Introduction to RTDs: Realistic Doping Profiles

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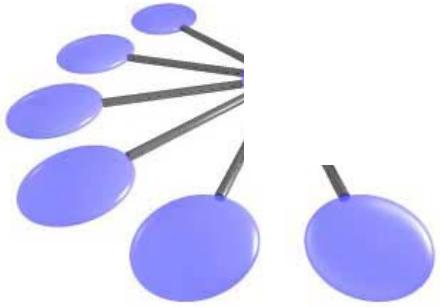
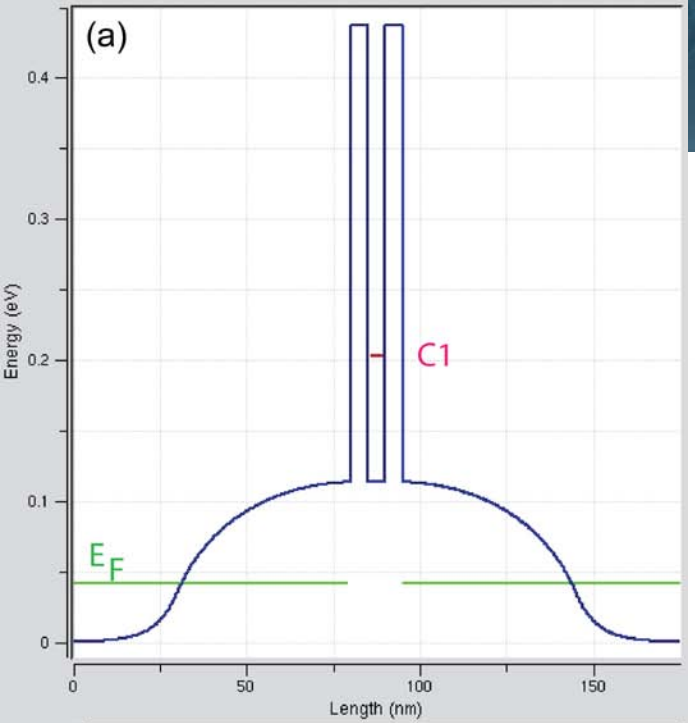
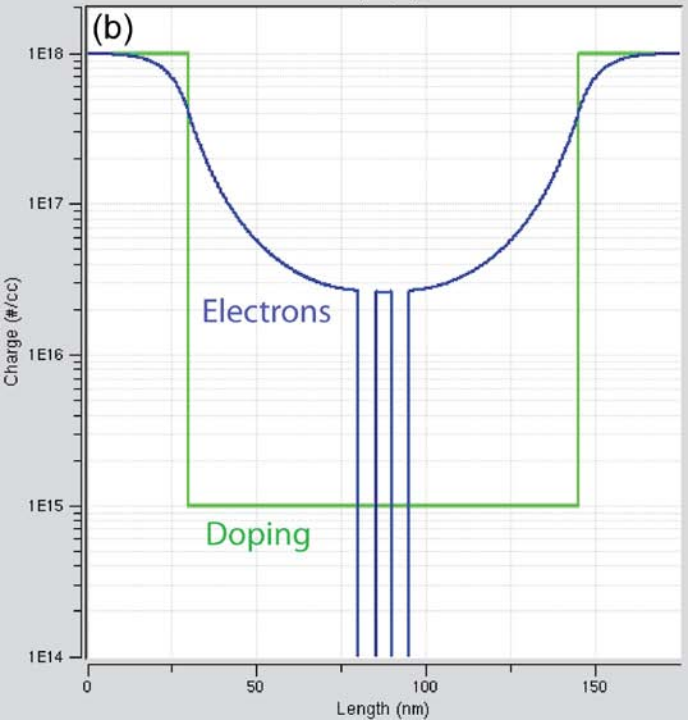


