Silicon LEDs – device architecture, experiments, and applications

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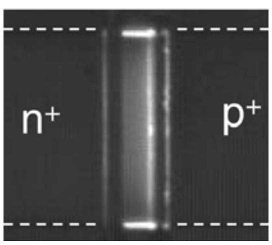
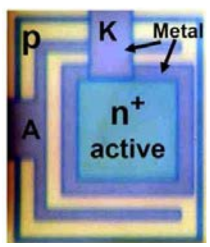
Literature often mentions that light emission from Si is of the order of 10^{-6} efficient [1, 2]. Various groups (including mine) have however convincingly shown band-to-band emission efficiencies close to 1% at room temperature [3–5]. The indirect bandgap and the fierce competition from nonradiative processes do require special measures if one is to produce a silicon LED with appreciable light output.

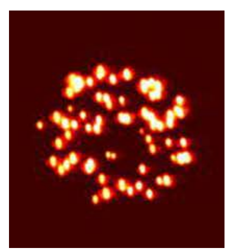
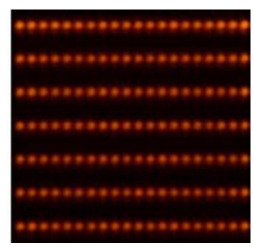
In this presentation I will address the basic requirements for a bright silicon LED. A well-chosen architecture can suppress non-radiative recombination processes and facilitate out-coupling. Besides efficiency and out-coupling, the use of standard platform technologies is preferred. I will present examples of LEDs designed and manufactured in standard fabrication lines, from planar CMOS to FinFET, and discuss their performance in terms of form factor, speed, and efficiency [6–8].

Distinctly different from band-to-band recombination, avalanche current from a reverse-biased diode delivers a broad spectrum of light from near-infrared to near-UV. This silicon LED requires an entirely different optimization. Recent experiments show an optimum in light emission efficiency at a diode breakdown voltage around 5–6 V [6], which is supported by analytical and TCAD models. I will present recent investigations to improve the uniformity of the avalanche light-emission process.

Finally the possible applications of light from silicon will be discussed. Opportunities exist where monolithic solutions offer an advantage over hybrid assembled systems (for cost and/or form factor) when the efficiency, directionality and narrow linewidth of lasers are not *per se* necessary. Within-chip data communication (opto-coupling) is one attractive application when galvanic isolation is needed. Further applications may be found in lab-on-a-chip systems, proximity detection, and anti-fouling.



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