Mid-infrared Semiconductor Lasers Grown on group-IV Platforms

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The direct epitaxy of III-V lasers on silicon has long been considered a fundamental step towards the realization of functional integrated photonic chips. While most of the work is focused on data/telecom applications, the integration of mid-infrared lasers would open the way to the development of compact on-chip sensors and allow their widespread use in smart sensor networks. In addition, replacing scarce III-V substrates with abundant Si substrates would be a major step toward sustainable optoelectronics. However, the difference in crystal structure, lattice constant and thermal expansion coefficient between III-V and group IV materials, as well as issues related to the reactivity of the Si surface, have made this approach extremely challenging.

The so-called antimonides, *i.e.* the III-V semiconductors based on GaSb, AlSb, InAs, InSb, their alloys and heterostructures, exhibit unique properties in terms of bandgap and band-offset engineering which allow them to cover the whole near- to far- IR wavelength range. They are perfectly suited to develop a broad range of mid-IR optoelectronic devices.

In this talk we will review our recent work on antimonide mid-IR lasers (diode lasers (DLs), interband cascade lasers (ICLs), quantum cascade lasers (QCLs)) grown by molecular-beam epitaxy on (001) Si or Ge substrates. We will show that a dedicated epitaxial growth strategy allows solving a long lasting issue, the formation of anti-phase boundaries, a device-killer defect typical for the growth of III-Vs on group-IV substrates [1]. We will compare the laser performance to that of similar devices grown on their native substrates. If DLs are very sensitive to the residual dislocation density, ICLs and QCLs appear to be relatively immune to these defects [2]. We will demonstrate light coupling from DLs grown on patterned Si photonics wafers to passive SiN waveguides, with a coupling efficiency in line with simulations [3]. Finally, we will discuss and evaluate strategies to enhance the coupling efficiency.

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References

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