RTD Conduction band profile with realistic doping profile



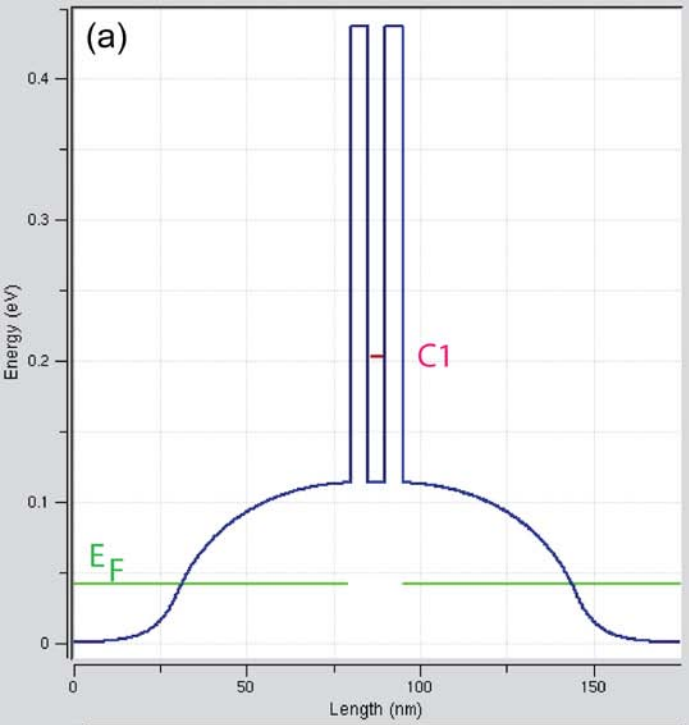


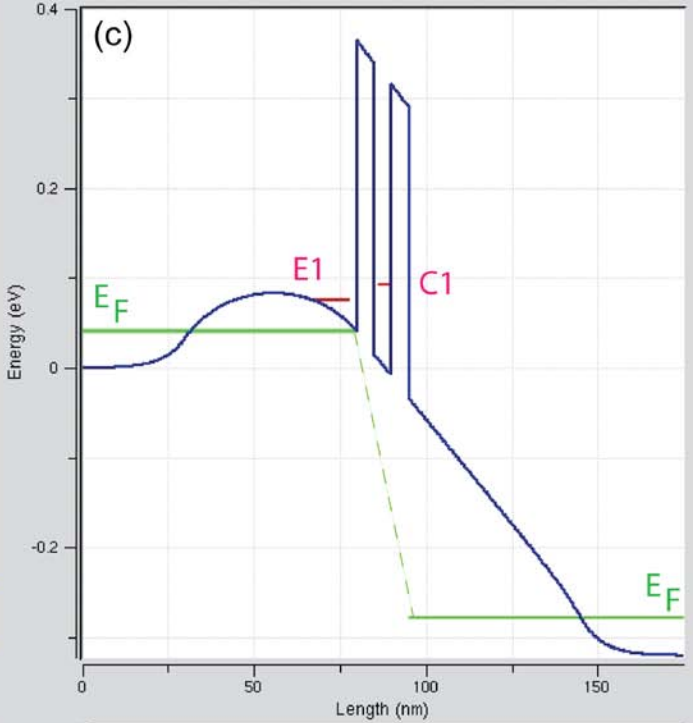
- Need extremely high doping for high current densities
- Impurity scattering can destroy the RTD performance

