3D Simulation of Ge/SiGe Electro-absorption Modulator

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Introduction

- Si-compatible optical components are critical for integrating photonics with CMOS electronics
- Strained Ge/SiGe quantum-wells with type-I band alignment could be used as optical modulator at 1.55um
- Quantum-confined Stark effect of Ge/SiGe QWs grown on Si substrate was observed in experiments

Theoretical models

- 3D coupled electric and optical simulations
- Self-consistent calculation of Shrodinger and Poisson equations for QCSE
- k.p model for multi-band structure

Device structure

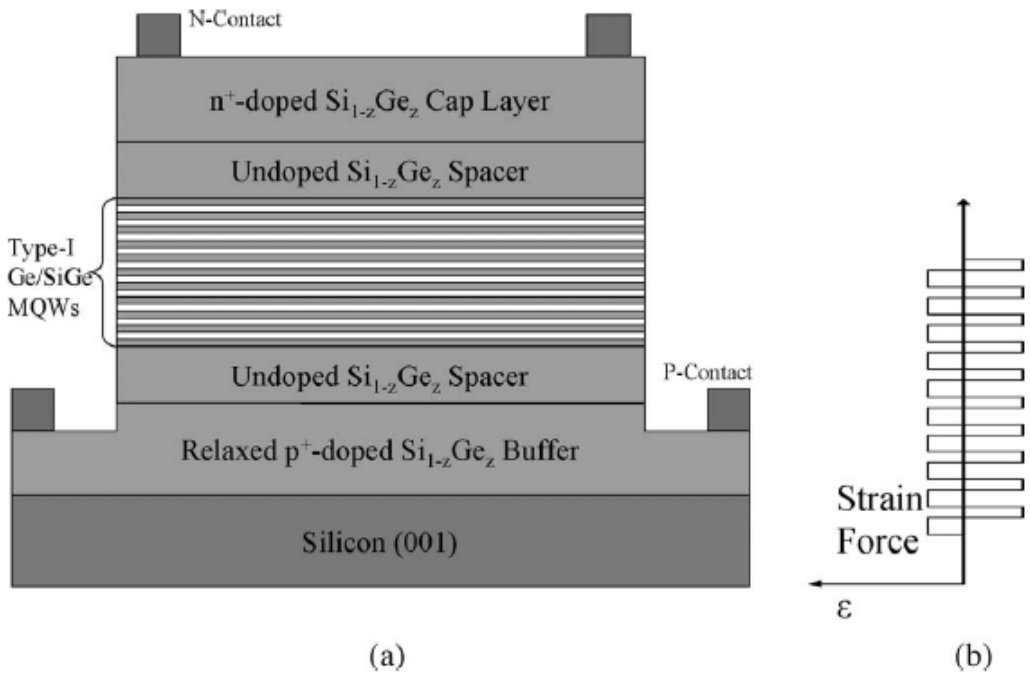

Fig. 1. (a) A p-i-n structure on silicon with Ge/Si_{1-x} Ge_x quantum wells on relaxed Si_{1-z} Ge_z buffer. (b) Compressive and tensile strain forces are balanced in each quantum well pair, so no strain energy is accumulated.

J. Sel. Top. Quan. Elec. V12, p1503 2006

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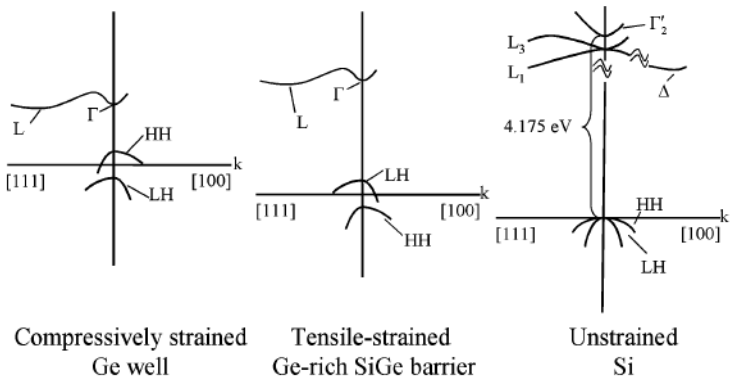
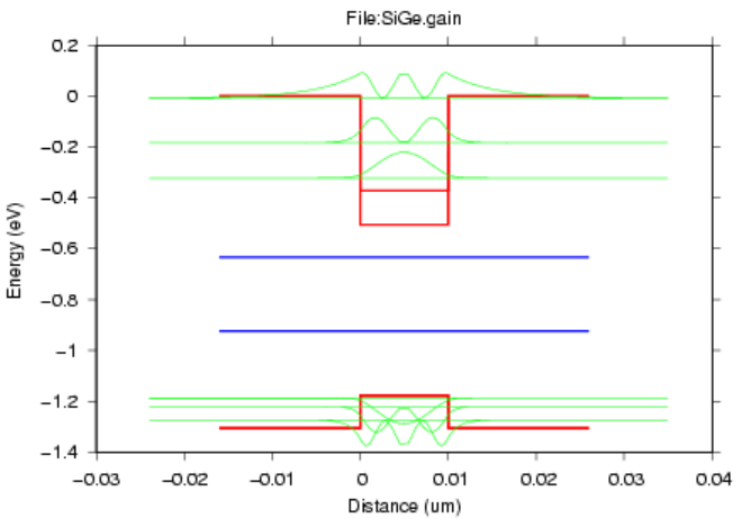
Direct Band gaps of strained Ge and SiGe





