Progress of Hybrid III-V Lasers on Si and SOI substrates

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Researches and developments of Si-photonics are hot topics in photonics field. This is because the technology has potentials to realize low-cost and compact products for various applications such as optical interconnection, sensing, LiDAR (Light Detection and Ranging) and so on. For passive components, most of components such as waveguides, splitters, combiners, filters, are being established. On the other hand, active components, especially semiconductor lasers, are still under developments since Si has indirect bandgap property and cannot achieve efficient emission. To overcome this problem, hybrid lasers, composed of III-V layer on top of Si or SOI substrates, were proposed and demonstrated. In this talk, I will review the progress of two types of hybrid lasers in our group, one is membrane lasers and the other is direct bonded hybrid lasers.

Figure 1 shows the schematic of the membrane lasers on Si [1]. The membrane structure has III-V thin core layer (~270 nm) sandwiched by low index dielectric materials such as SiO_2 and air. The structure was bonded on Si by BCB. Due to this large index difference between the core and cladding layers, optical confinement can be three times stronger than that of the conventional laser structure. This strong optical confinement properties give superior characteristics such as low threshold current, high modulation speed with low bias current and compact device size. We actually demonstrated such characteristics by the membrane DFB (distributed feedback) and DR (distributed reflector) lasers with a GaInAsP core layer. These membrane lasers and photonic integrated circuits are suitable for on-chip optical interconnection.

Figure 2 shows the schematic of the direct bonded hybrid lasers on SOI with ring resonators [2]. III-V layers are bonded by direct bonding method (in our group, plasma activated bonding is used). Basically, resonator can be defined by Si circuits and III-V layers just act as a gain medium. Our group demonstrated CW operation of GaInAsP hybrid lasers. The advantage of this platform is an integration of many other Si photonics components. By similar form, we can realize amplifiers, photodetectors, and modulators. Therefore, this platform can be applicable for larger scale integration such as one-chip optical routers or LiDAR applications.

Acknowledgments

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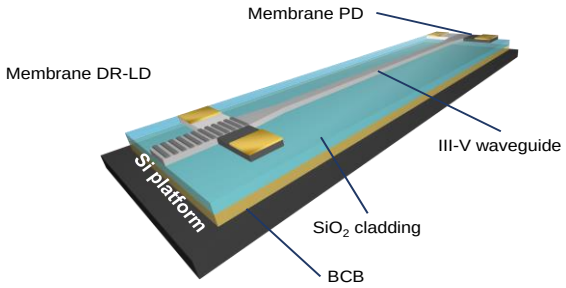

Fig. 1 Membrane lasers on Si.

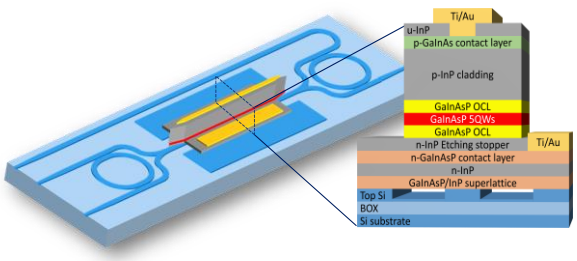

Fig. 2 Direct bonded hybrid lasers on SOI.