Time Resolved X-ray diffraction from Laser Induced Strain Propagation in Epitaxial Thin Films

S. Lee, D. Fritz, A. Cavalieri, and D. A. Reis
FOCUS Center, University of Michigan, Ann Arbor, M.I., U.S.A

R. Hegde and R. S. Goldman
Materials Science and Engineering, University of Michigan, Ann Arbor, M.I., U.S.A.

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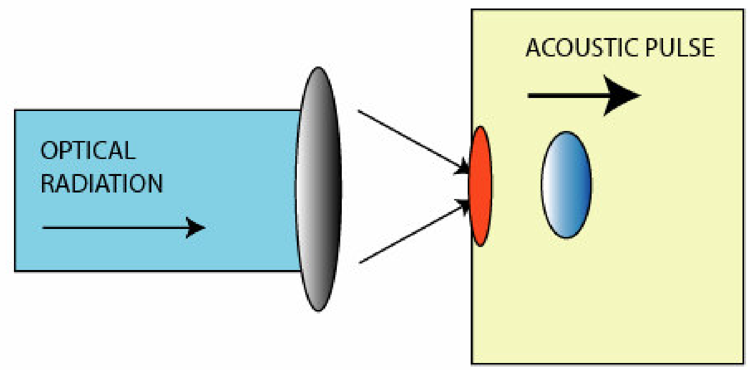
Presentation Outline

- ✔ Objective
- ✔ Sample Selection
- ✔ Numerical Model and Prediction
- ✔ Experimental Setup
- ✔ Result and Discussion

Strain Propagation in Crystals

- To enhance our understanding of transient changes of the lattice due to acoustic phonons and thermal expansion of the substrate upon ultrafast laser excitation

- To gain better understanding about the elastic response of the lattice due to the unipolar compression wave that propagates in the epitaxial layer