Compressive strained Ge well and tensile-strained $Si_{0.15}Ge_{0.85}$ barrier are used

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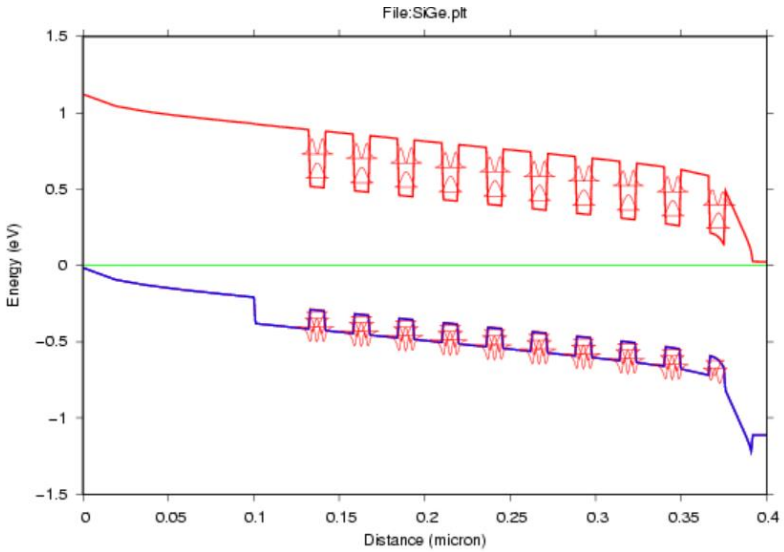
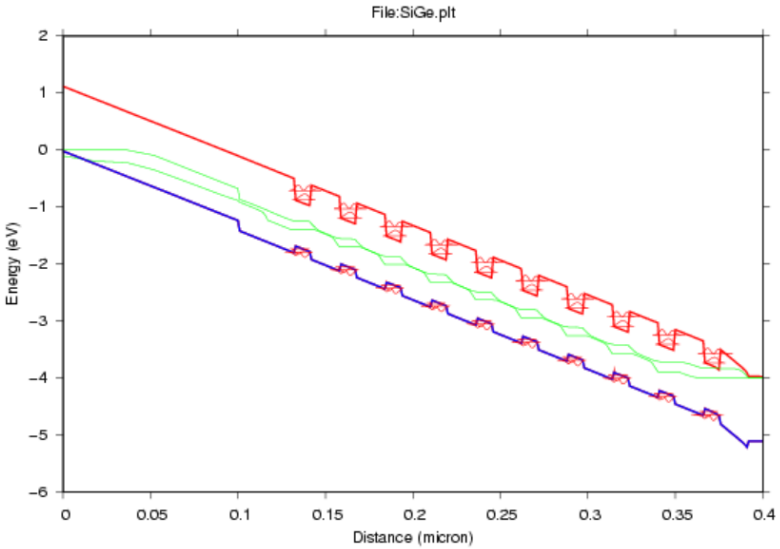
Band diagram



