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Si-based near-infrared detection and emission: highlights from the (uncompleted) trail towards monolithic integration with CMOS

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Photodetection and emission of near infrared (NIR: 0.8-2μm) light has been a fast growing area in recent years owing to the diffusion and importance of related applications. The latter include, but are not limited to, optical communications, remote sensing, biology and artwork restoration. This field has been historically dominated by III-V based lasers and photodiodes exploiting the excellent optical and electrical characteristics of InGaAs compounds. Fast (speed in excess of 40GHz) and sensitive photodiodes, [1] focal plane arrays, [2] as well as efficient laser sources [3] have been demonstrated and commercialized using this technology.

Large efforts have been devoted to achieve the monolithic integration of III-V optoelectronic devices along with Si electronics, in order to solve the interconnect issues arising in ultra large scale Si integrated circuits as well as demonstrate compact, single-chip, solutions for telecom applications. Unfortunately, despite a few remarkable milestones [4], formidable issues still await suitable solutions, while hybrid approaches lack reliability, low cost, easy connection and packaging featured by the monolithic approach.

Among the Si-based approaches proposed to this extent, the use of Ge, sometimes alloyed with Si and C, has been successfully demonstrated as a feasible technology for fabrication of NIR photodetectors integrated on Si. Responsivity as high as 890 mA/W at 1.3 μm and 750 mA/W at 1.55 μm with speed in the GHz range have been reported in p-i-n structures [5].

Conversely, Si-based light emission is still a fully open issue, with poor efficiency if compared to III-V devices and no lasers demonstrated to date. Among the numerous approaches, the most promising seems to be the use of quantum/surface properties of Si nano-crystals embedded in an insulator matrix such as SiO_2 [6] possibly exciting Er ions [7] and band-to-band recombination in very high quality Si. [8]

In this Communication we illustrate and review the various approaches proposed and investigated to achieve CMOS-compatible light detection and emission in the NIR.

References:

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