All-telluride channel waveguides for mid-infrared applications

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Abstract: In the framework of the "Integrated Optics" project, single-mode RIB waveguides for both [6-11µm] and [10-20µm] spectral bands were developed in order to manufacture modal filters for spatial interferometry. In this paper, the different steps of the fabrication of such components are described and the first results in term of light guiding and modal filtering are presented.

OCIS codes: (130.3130) Integrated optics materials; (130.3060) Infrared; (160.2750) Glass and other amorphous materials

The search for Earth-like exoplanets showing biological activity is a very challenging quest. Nulling interferometry from space, in the mid-infrared, seems to be a promising technique for a direct observation of these extra-solar planets. It is studied by ESA and NASA in the framework of the Darwin and TPF-I missions, respectively. Although the studies began about 10 years ago, nulling interferometry remains a technological challenge at different stages. One of the challenges is the development of a modal filter that allows the filtering of the wavefronts to such quality that the central star flux can be rejected with an efficiency of about 10^{-5}. The modal filter may be based on either single-mode integrated optics or fiber optics. In this paper, we are addressing the integrated optics solution.

In the framework of the Integrated Optics project, we worked on the fabrication of light-guiding structures for both [6-11µm] and [10-20µm] spectral bands. $Te_{82}Ge_{18}$ thick films of controlled thickness and refractive index were deposited by thermal co-evaporation on $Te_{75}Ge_{15}Ga_{10}$ bulk glass substrates. Their geometry was then modified by reactive ion etching using a gas mixture of 59.5% CHF_3/10.5% O_2/30% Ar. After polishing of the input/output facets of the manufactured RIB waveguides (Figure 1), light guiding was confirmed at λ = 10.6 µm (Figure 2). To end, the first experimental assessments of the modal filtering capability of these components were performed using a nulling interferometer operating at λ = 10.6 µm. We demonstrated light rejection efficiency of 6.10^{-5} using a preliminary non-optimized component. This result is very encouraging since it is in line with ESA's requirements and provides a confirmation of the potential of integrated optics for nulling interferometry.

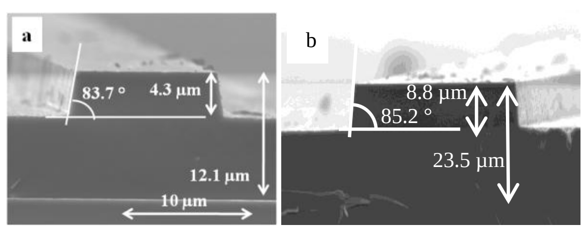

Fig. 1. RIB waveguides: a) for the [6-11 µm] spectral band; b) for the [10-20 µm] spectral band. In both cases, the film composition is $Te_{82}Ge_{18}$, in order to achieve a $\Delta n = n_{layer} - n_{substrate} = 4.10^{-2}$, approximately.

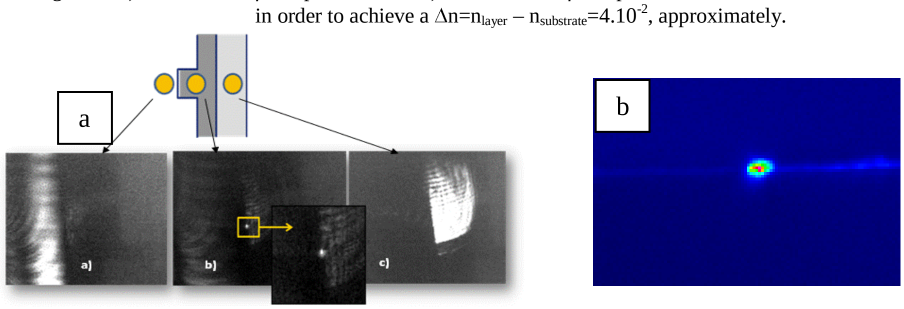

Fig. 2. Evidence of the guiding properties: a) in the case of a RIB waveguide for the [6-11 µm] spectral band. Observation of a luminous spot when light (λ = 10.6 µm) is centered into the RIB structure. A 1.7 % transmission was obtained, to be compared with a prediction of max. 4.5 %. b) Case of a RIB structure for the [10-20 µm] spectral band, observed in the 1.5-5.5 µm band using a cooled InSb infrared camera. Illuminating light is coming from a pinhole lighted by a globar infrared source.