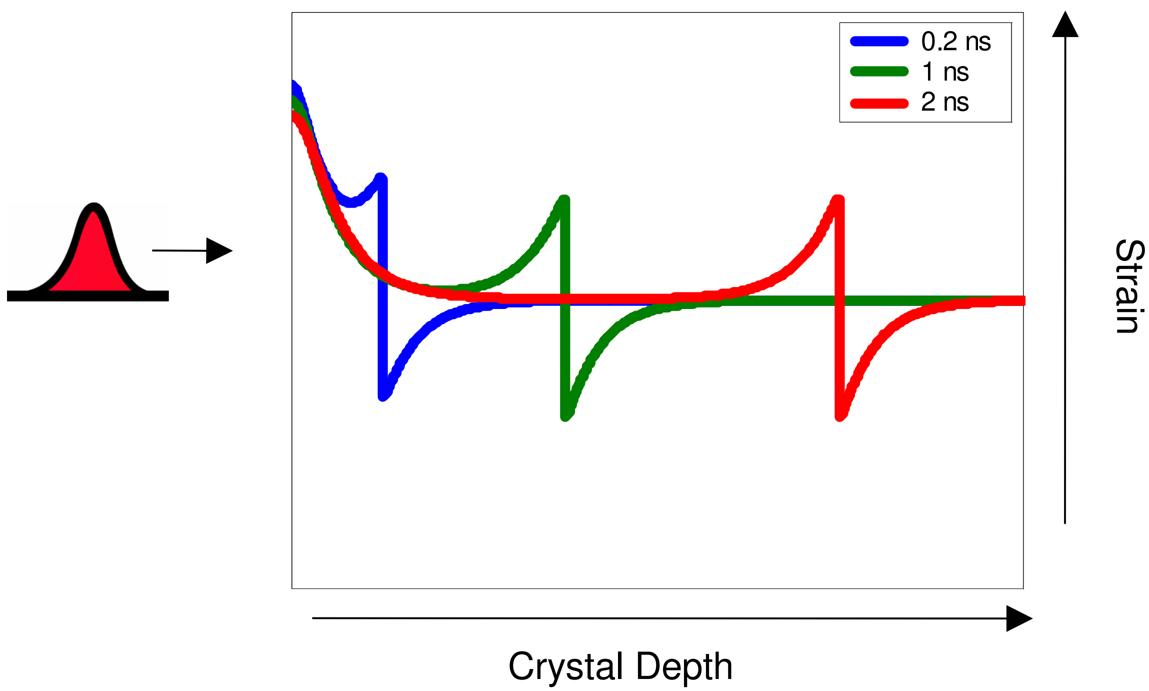


Thomsen Model

- An intense ultrafast laser pulse incident upon an opaque material generates a nearly instantaneous thermal gradient.

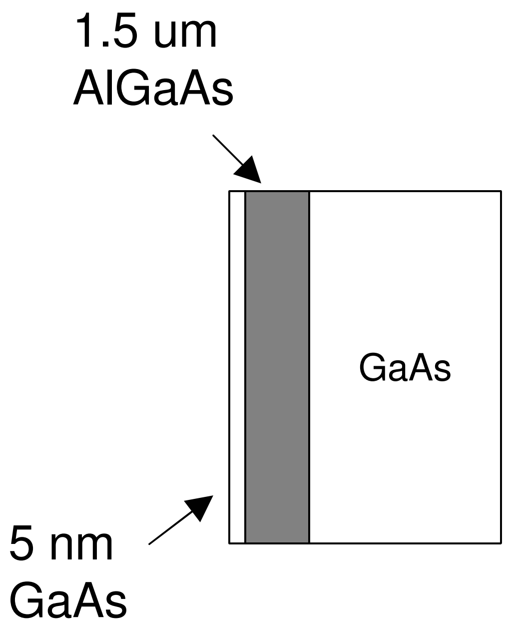
- Assuming the illuminated area is large compared to the laser absorption depth, a strain is created normal to the crystal surface.

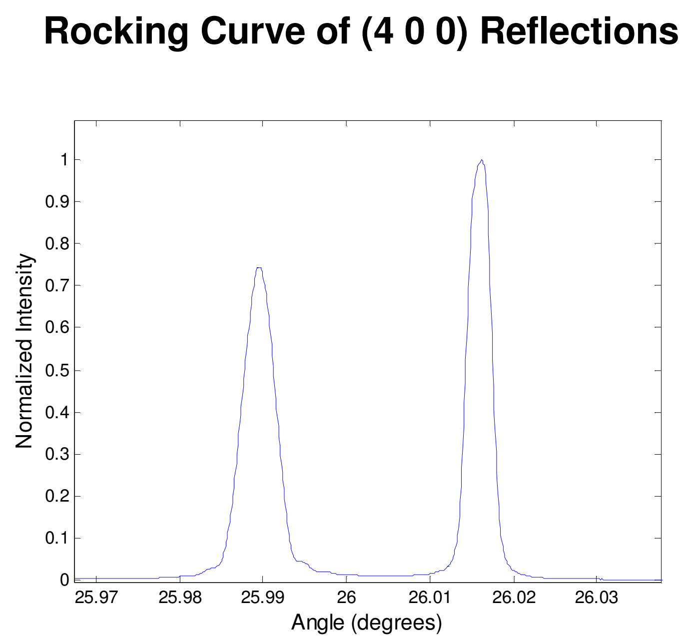
- Thomsen presented a solution to the thermo-elastic equation of motion consisting of a static thermal strain and a coherent acoustic pulse.



Thomsen, C. *et al.*, *Phys. Rev. B* **34**, 4129-4138 (1986).

