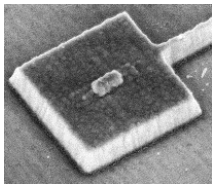
E3S Retreat
September 19, 2019

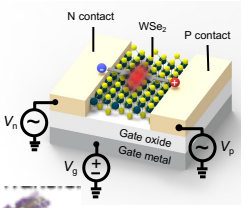
Theme III: Nanophotonics For Energy-Efficient Communications

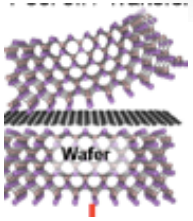
Theme Leader: Ming C. Wu

Current Theme Projects & PI's

➢ Optical antenna-enhanced nanoLED







- Electrical injection III-V antenna-LEDs
  [Wu, Yablonovitch, UCB; Kim, MIT]
- Monolayer TMDC antenna-LEDs
  [Javey, Wu, Yablonovitch, UCB]
- Heterointegration, remote epitaxy
  [Kim, MIT]



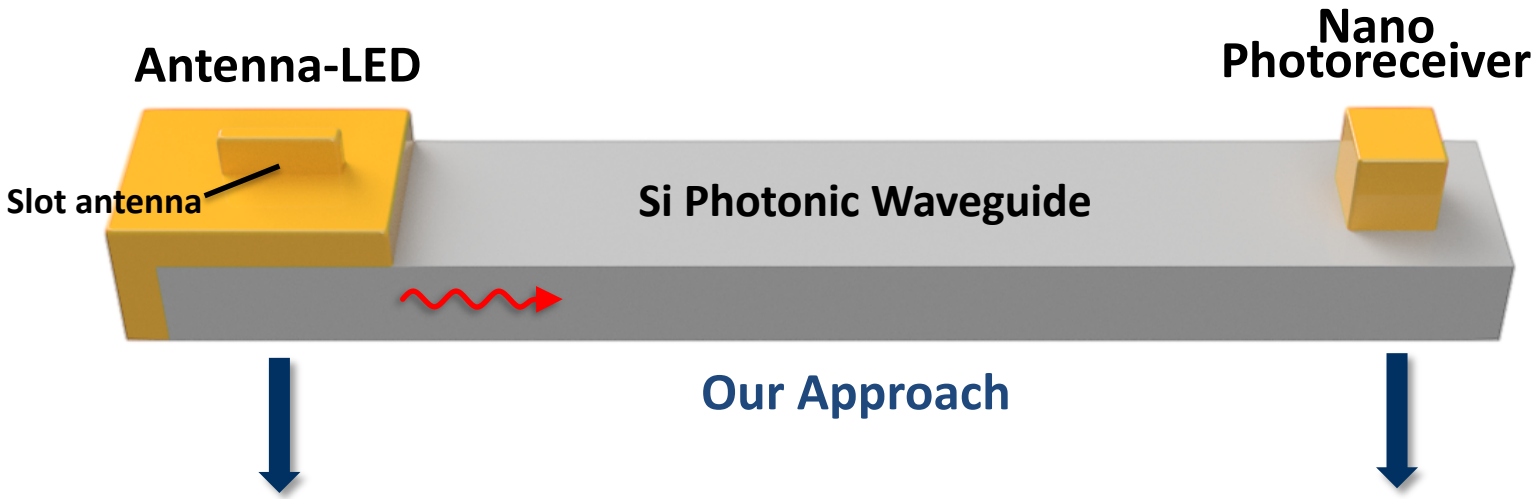

➢ Link modeling and system analysis
[Stojanovic, UCB]

Team Members

- **Graduate Students:**
  - **Nicolas Andrade, Sean Hooten, Shiekh Uddin, George Zhang (UCB)**
  - **Yunjo Kim, Kuangye Lu, Hyunseok Kim, and Sanghoon Bae (MIT)**
- **Postdocs:**
  - **Der-hsien Lien**
- **Alum**
  - **Recent: Matin Amani (Intel), Seth Fortuna (Sandia), Kevin Han (Berkeley)**
  - **Sujay Desai (Intel), Peida Zhao (Lam), Chris Heidelberger (MIT-Lincoln Lab), Indrasen Bhattacharya (KLA-Tencor), Kevin Messer (Magic Leap), Christopher Keraly (stealth start-up), Ryan Going (Infinera), Michael Eggleston (Bell Labs), Wilson Ko (OURS), Yue Lu (DiDi), Geun Ho Anh (PhD at Stanford)**

