Quantum Wave Transistor: Demonstration of manipulation of electron wave in a nanometer-scale, ballistic, semiconductor waveguide

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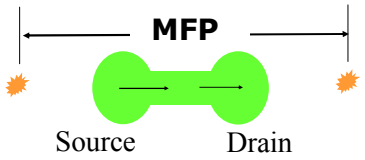
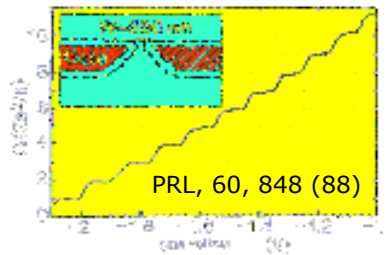
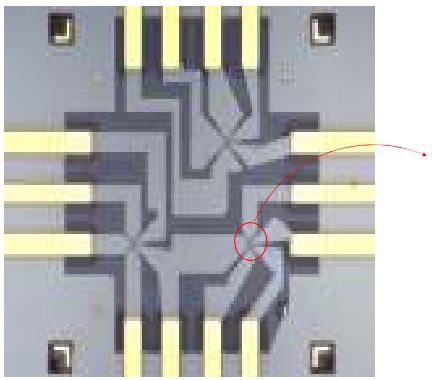
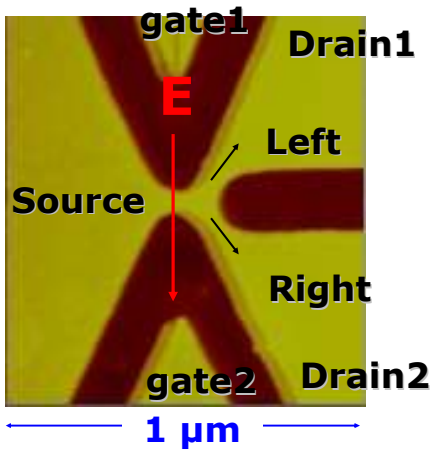
- What happens to a field-effect transistor when it is downsized to nanometers?
- Answer: If the "device length" < MFP (elastic mean free path), quantum wave phenomena dominates ➔ ballistic, phase coherent, Bloch-wave transport



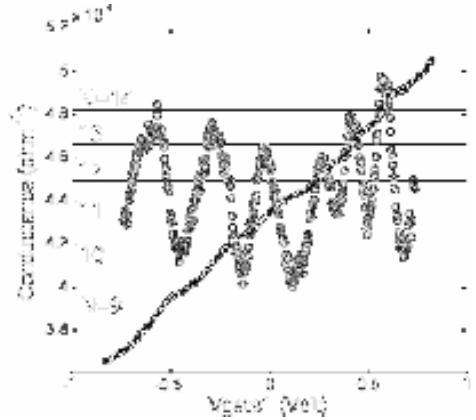


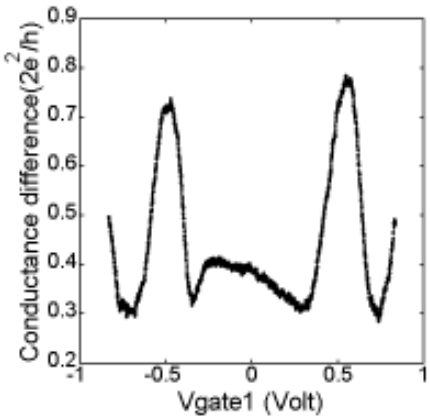
- We demonstrate this key concept using the InAs quantum wire system; to distinguish the quantum wave behavior from the classical ON-and-OFF characteristic, the transistor is patterned into a Y-shaped waveguide, i.e., a quantum mechanical version of the differential-pair amplifier.





- Our YBS shows oscillatory conductances; the oscillatory conductances are nearly 100% anti-correlated, and this feature provides the first direct experimental evidence of quantum mechanical switching of electron waves in a transistor.





- Potential applications:
- THz (1ps) electronics;
- Low-power coherent wave manipulation;
- Spin phase coherent transport for quantum information processing;
- The transport physics is applicable to any one-dimensional electron waveguides such as carbon nanotubes, semiconductor nanowires, and molecules.