TECHNISCHE UNIVERSITÄT WIEN
INSTITUT FÜR PHOTONIK
Photonics Institute
Gußhausstraße 27-29, 1040 Wien / Tel: +43 1 58801 38701 / http://www.tuwien.at/etit/photonik
fke
Institut für Festkörperelektronik

SEMINAR

Prof. Dr. Gérald Bastard

Physics Department ENS-PSL, Paris, France
Würzburg University, Germany

Thermionic electron cooling in asymmetric double barrier structures

Increasing down - scaling of semiconductor devices leads to overwhelming power dissipation and heat production in devices (see e. g. [1]). Recently, heterostructures where the electronic temperature can be decoupled from and made lower than the lattice one were realized [2,3]. The asymmetrical double barrier (ADBS) heterostructures under an applied external bias have proven very effective since at room temperature the electronic temperature in the well could be made lower than the lattice one by several tens of degrees. This is because cold electrons are injected in the well by resonant tunnelling while hot electrons are extracted from the well by LO phonon absorption.
We shall review the experimental efforts underlying the electron cooling in these devices The modelling of the cooling effects uses either Non Equilibrium Green Function technique [4] or the rate equation approach [5]. There is a good agreement between NEGF modelling and experiments.In the last part, we shall discuss the generalization of the ADRS to “Quantum Cascade Coolers” where further electron cooling has been observed when there are several quantum wells in the tunnelling structures. Issue regarding the QW electrons heating by “residual” 3D electron gases have poped up.
This work results from an excellent collaboration between IIS Tokyo (Kaz Hirakawa), Marseille University (Marc Bescond) and ENS

[1] E. Pop and K. E. Goodson, J. Electron. Packaging 128, 102 (2006)
[2] A. Yangui, M. Bescond, T. Yan, N. Nagai and K. Hirakawa, Nat. Commun. 10, 4504 (2019)
[3] X. Zhu, M. Bescond, T. Onoue, G. Bastard, F. Carosella, R. Ferreira, N. Nagai, and K. Hirakawa, Phys. Rev. Applied 16, 064017 (2021)
[4] M. Bescond, G. Dangoisse, X. Zhu, C. Salhani and K. Hirakawa. Phys. Rev. Applied 17, 014001 (2022)
[5] Rate equations description of the asymmetric double barrier electronic cooler
A. Philippe et al. Journ. of Applied Physics 2023

Thursday, 9th January 2025, 16:00h c.t.

Seminarraum 387 (CBEG02) - Institut für Photonik
Gußhausstraße 27-29, 1040 Wien

HOST: Karl Unterrainer
karl.unterrainer@tuwien.ac.at