High contrast mid-infrared chalcogenide waveguides for biosensing applications

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Mid-infrared spectral band from 2 µm – 20 µm is ideal for label-free biosensing as the fundamental vibrations of many significant biomolecules take place in this region. Mid-infrared absorption spectroscopy using FTIR has been exploited for the last few decades to provide sensing capabilities for biomedical diagnostics. However, the sensitivity and the detection limit of the sample under test can be tremendously improved by using the evanescent field based integrated planar waveguide devices. In this paper, we present the fabrication and characterization results of chalcogenide waveguides transparent in the mid-infrared region for such applications. $GeTe_4$ waveguides on ZnSe substrates were fabricated using lift-off technique. Lift-off resist was used to create the patterns on ZnSe substrate using photolithography and $GeTe_4$ was deposited on these patterned samples using RF sputtering. The lift-off resist was stripped off to obtain the desired channels. The waveguides were characterized in both mid wave (2.5 µm – 3.7 µm) and long wave (6.4 µm – 7.5 µm) spectral bands using optical parametric oscillator-based laser source and quantum cascade laser, respectively [1]. Fig. 1 (a) and (b) show the cross-section and top view of the infrared camera images of the output facet of a $GeTe_4$ channel waveguide showing light guidance at $\lambda = 3.5$ µm and $\lambda = 6.5$ µm, respectively.

ZnSe used as a substrate is a soft polycrystalline material and it was difficult to polish the end-facets of the samples using conventional polishing without chipping. An alternative approach of depositing both lower cladding (isolation layer) and core material of the waveguides on Si substrate was employed to utilize the well-known cleaving planes of Si to avoid polishing. Silicon is also a cheaper and convenient substrate. Here, thickness of ZnSe ($n \sim 2.4$), which is the isolation layer between the high refractive index Si substrate ($n \sim 3.5$) and the core of the waveguide ($GeTe_4$, $n \sim 3.3$) was calculated by numerical modelling so that the propagating mode does not get affected by the underneath high refractive index Si substrate. ZnSe was deposited using thermal evaporation on Si and was annealed to release the thermal stresses in the film and to increase its adhesion. $GeTe_4$ waveguides were then fabricated on top of ZnSe/Si using lift-off technique. The end-facet of the sample was cleaved for coupling the light into the waveguides and the waveguides were characterised in the mid-infrared region.

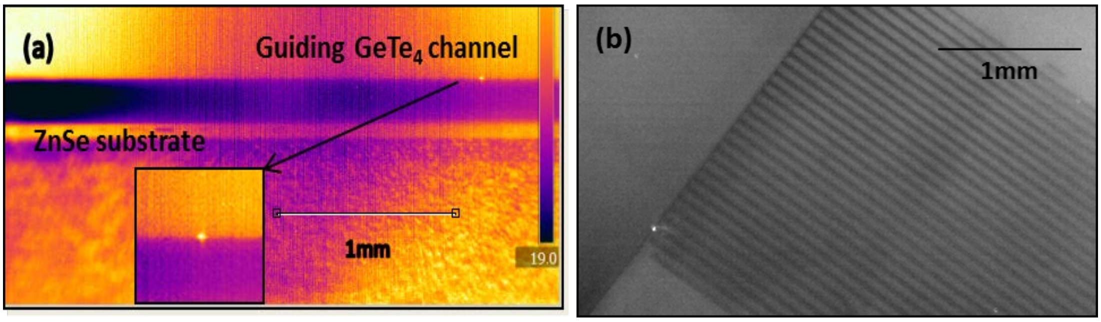

Fig. 1 Infrared images of the output facet of a channel waveguide showing light guidance (a) at a wavelength of 3.5 µm (cross-sectional view) and (b) at a wavelength of 6.5 µm (top view)

Acknowledgement: This research is funded by the European Research Council under the EU 7th Framework Programme (FP7/2007-2013) / ERC grant agreement no. 291216.

References:

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