# 21st Century Optical Engineering: Manipulating Nonequilibrium Many Body Effects to Create new THz Devices

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**Abstract**: In this talk I will start with the basic principles of operation of semiconductor lasers and then describe in simple terms how laser light can be generated in a semiconductor device.
Applications of THz and MIR devices will briefly highlighted.

I will then compare and contrast conventional interband optics with intersubband optics and the frontier of microscopic design of semiconductor lasers: the quantum cascade laser. These are the most complex structures ever grown in a laboratory and some of them already have commercial applications. The need for advanced quantum statistical mechanics, many particle and nonequilibrium Physics to describe these devices will be explained. Results of our state of the art device simulator will be presented and the difficulties to create new mid infrared and THz devices will be explained. Both technological and mathematical/simulations issues will be addressed and the role of complex scattering mechanisms will be explained. It will be further demonstrated how we can now visually study the nonequilibrium charge distribution in the structure and use it to analyse potential design failures and re-design the lasers based on those studies.

A possible solution for intervalence THz gain without inversion is discussed.

I will close the lecture with a highlight on fundamental physic and demonstrate that the coupling between light and intersubband excitations in semiconductors is fundamentally different from the well understood coupling to interband transitions that leads to excitonic polaritons and a more general intersubband antipolariton concept is introduced.

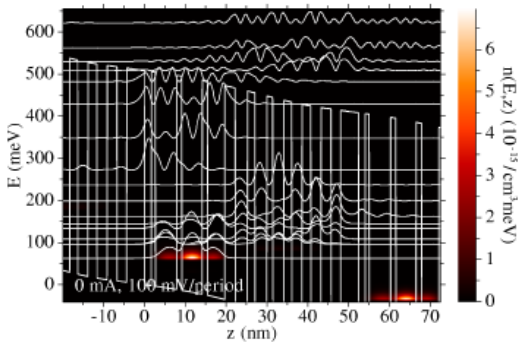


*Fig. 1a: Calculated energetically resolved electron concentration and modulus squared of 19 Wannier-Stark States for the central period under low bias[2] for the structure of Ref. [6].*

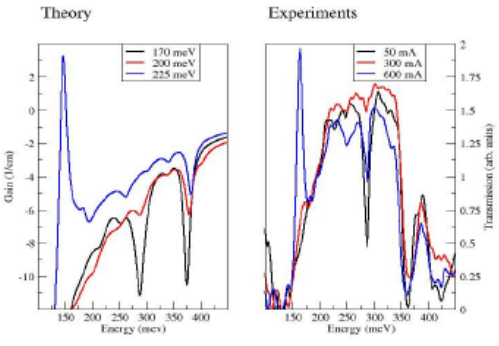


*Fig. 1b: Calculated gain per period (left) and measured transmisssion for different values of the biasing voltage (current) for the structure of Ref. [6] considering a phonon bath temperature of 78K.[1]*

***References***

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**Short Biography:** Mauro F. Pereira was born in Rio de Janeiro, Brazil and received the BSc in Physics at PUC/RJ in 1983 and the MSc in Physics in 1985. He completed the PhD in Optical Sciences at the Optical Sciences Center in Tucson/AZ in 1992 and received an equivalent Dr. Sci. degree in Physics from UFRJ in 1993. He was a Research Associate at PUC/RJ, CBPF, Uni-Rostock, and the TU-Berlin, an Invited Lecturer in Bremen, an Associate Professor at UFBA and a Senior Researcher at Tyndall National Institute before joining the Materials and Electrical Engineering Research Institute of Sheffield Hallam University as a Professor where he holds the Chair of Theory of Semiconductor Materials and Optics.

Highlight of forthcoming THz conference

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