



**Winter 2014 Joint Colloquium**

**Friday, March 21st, 2014**

**4:00 PM, ESB 1001**

**The Materials Department  
&**

**Materials Research Laboratory**

*Proudly Welcome...*

**NAKAMURA LECTURER**

**Dr. Claire Gmachl**

*Eugene Higgins Professor of Electrical Engineering*

**Princeton University**

## **Mid-Infrared Quantum Cascade Lasers and Applications**

### **Abstract**

Quantum Cascade (QC) lasers are a rapidly evolving mid-infrared and THz, semiconductor laser technology based on intersubband transitions in multiple coupled quantum wells. The lasers' strengths are their wavelength tailorability, high performance and fascinating design potential.

We will first give a brief introduction into QC lasers followed by a discussion of several recent highlights, such as the quest for high performance QC lasers and the implementation of unconventional laser schemes and new materials for intersubband devices. We will also briefly touch on several applications, such as field campaigns of QC laser-based sensing, and our recent work in non-invasive *in vivo* glucose sensing.

As an example for high-performance QC lasers, we examine lasers around 5 mm wavelength. A recent innovation lies in how the carrier injection into QC laser active regions is described; ultra-strong coupling between injectors and active regions is required, and the importance of interface roughness scattering is documented.

With respect to spectral innovations, a spectrally broadband QC laser based on a 'continuum-to-continuum' design will be presented. When this laser is put into an external cavity, a wide, continuous single-mode tuning range of well over 400  $\text{cm}^{-1}$  is achieved. Next we explore opportunities for obtaining single-mode and tunable emission without the need of dispersive gratings. Folded cavities, "candy-cane"-shaped lasers, and tunable Asymmetric Mach Zehnder cavities have all shown great potential for achieving single-mode emission at reduced fabrication complexity and cost.

Opportunities exist for broadening the spectral availability of Quantum Cascade lasers through the adoption of new material systems beyond the conventional InP- or GaAs-based ternary alloys. We will review our recent work in II-VI and III-nitride intersubband devices.

Finally, we provide a quick overview on QC laser applications; a recent advance is the demonstration of non-invasive glucose monitoring *in vivo* with near clinical accuracy.

The work presented is mostly supported by MIRTHE (NSF-ERC) with smaller contributions from other sources; the work has been conducted in collaboration with many valued colleagues in our own research group and across MIRTHE.



**HOSTED BY: PROFESSOR CHRIS PALMSTROM**

**LIGHT REFRESHMENTS WILL BE SERVED BEFORE THE  
SEMINAR AT 3:45**