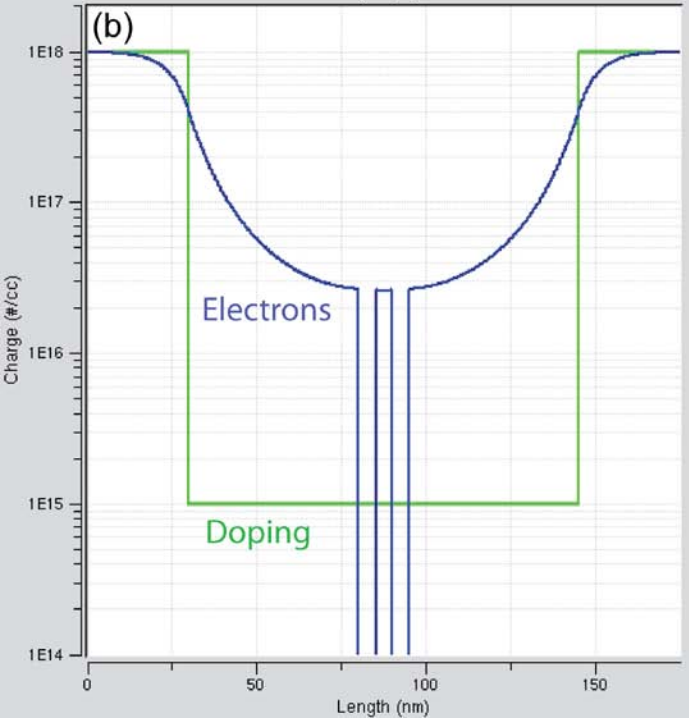
=> undoped spacer 20-100nm

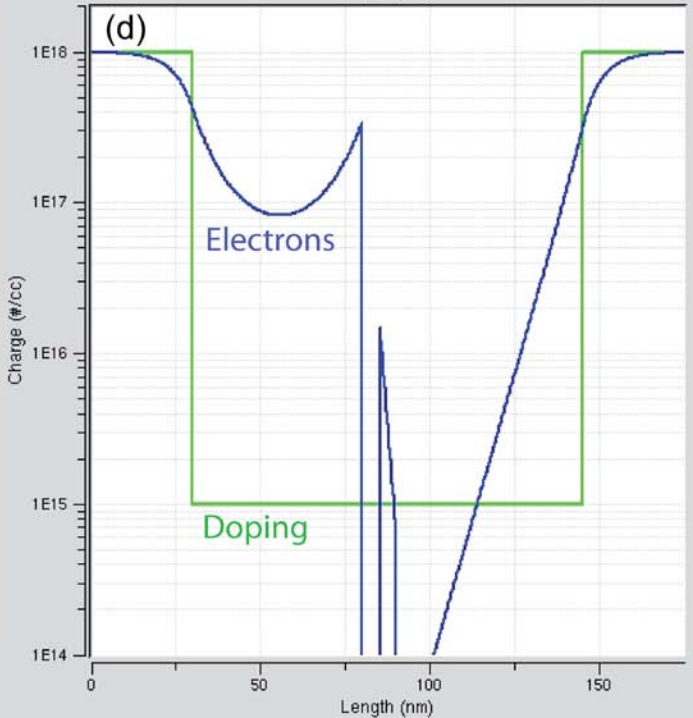
- Electrons diffuse from high density contacts to low density RTD
- Potential floats up to repel the electrons
- Overall RTD is raised above the Fermi levels