At 0V



At 4V

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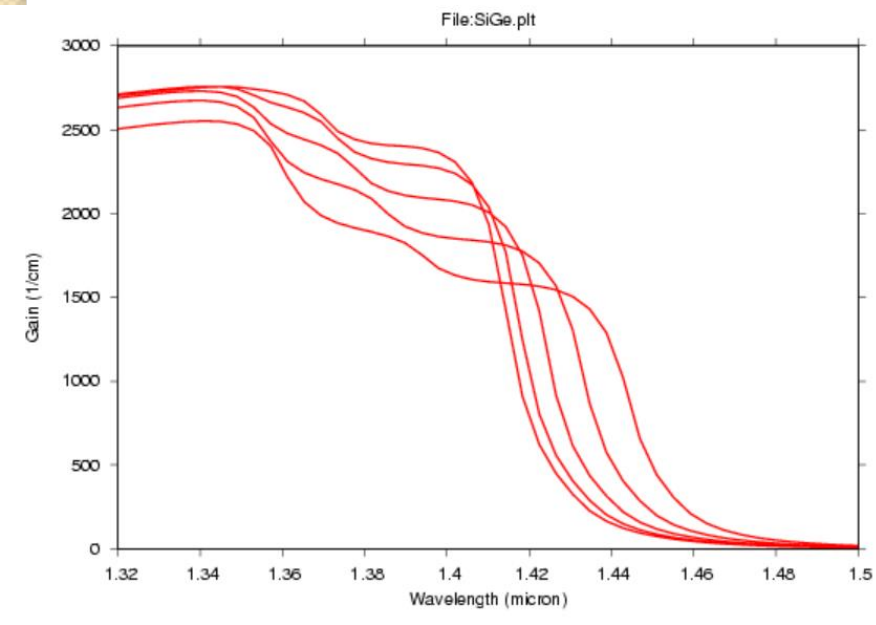
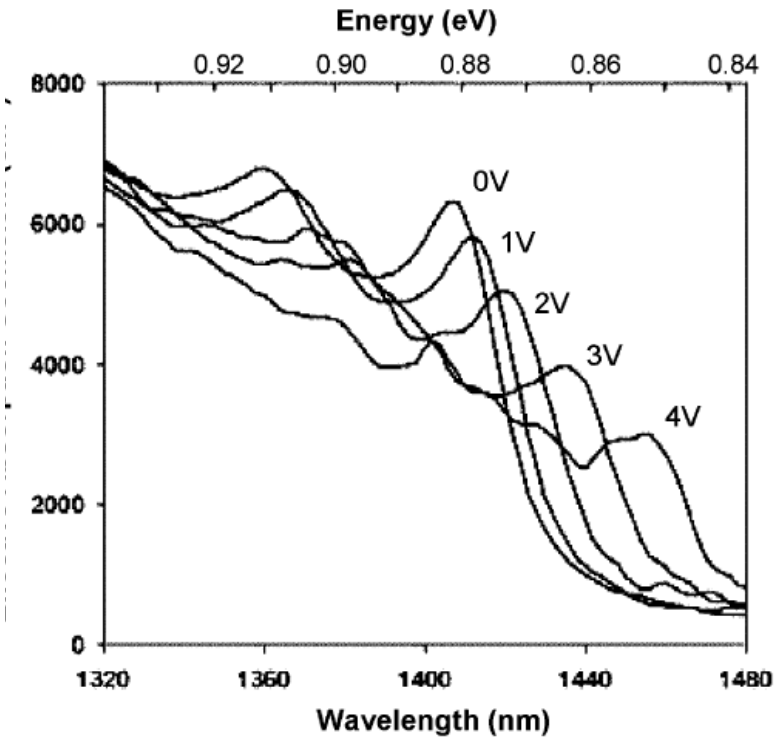
Absorption spectrum





Calculated

Experiments

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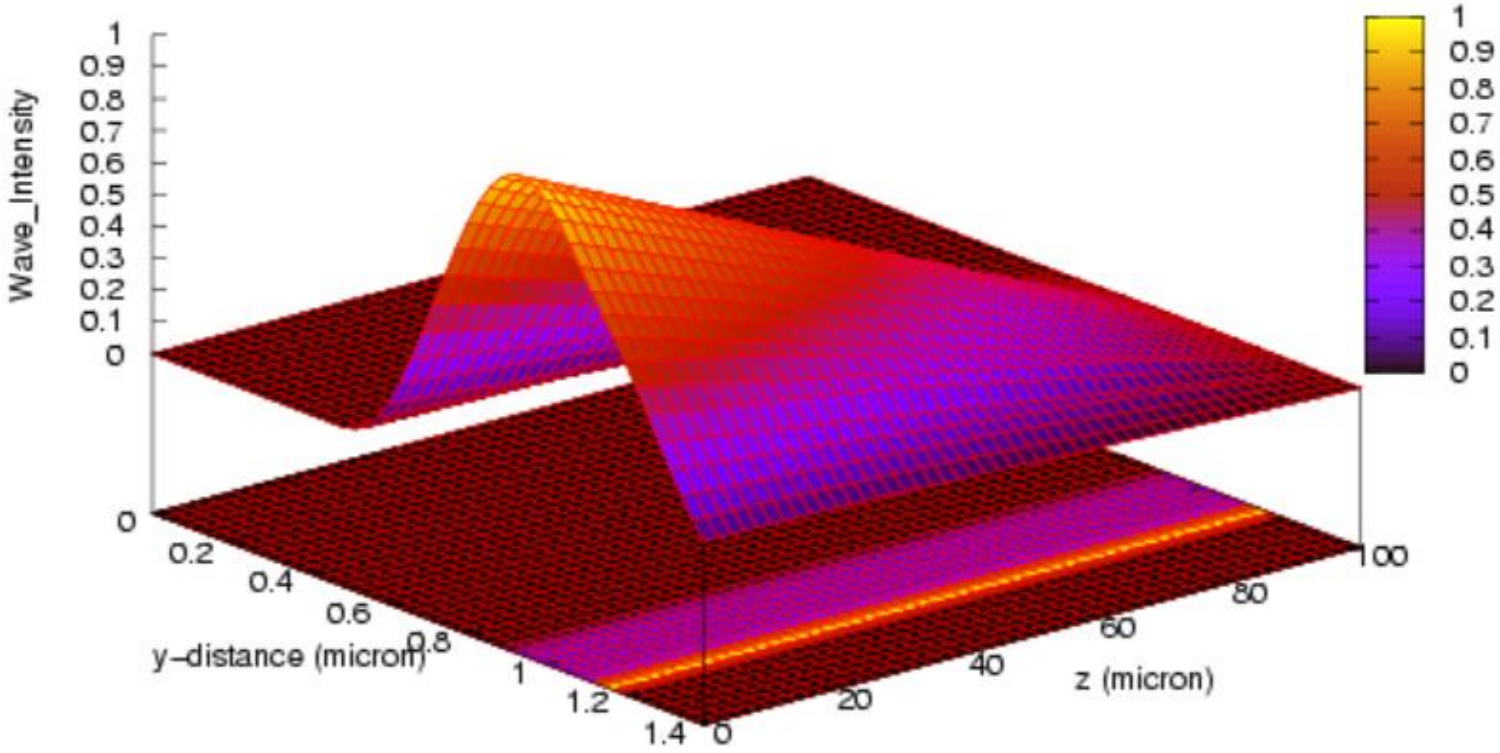
3D wave intensity



