Nanostructures Research Group

25 years
1983-2008
Ultra-Short Channel MESFETs & HEMTs

25 nm HEMT
Ultra-Short Channel MESFETs & HEMTs

Onset of overshoot

167 GHz
InP MOSFET

InGaAs p-HEMT

Predictions for Today’s $\text{In}_{0.75}\text{Ga}_{0.25}\text{As} \ p$-HEMTs
Lateral Surface Superlattices
Large Arrays of Quantum Dots

- Established period band structure at both low and high magnetic fields
- Cooperative effects and shifts of energy in applied bias demonstrated

160 nm period lateral superlattice on AlGaAs/GaAs heterostructure

Prog. Quantum Electron. 16, 251 (1992)
Poly-Si Based Single-Electron Devices
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Device 1

- $V_D = 0$ V
- $t_H = 60$ s
- $t_D = 100$ ms

Device 2

- $V_D = 0$ V
- $t_H = 60$ s
- $t_D = 100$ ms

Graphs showing current ($I_D$) against $V_{DS}$ for different temperatures (4K, 7K, 40K, 77K, 300K) for Device 1 and Device 2.
MOS-based Nanodevice
Dot 1

Position of peaks does not change with the drain bias--this indicates role of single electron charging.
Charging characteristics:
Peak positions “crossover” possible

\( V_{tg} = 3.1 \text{ V} \)

20 mV steps

\( V_{tg} = 2.96 \text{ V} \)
Introduction

Scanning gate microscopy (SGM)

Metalized AFM tip with negative bias applied.

Detection of:
- local potential
- local charge
- local current distribution

Imaging of Current flow from QPC

M.A. Topinka et al., Nature 410, 183 (2001)
Cryogenic SPM System

Piezo resistive cantilever
  Ptlr coated tip
  Biased up to –3 V
Scan mode
  Contact mode for topography
  Lift mode for SGM

Cryogenic SFM head by Omicron
Scan window = 20 μm x 20 μm at RT,
decreasing 2.7 μm at 0.3 K

He³ cryostat by Janis
Base temperature: 0.27 K
Isolators by Minus-K
< 0.5Hz resonant freq.
Measurements in a Quantum Point Contact

1.5 $G_0$

(700 nm $\times$ 700 nm)

Resistance image

0 T

200 mT

0.4 $G_0$

High pass filtered
Imaging Incompressible States in QHE

Cross section at the center of image

Self-consistent electrostatic picture of IQHE

Imaging of incompressible edge state?

And the future holds…

- Transition of NRG into a Center within AINE, designed to couple the nanoelectronics activities within EE to the nano-physics thrusts within the Physics Department
- Expand simulation activities to more devices as part of the Computational Science Center
- Transport in new materials (graphene, oxide heterojunctions, nanowires, …)
- Continue SGM studies of quantum coherence in quantum dots