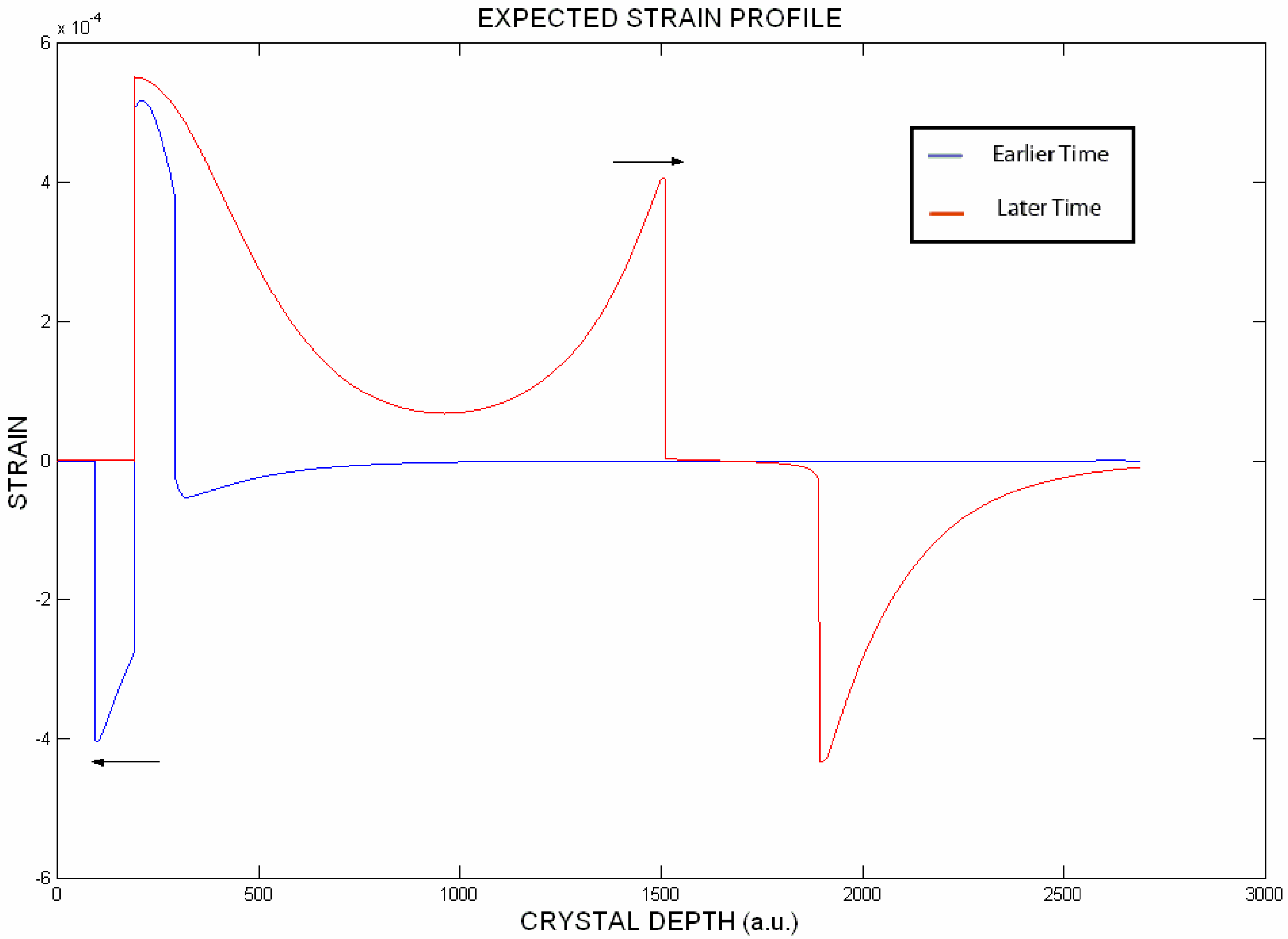
Sample Selection





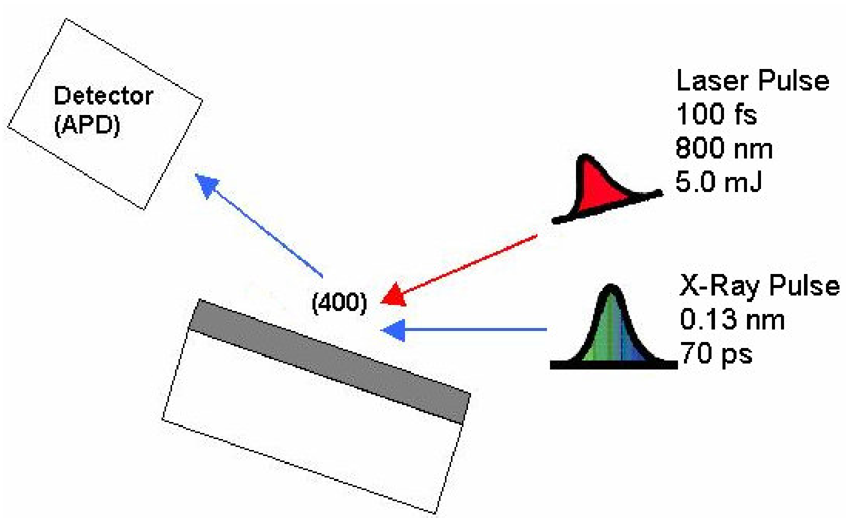
- 30% Al and 70% Ga composition chosen to create a bandgap of 1.79 eV
- Lattice matched to within 0.2%
- A GaAs buffer layer was grown on the AlGaAs to prevent corrosion