Energy efficient on-chip optical interconnect link

- **Current state of the art: 100+ fJ/bit**
- **Desired: < fJ/bit**



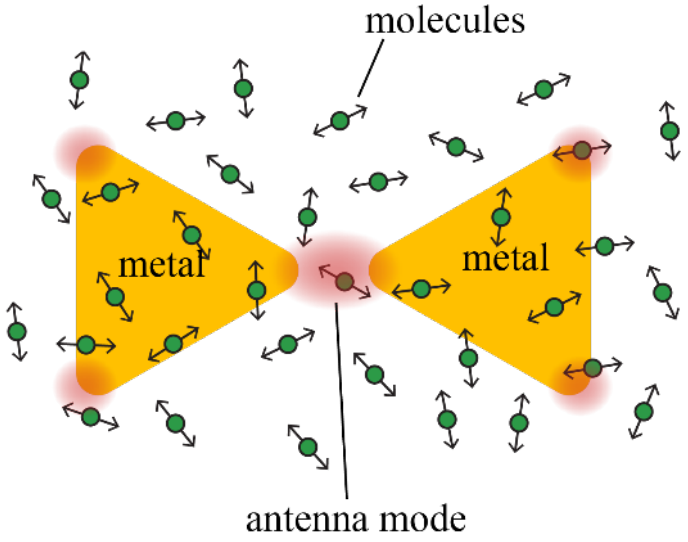
Antenna-Enhanced LED

- Nanoscale
- High efficiency
- Spatial coherence (single mode)
- Spontaneous emission faster than stimulated emission

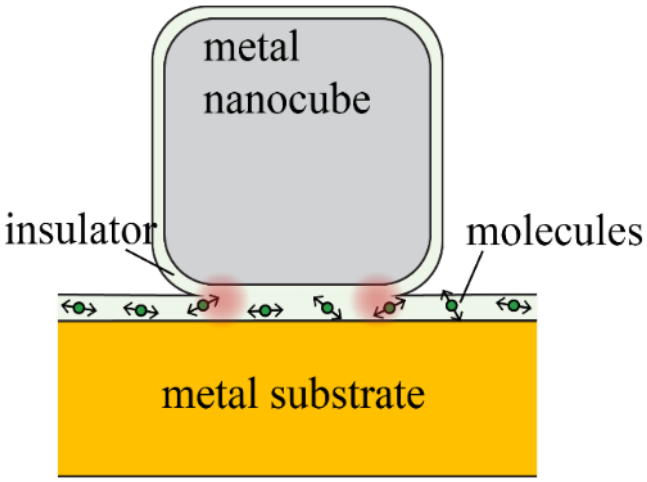
Photoreceiver

- Ultralow capacitance to enlarge photo signal

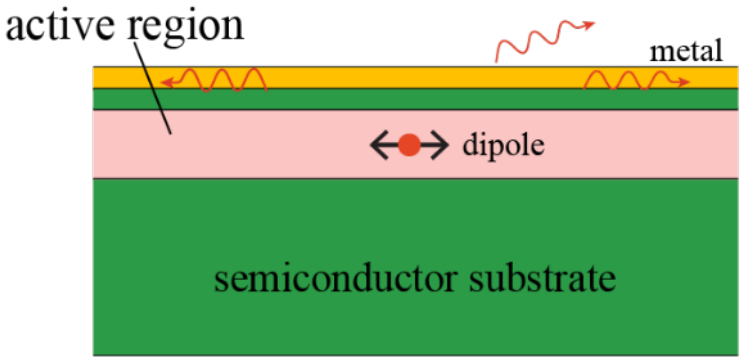
Examples of antenna-enhanced emitters



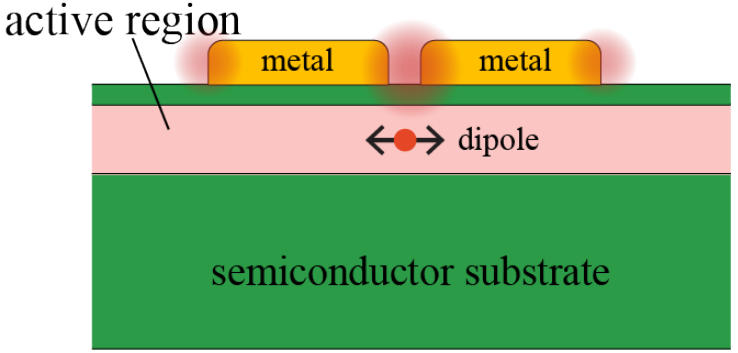
Kinkhabwala et al. Stanford. *Nat. Phot.* 2009.



Hoang et al. Duke. *Nat. Comm.* 2015.

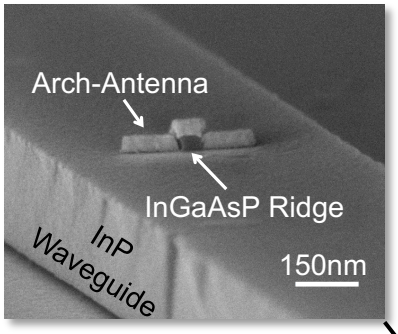


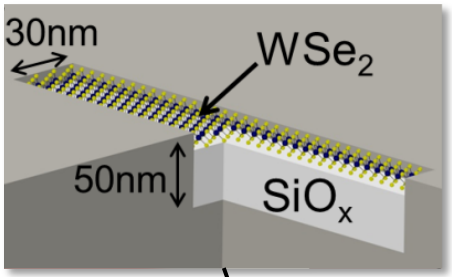
Okamoto et al. Nichia/Cal Tech. *Nat. Mat.* 2004.



Arbel et al. Technion. *Opt. Exp.* 2011.

Electrical Injection Antenna LED





Current Focus:

- Temporal response
- Efficiency
- Output power
- Waveguide coupling
- Link demo