Optical Antennas Make Fast LEDs

Ming C. Wu
Electrical Engineering and Computer Sciences Department,
University California, Berkeley, CA 94720
wu@eecs.berkeley.edu

Interconnects accounts for a significant portion of energy consumption in integrated circuits. Optical interconnects, now widely used to link electronic systems such as servers and top of rack switches in data centers, can potentially reduce the energy consumption of electrical interconnects. However, current optical links consumes about 100s fJ/b to 1 pJ/b, still much too high for on-chip communications. Orders of magnitude improvement in energy efficiency can be achieved by combining ultra-low capacitance optical receivers and optical antenna-enhanced nanoscale light-emitting diodes (LED). In this talk, we will focus on the latter. Traditional laser source consumes too much power due to the need to bias the laser, usually at several times the threshold current. LEDs, on the other hand, can operate efficiently without threshold. Unfortunately, their modulation speeds are limited by the relatively slow spontaneous emission. Recently, progress has been made using optical antennas to increase the rate of spontaneous emission, opening up the possibility of an efficient, high speed, nanoscale emitter. We have observed 115x enhancement of spontaneous emission rate in optically pumped InGaAsP nano-LEDs with arch-dipole antennas.[1] Recently, using cavity-backed optical slot antennas, electrically injected nano-LEDs with 200x enhancement of spontaneous emission rate have been demonstrated.[2] Even higher enhancement has been observed in nano-LEDs with monolayer two-dimensional semiconductor such as transition metal dichalcogenide, WSe_2.[3] In this talk, we will review the principle and the recent progress in optical antenna-enhanced nano-LEDs.

Acknowledgment: The work presented here is in collaboration with Profs. Eli Yabnovitch and Ali Javey, with contributions from Seth Fortuna, Kevin Messer, Michael Eggleston, Sujay Desai, Kevn Han, and Surabhi Madhvapathy. This work was funded by the Center for Energy Efficient Electronics Science through a grant from the National Science Foundation (NSF Award ECCS-0939514) and AFOSR Award FA9550-09-1-0598.

---

1. Eggleston MS, Messer K, Zhang L, Yablonovitch E, Wu MC. Optical antenna enhanced spontaneous emission. *Proc Natl Acad Sci*. 2015;112(6):1704-1709.
2. Fortuna SA, Eggleston MS, Messer K, Yablonovitch E, Wu MC. Large spontaneous emission rate enhancement from an electrically-injected nanoLED coupled to an optical antenna. *IEEE Photonics Conference*, 2015.
3. Eggleston M, Desai S, Messer K, et al. Enhanced Spontaneous Emission from an Optical Antenna Coupled WSe 2 Monolayer. In: *CLEO: QELS_Fundamental Science*. Optical Society of America; 2015:FTu1E - 5.