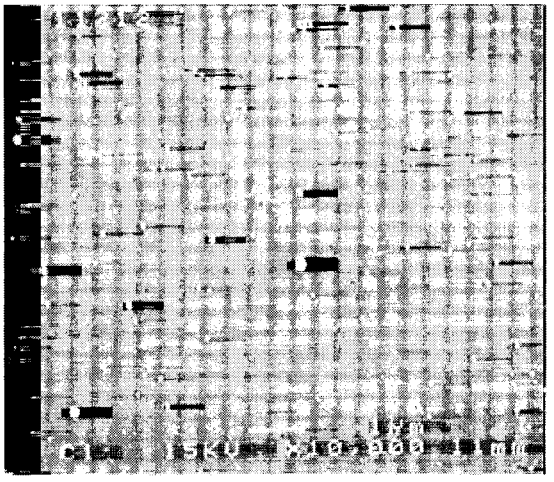

Figure 1. *Relief grating in a 105nm thick Ta_2O_5 film, using 5 pulses of 110mJ/cm² energy density.*

The principal objective is to study the feasibility of successful ablation of periodic nano-structures in thin films, using nanosecond pulses, where the dimensions of the patterned structure are comparable to the optical absorption length and the thermal diffusion length of the material. The Ta_2O_5 and InO_x films have been fabricated using RF- and DC- magnetron sputtering respectively. The dependance of the grating growth process on the machining conditions is investigated and diffraction efficiency graphs have been obtained to characterise grating strength. Real time diffraction efficiency measurements revealed non-monotonic behaviour of grating depth growth, yielding optimum ablation conditions. High quality relief gratings can be fabricated in InO_x and Ta_2O_5 (Figure 1) thin films, of thickness comparable to or lower than the thermal diffusion depth, by precise control of the energy density and number of pulses of the exposures. Grating depths up to 115nm have been ablated on a variety of films thickness of both materials. SEM microscans revealed that high-damage volume gratings are formed in both of the materials for exposures below the ablation threshold. Relief gratings of Ta_2O_5 and InO_x thin oxide films have been overlaid on K^+ ion-exchanged channel waveguides in BK-7 glass and strong Bragg reflectors have been demonstrated.

[1] S. Pissadakis, L. Reekie, M. Hempstead, M.N. Zervas, J.S. Wilkinson, Relief gratings on Er/Yb-doped borosilicate glasses and waveguides by excimer laser ablation, Appl. Surf. Sc. **153/4**, 200-210, (2000)