Heterogeneous silicon photonics for SWIR/MWIR applications

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In this paper I review our work on silicon photonic integrated circuits for spectroscopic sensing applications.

Silicon photonics is an emerging technology for the realization of high-speed transceivers. However, the application range is not limited to optical communication. The wide transparence range of group IV materials such as silicon and germanium enable photonic integrated circuits operating in the mid-infrared. Passive waveguide circuits containing spectrometers have been realzed both in the short-wave infrared (on silicon-on-insulator) and in the mid-infrared (on silicon-on-insulator and germanium-on-silicon). In order to realize chip-size spectroscopic sensors the integration of light sources (lasers, LEDs) and photodetectors are required as well. For this purpose GaSb-based layer stacks are bonded on the silicon waveguide circuits, which are then processed into opto-electronic components. This way, a InGaAsSb on silicon spectrometer with 46 channels was demonstrated, operating in the 1.5-2.5um wavelength range. Laser integration has been demonstrated as well in this wavelength range. An alternative approach for photodetection in this wavelength range is the integration of PbS and HgTe colloidal nanocrystal films on silicon waveguide circuits. Short-wave infrared photoconductors integrated on silicon were demonstrated. An alternative approach to mid-infrared light generation is the use of the large Kerr nonlinearity of silicon together with the broad dispersion engineering feasible in high index contrast silicon photonic waveguide circuits. This way, the efficient generation of mid-infrared radiation is possible using 'standard' optical pump sources. We demonstrated the generation of 3.6um radiation using a pump around 2um wavelength and a signal in the telecommunication wavelength band. Also, an octave spanning frequency comb in the 1.5-3um wavelength range using spectral broadening in a silicon photonic wire was demonstrated. Using silicon photonic technology we demonstrate the on-chip spectroscopic detection of glucose at physiologically relevant concentrations.

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