0 and 0.32V bias





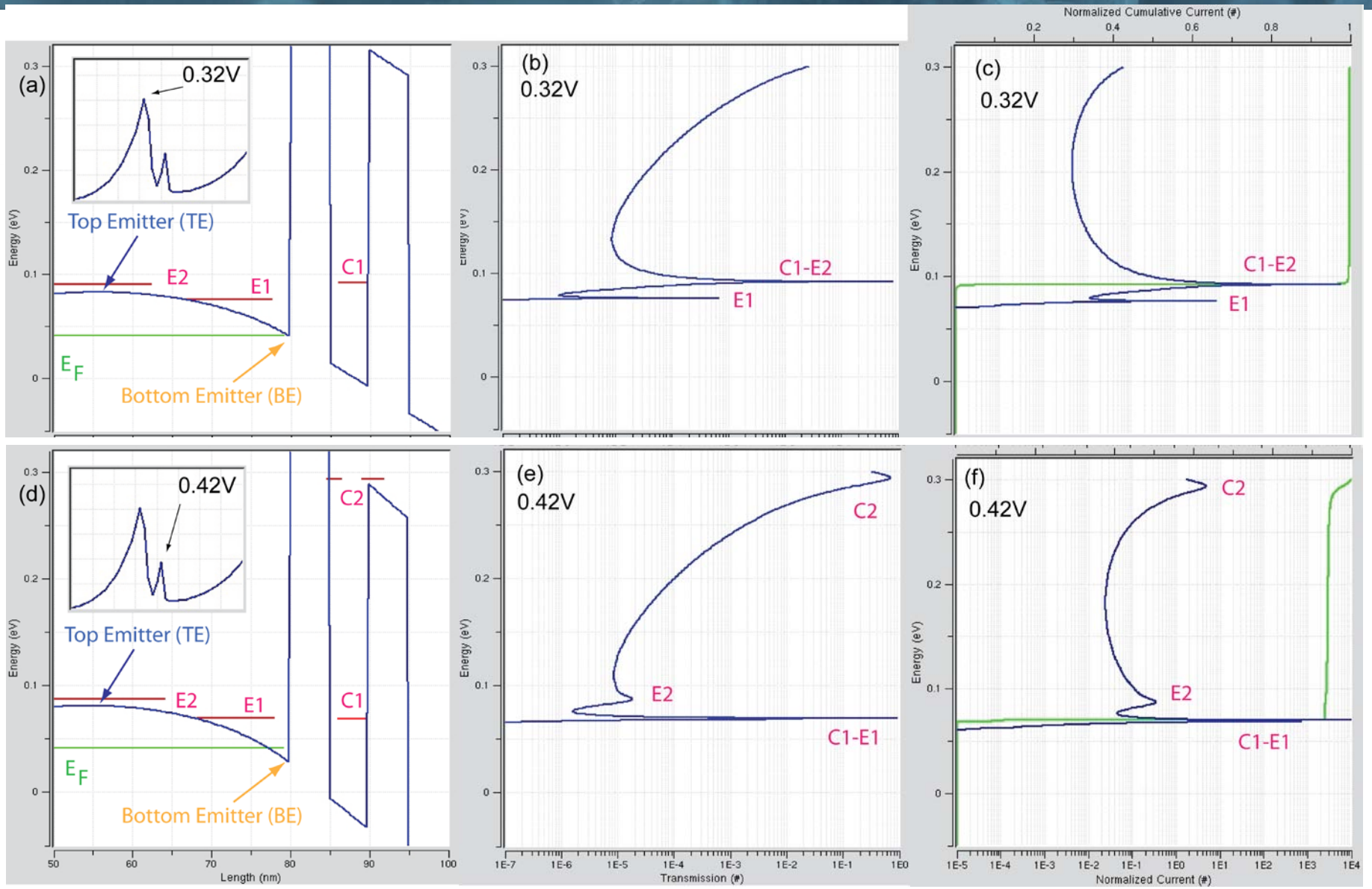




Under Bias;

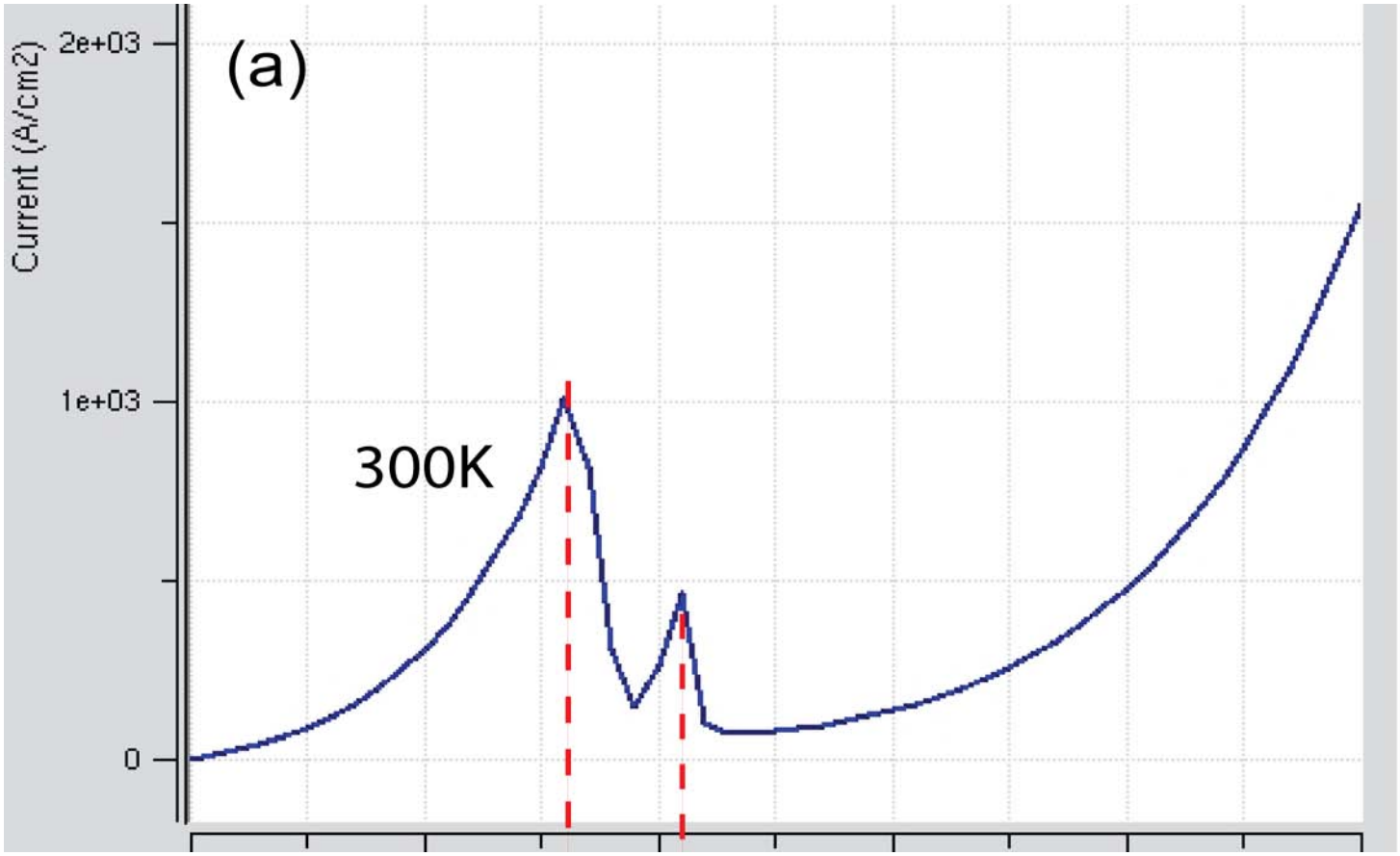
- triangular quantum well in emitter.
- charge build-up against the RTD in emitter
- charge depletion on the collector side.
- charge shows a strong spike which cannot occur in reality due to the wave-nature of the carriers.