At 4V

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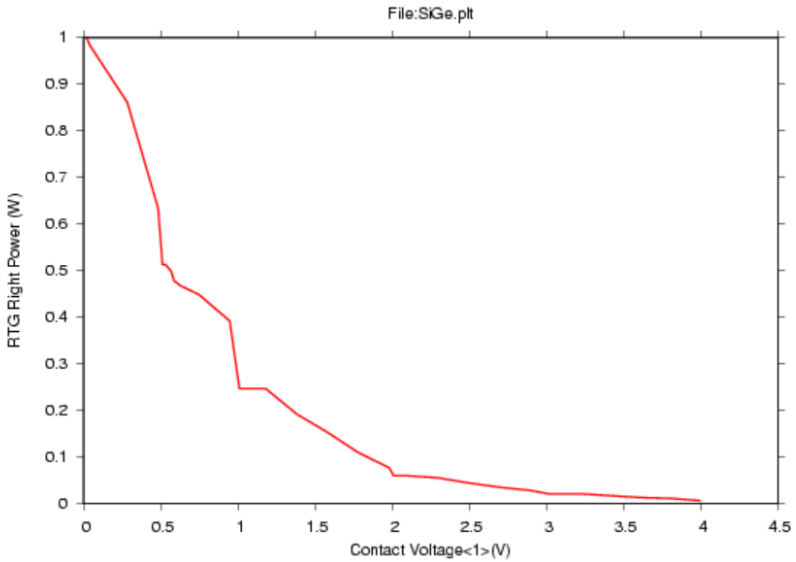
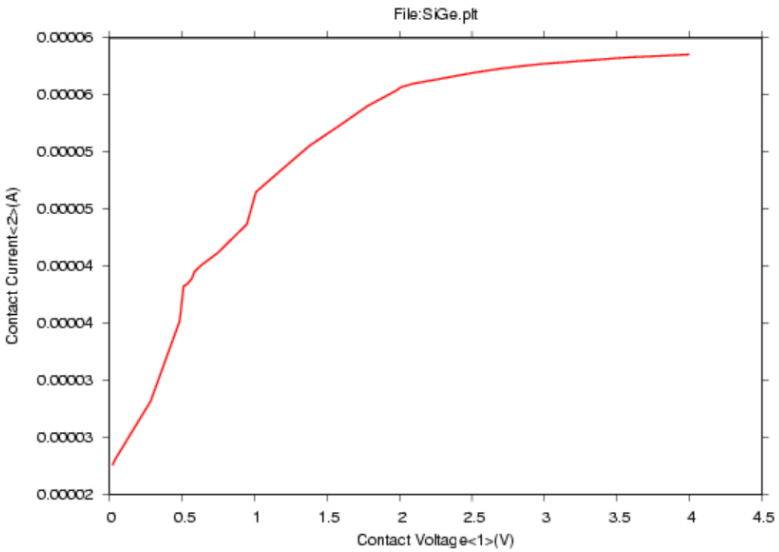
Optical power and photo-current vs. voltage





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