SAND2006-5222P

Molecular Beam Epitaxy

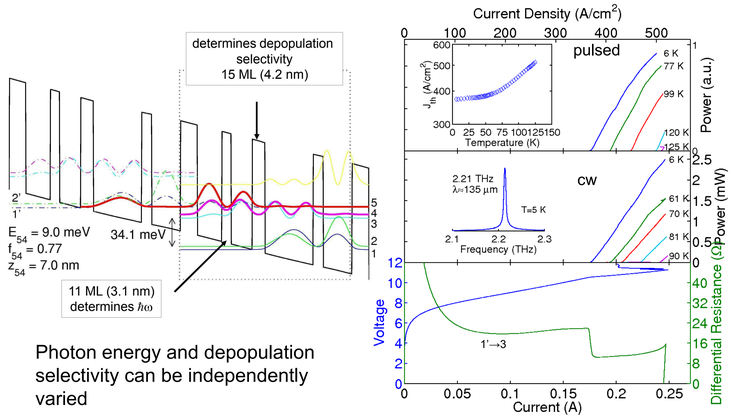
MBE AlGaAs Growth of:

- **High Purity Materials**
- **High Mobility Materials**
- **High Precision Composition and Thickness Controlled Materials**

Present Research Applications:

- **Quantum Transport**
- **Quantum Wires**
- **Quantum Point Contacts**
- **Intersubband Transitions**
- **Bloch Oscillators**
- **Quantum Cascade Lasers (THz and IR)**
- **Plasmon THz Detectors**
- **QWIPs**

2.2 THz (λ=135 μm) Resonant-Phonon QCL



Photon energy and depopulation selectivity can be independently varied

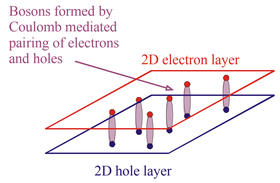
T_{max} = 128 K (pulsed)
T_{max} = 93 K (CW)

$k_B T_{max} = 1.2 \times \hbar\omega$

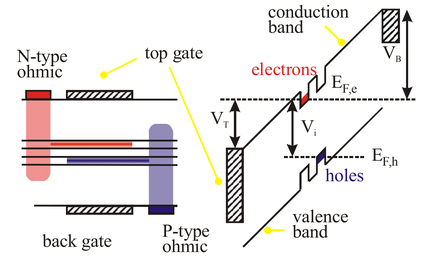
Search for exciton condensation in electron-hole bilayers

Search for superconducting transition requires:

1. closely spaced layers
2. low density
3. low temperature
4. high mobility



Implementation based on undoped GaAs heterostructures



1D-1D tunneling spectroscopy in coupled quantum wires

Why Sandia: Unique capabilities in state-of-the art semiconductor material growth, and semiconductor nanostructure fabrication.

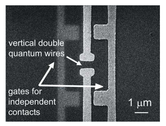
The Science Question: Can electrons be precisely controlled and manipulated at the wavefunction level?

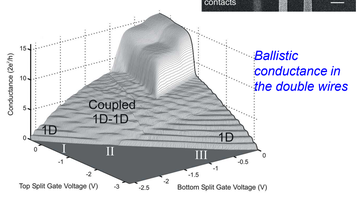
Accomplishment: We have measured quantum electron tunneling between two 1D wires, whose quantized energy levels can be independently controlled.

What is the progress/answer: The tunneling data shows a complex pattern that reflects energy subband occupations in a systematic way. This clearly demonstrates precise control of electron nanostructures at the wavefunction level.

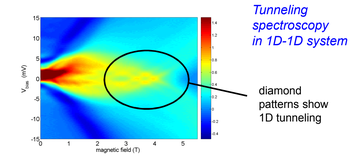
Why it matters: This work demonstrates a new technique for approaching nanoscale physics questions, such as if 1D electron systems are Fermi liquids or novel collective states of matter. It could also impact quantum computing.

Vertically coupled semiconductor quantum wires





Ballistic conductance in the double wires



Tunneling spectroscopy in 1D-1D system

diamond patterns show 1D tunneling

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