Interaction the triangular well states and the central RTD



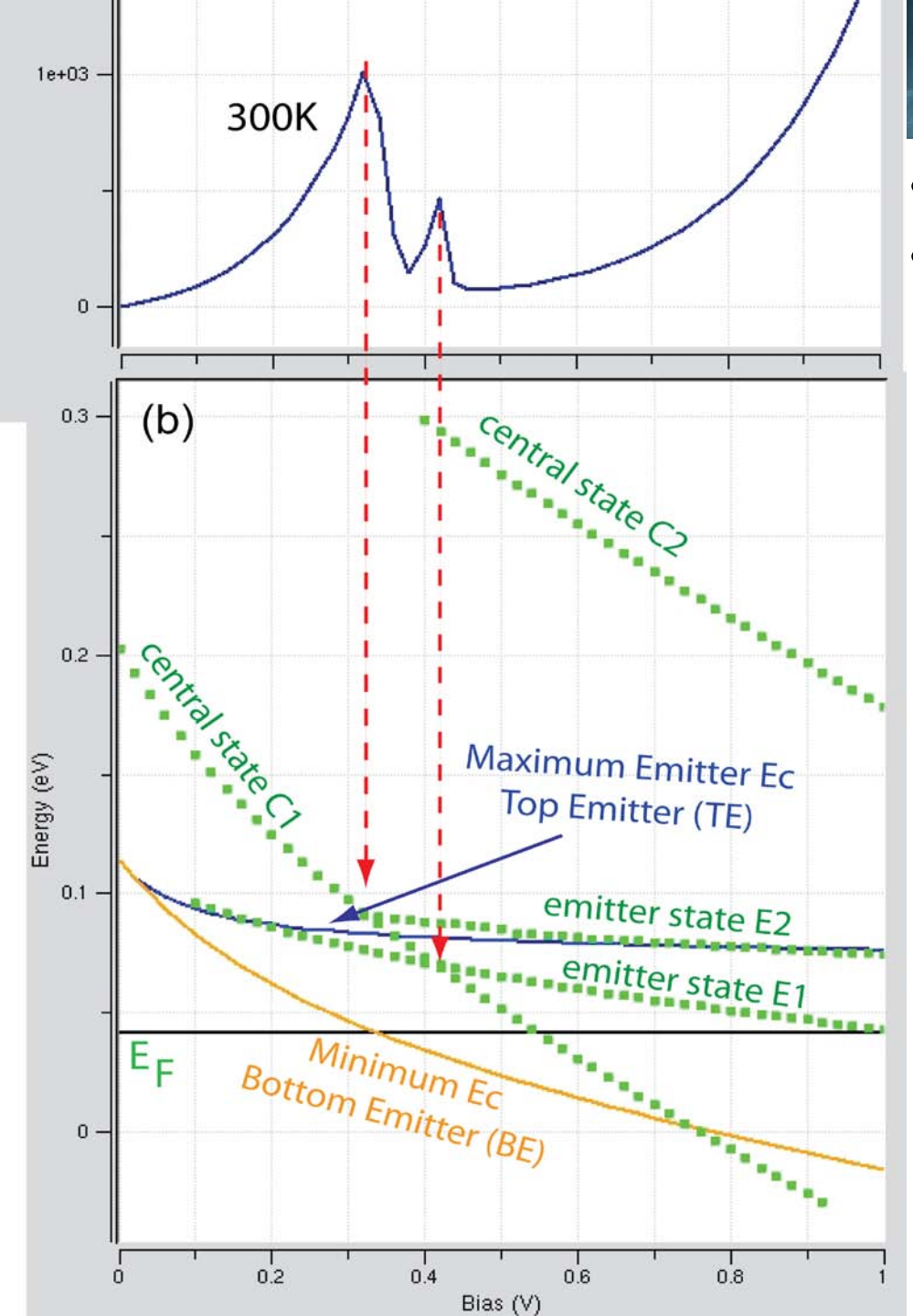
Current-Voltage characteristic

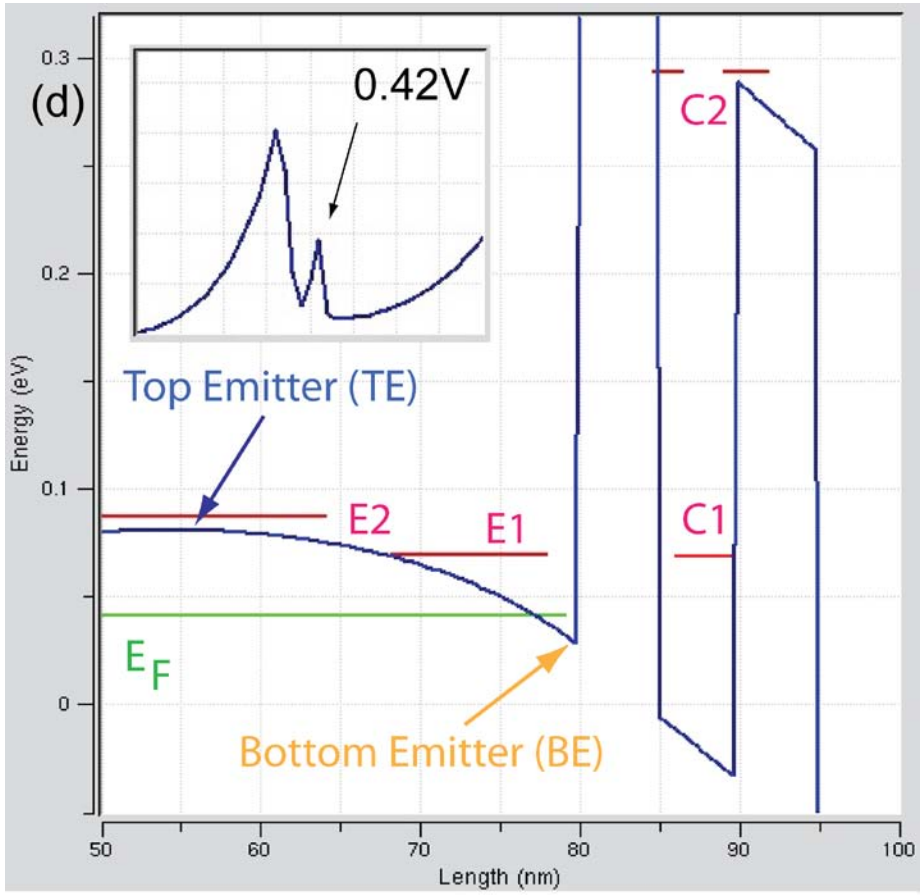
- Multiple peaks are visible.
- Central resonance probes the states in the emitter



