Nanotek-2013

OMICS Group Conferences
Accelerating Scientific Discovery

3rd International Conference on
Nanotek & Expo

December 2-4, 2013 Las Vegas, USA

Optoelectronics with nanowires and quantum dots

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Abstract

In this talk, I will discuss electrical and optical properties of infrared photodetectors based on self-assembled III-V semiconductor nanowires and quantum dots with possible applications in optical communication and thermal imaging.

The photodetectors operating at near-infrared wavelengths are fabricated from self-assembled ensembles of vertical p-i-n InP nanowires grown on p-InP substrates. The nanowire junctions display excellent rectifying behavior with small leakage currents. The detailed spectral signatures of the photocurrent depend on the length of the n- and p-segments in the NWs, temperature and polarization of incident radiation. Without p-segment, the main photocurrent contribution comes from an efficient funneling of photogenerated carriers from the substrate into the nanowires. Increasing the p-segment length instead leads to a dominant generation of photocurrent in the nanowires, in agreement with sophisticated modeling. Since III-V nanowires can be monolithically grown on Si, we believe that a subsequent integration of our nanowire detectors on silicon offers a viable route to on-chip optoelectronics in line with the ”More than Moore” concept.

I will also discuss electrical and optical characteristics of long-wavelength infrared photodetectors based on intersubband transitions in self-assembled InAs quantum dots embedded in multiple $In_{0.15}Ga_{0.85}As/GaAs$ quantum wells. The detailed electronic structure of the dots and well was determined from combining photoluminescence (PL), PL excitation (PLE) spectroscopy and tunnel capacitance spectroscopy. Intersubband photocurrent spectroscopy revealed a dominant transition at 8.5mm between the ground state of the quantum dots and the excited state of the quantum well. The spectral window of the detectors can be effectively tuned with the applied bias. Results from 3D calculations of the electronic structure, including effects of composition intermixing and inter-dot interactions, confirm the experimentally unraveled energy level scheme of the dots and well.

Biography

Pettersson received his PhD in Solid State Physics from Lund University, Sweden, in 1993. Between 1997 and 1999 he did a postdoc at the Ludwig-Maximilans-University in Munich, Germany. Prof. Pettersson´s research field was initially spectroscopy on deep impurities in semiconductors, in particular silicon. Subsequently, he changed his research focus to nanoscience, and in particular to studies on electrical and optical properties of nanoscale optoelectronics. More recently, he has broadened his research focus to include also nanospintronics. He currently holds a position as Prof. of physics and Head of the Dept. of Mathematics, Physics & Electrical Engineering at Halmstad University, Sweden.