SILICON PHOTONICS AND APPLICATIONS IN AEROSPACE

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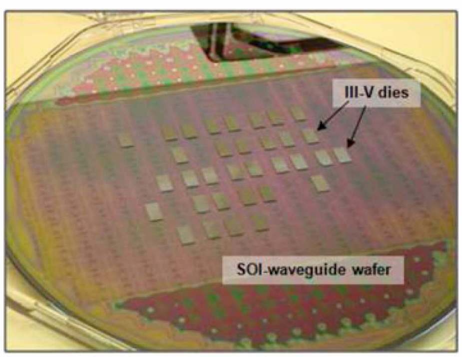
Introduction

Silicon photonics has the potential to significantly reduce the cost of optical devices used in many traditional applications in addition to enabling new devices and applications[1]. This is because of the maturity of CMOS processing facilities and infrastructure and because of the capabilities and efficiency of photonic integration. The ability to integrate photonic devices with CMOS electronics in a wafer scale manner can greatly increase the capacity of integrated circuits and reduce the size, weight, power dissipation while simultaneously increasing the reliability of the systems employing these components. The low loss of silicon waveguides [1] enables large, complex passive components to be made without significant signal attenuation. It also improves the performance of lasers, resulting in lower thresholds and narrower linewidths.

Many novel CMOS compatible devices have been introduced, including optical modulators [2], high speed photodetectors [3], and complex passive waveguide structures for routing separating and combining light [4]. An electrically driven light source is needed. We will review heterogeneous integration of III-Vs on silicon as well as epitaxial growth on silicon for integrating lasers and amplifiers. We will also review recent result extending the range of wavelengths of lasers on silicon to shorter wavelengths (< 1 um) and longer wavelengths (>2 um).

Heterogeneous Silicon Photonic Integration

Heteroepitaxy and wafer bonding represent two main approaches for integrating lasers on silicon, with the latter more successful so far due to much lower threading dislocations, process simplicity and low cost. Recently, a heterogeneous silicon photonic integration (HPIC) platform has been developed and demonstrated a group of key components including lasers, amplifiers, photodetectors, and modulators [1,5]. Figure 1 illustrates the wafer bonding concept used for the creation of HPIC and shows the scalability of this process up to 150 mm wafer sizes.

a)


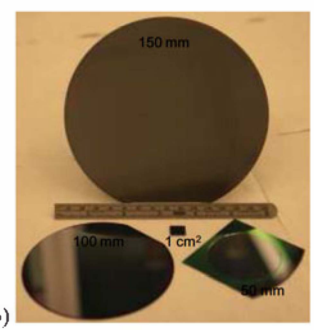
b)


Figure 1 Heterogeneous integration of III-V and silicon wafers. a) Multiple individual die[6], b) Whole wafer bonding in sizes from 1 cm^2 up to a full 150mm wafer[5].

Silicon Photonics in Avionics Applications

Avionics presents an environment for its optical systems that has extreme requirements for both physical form factor and environmental robustness, for which photonic integration is a very attractive solution as it can achieve the most compact footprint while reducing bulky and potentially unreliable fiber connections to a minimum. Both digital and analog applications can benefit from Si based photonic integration as illustrated in the figure below. Figure 2a shows a widely tunable (55 nm tuning) laser employing coupled ring resonators.

The high Q of the silicon rings results in narrow linewidth (40 kHz). Fig 2b shows a two dimensional scanner that uses a tunable laser and grating array for scanning one dimension and 32 parallel emitters for an optical phased array emitting in the other dimension.

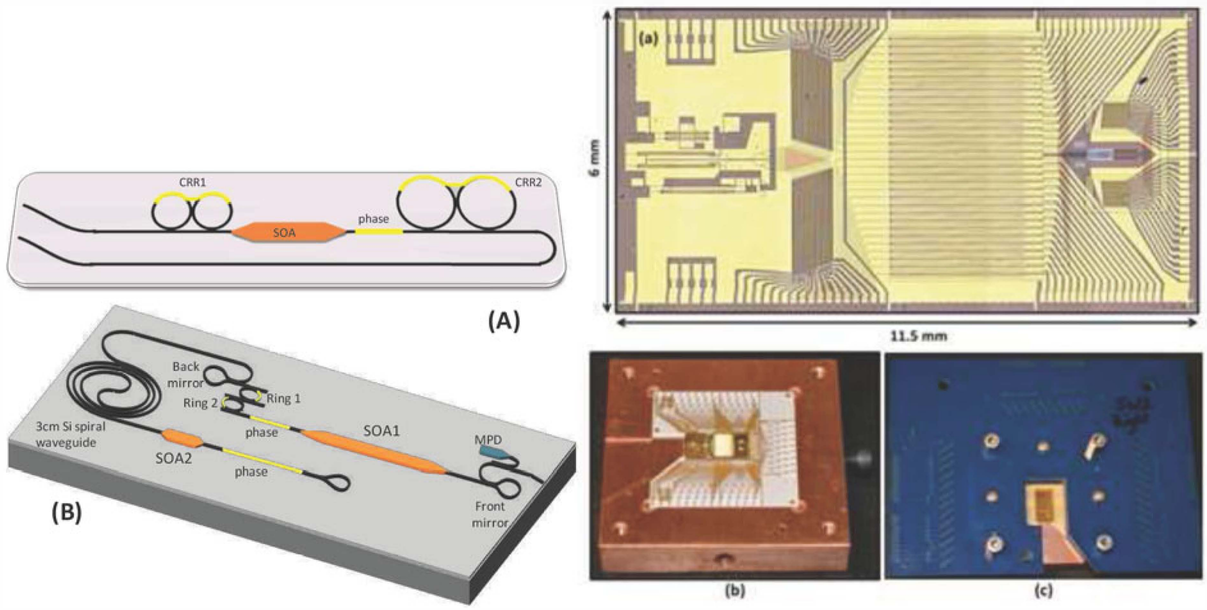


Figure 2 a) Widely tunable, narrow linewidth heterogeneous ring laser on silicon[7]. b) Two dimensional scanner employing 32 parallel waveguide emitters[8].

Conclusion

Silicon based photonic integration technology has advanced significantly in the last several years and is now being deployed commercially in data center applications. It can bring unique opportunities for avionics systems to utilize photonics.

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