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# ABSTRACT BOOK

# Towards long-wave infrared lab-on-chip sensors using plasmonic and quantum cascade technology

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Many molecules of interest in chemistry and life science have their fingerprint absorptions in the mid-infrared (mid-IR), some of them extending to the Long-Wave Infrared (LWIR, 8-12 µm), including e.g. ammonia, glucose and TATP. Noteworthy, significant progress in the monolithic integration of fast and compact mid-IR sources, i.e. (QCLs) and detectors (QCDs), have accelerated the development of a new generation of Photonic Integrated Circuits (PICs). This opens the way to lab-on-chip spectroscopy [1], which also addresses the LWIR spectral region. In this context, Dielectric-Loaded Surface Plasmon Polariton Waveguides (DLSPPWs) have been used as key technology, since they are an effective and simple solution for on-chip guiding of light while simultaneously offering a platform for chemical analysis and sensing. However, the principal challenge towards the realization of LWIR PICs, is to attain low-loss on-chip waveguiding, as most of the commonly used mid-IR materials absorb in this spectral region. In this work, we address this problem, and design, simulate, fabricate and experimentally characterize a hybrid semiconductor-metal plasmonic scheme based on a Germanium (Ge) stripe on top of a gold layer. We optimize the cross-sectional geometrical factors together with numerical simulations aiming at long range propagation as an important figure of merit. Next, we fabricate such optimized Ge ridges on a gold layer evaporated on Silicon substrate for different Ge stripe widths. Measurements of the attenuation and lateral mode profile of the supported mode were performed including using the cut-back method for extrapolation of the coupling losses at a wavelength of interest of 9.12 µm. We used an end-fire coupling characterization setup provided with an EC-QCL which covered the wavelength range between 5.66 and 11.24 µm. The measured plasmonic modes show low loss propagation (<20 dB/mm) for the entire supported mid-IR spectrum of the EC-QCL, being in good agreement with the simulations. The insertion loss measured trough the cut-back technique was found around 12 dB/mm at 9.12 µm, corresponding to a propagation length of 340 µm. The lateral mode profile shows excellent agreement between measurements and simulations. As for on-chip optical spectroscopy applications only distances of a few hundreds of microns need to be addressed, these results suggest germanium loaded plasmonic waveguides as an attractive solution for LWIR plasmon-photonics for on chip detection of species in the surrounding medium as well as chip-level integrated photonics.

[1] B. Schwarz et al., "Monolithically integrated mid-infrared lab-on-a-chip using plasmonics and quantum cascade structures," Nature Communications, vol. 5, no. 1, Art. no. 1, Jun. 2014, doi: 10.1038/ncomms5085

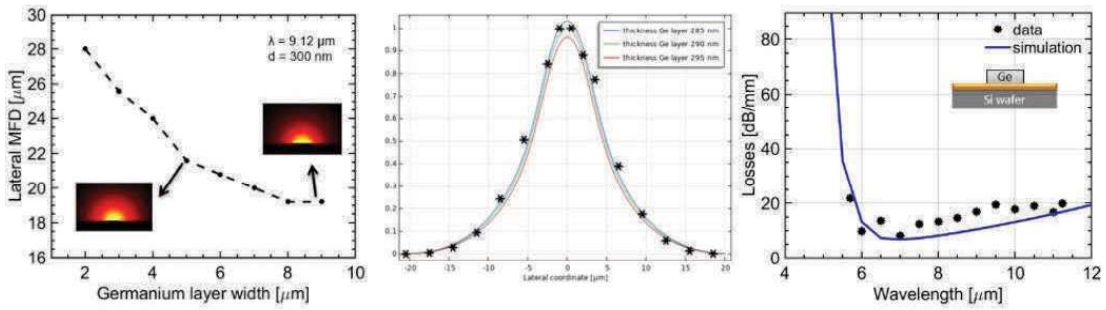


Figure 1: (Left) Lateral mode field diameter vs Germanium layer width. (Centre) Overlap integrals of the simulated (solid lines) and measured (stars) profiles. (Right) Spectral bandwidth of the waveguides and sketch of the cross-section.