Current-Voltage characteristic and trace of resonance energies

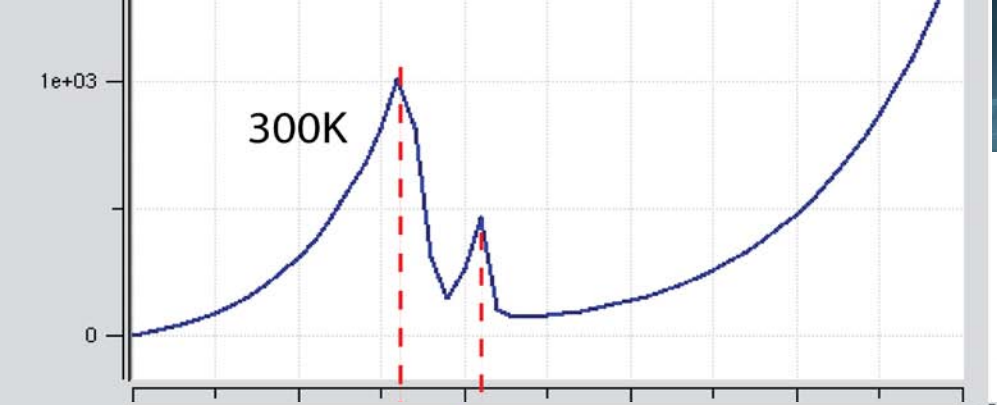
- Multiple peaks are visible.
- Central resonance probes the states in the emitter

