Sub-Micron Period Relief Grating Structures Inscribed on Erbium Doped Ta_2O_5 Waveguides Using 213 nm, 150 ps Laser Radiation

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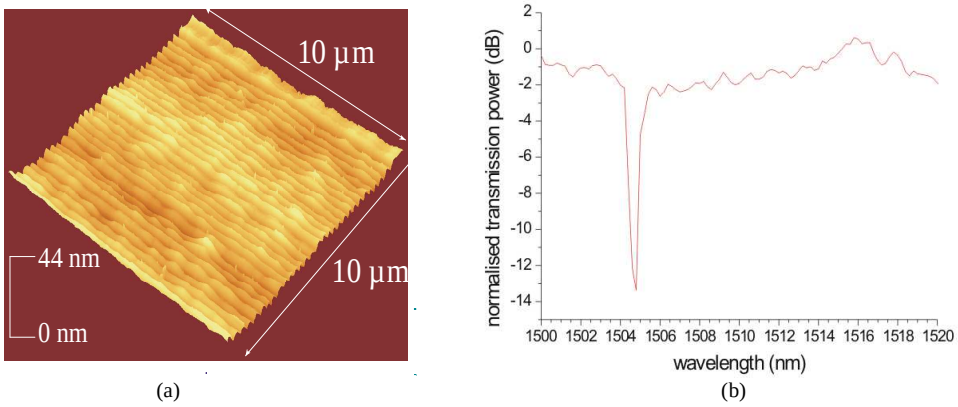
Tantalum Pentoxide (Ta_2O_5) films exhibit high refractive index (2.1 @ 1550 nm), transparency between 300 nm and 2000 nm wavelengths, compatibility with silicon processing techniques and high photosensitivity [1], making them ideal for realising compact multifunctional planar lightwave circuits (PLCs).

The inscription of sub-micron period relief gratings of period ~360 nm by interferometric ablation of erbium doped tantala (1 wt% Er_2O_3) rib waveguides using 213 nm, 150 ps Nd:YAG laser radiation is presented in this paper. Such gratings may find applications as wavelength filters [2] and as mirrors for waveguide lasers [3]. The fabrication of grating structures using interferometric ablation [4] offers many advantages due to its simplicity, the tuneability of the grating period, and the capacity to produce different kinds of gratings (photosensitive, relief and volume damage) by simply tuning the exposure dose conditions.

The principal objective of this study is to establish the feasibility and conditions for writing sub-micron period grating structures in thin film erbium doped tantala waveguides, where thermal diffusion effects play a deleterious role, and use those gratings as output couplers for lasing applications in the 1520-1550 nm wavelength band. Erbium doped tantala thin films 1.42 μm thick were deposited on silica substrates using RF magnetron sputtering. Channel waveguides of width 1-10 μm were patterned using standard photolithography and ribs realised by Ar ion milling with etch depth 160 nm. Volume damage and relief gratings were written on the waveguides using an elliptical Talbot interferometer, and real time diffraction efficiency measurements allowed study of grating depth growth and ablation threshold. Bragg reflectors were written with between 1000 and 72000 pulses at energy densities of ~10 mJ/cm^2 and ~23 mJ/cm^2, below and above the ablation threshold, respectively. Gratings with period ~ 360±10 nm and depths up to 200 nm were formed on the waveguides. AFM scans show formation of shallow relief gratings both below and above the ablation threshold (see Fig.1a).



(a) (b)

Fig. 1 Relief grating inscribed on erbium doped tantala waveguides with 1000 pulses of energy density 23 mJ/cm^2 a) AFM image; b) waveguide transmission spectrum.

Transmission measurements (Fig 1b) yielded a notch of spectral depth ~11 dB for a 2mm long grating written above the ablation threshold (1000 pulses, ~23 mJ/cm^2) and ~7 dB for 2mm long gratings written below the ablation threshold (72000 pulses, ~10 mJ/cm^2) for TE polarisation. The gratings exhibited substantially lower extinction for the TM polarization, due to significantly lower overlap with the grating corrugation than the TE polarisation. Work is in progress to tune the grating to the maximum erbium gain wavelength (~1530 nm) and to realise compact line-narrowed waveguide lasers.

References

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