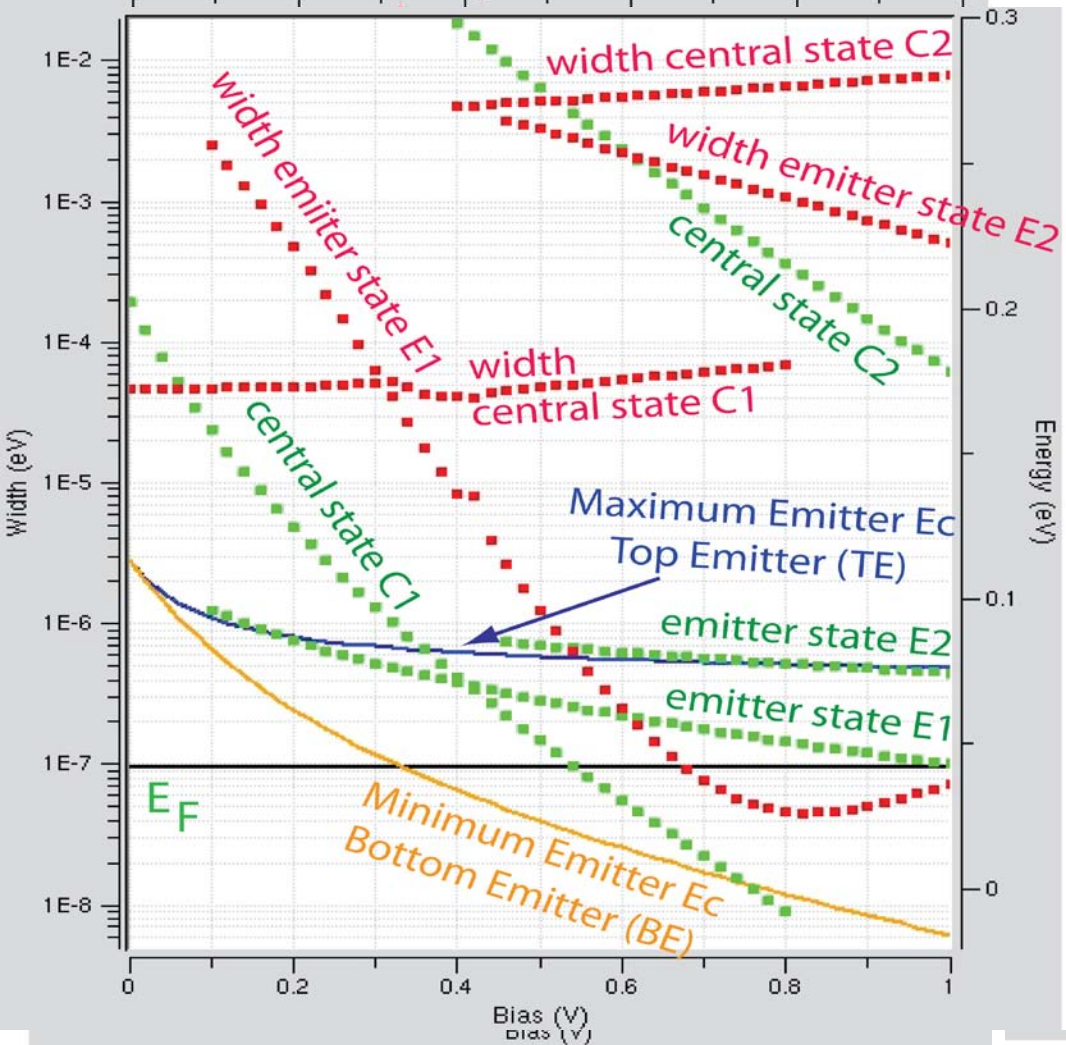


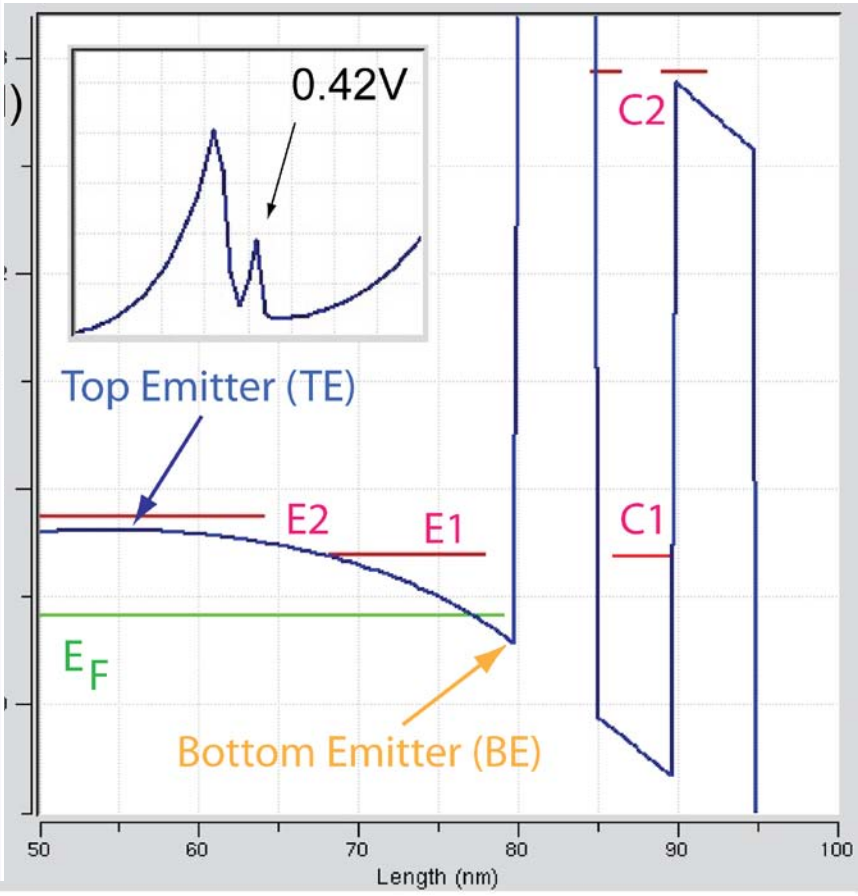


Bias Dependence of Resonance Widths

- Width of C1 ~0.4meV weak bias dependence
- Width of E1 varies exponentially with bias! Can become VERY narrow Truly bound state!







Conclusions

- Realistic RTDs have a non-uniform doping profile that keeps dopants away from the central RTD to avoid ionized impurity scattering
- The non-uniform doping profile results in a non-uniform electrostatic potential profile above the Fermi levels in the high contact regions
- An applied bias causes a potential drop not only in the central RTD region but also in parts of the emitter. That potential drop in the emitter creates a triangular potential well.
- The tri-angular potential well in the emitter binds quantum mechanical states which can interact with the central RTD states.
- The quasi-bound emitter states resonance widths vary exponentially with the applied bias and can become extremely narrow.