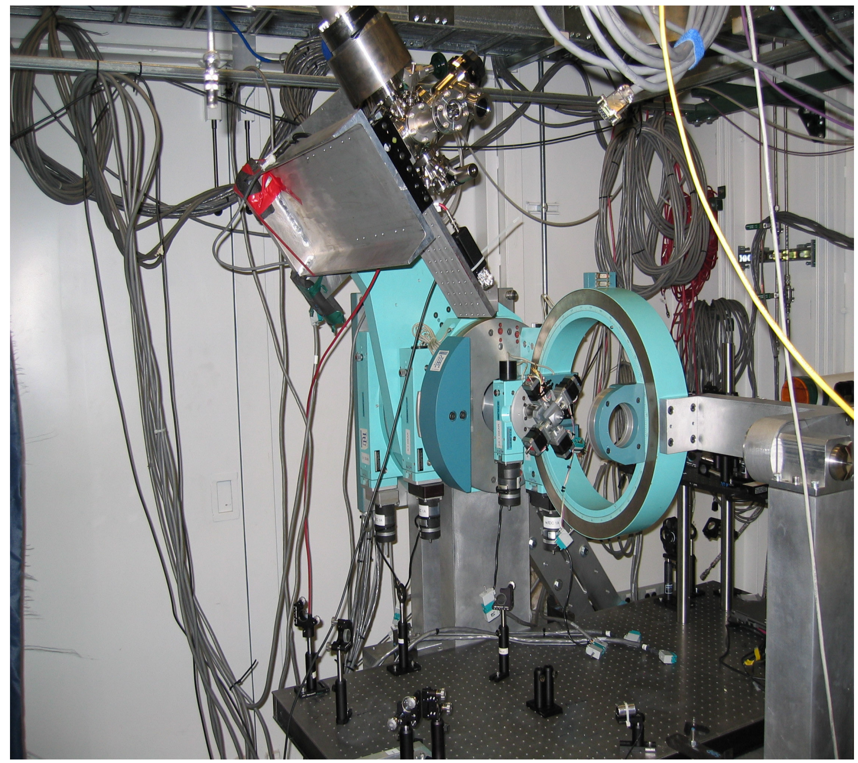
Numerical Modeling of Strains



- **Total Strain = eta_e (z,t) + eta_right (z,t) + eta_left (z,t)**
- Strain profile is computed and the resulting x-ray diffraction efficiency is calculated using a modified theory of dynamical diffraction

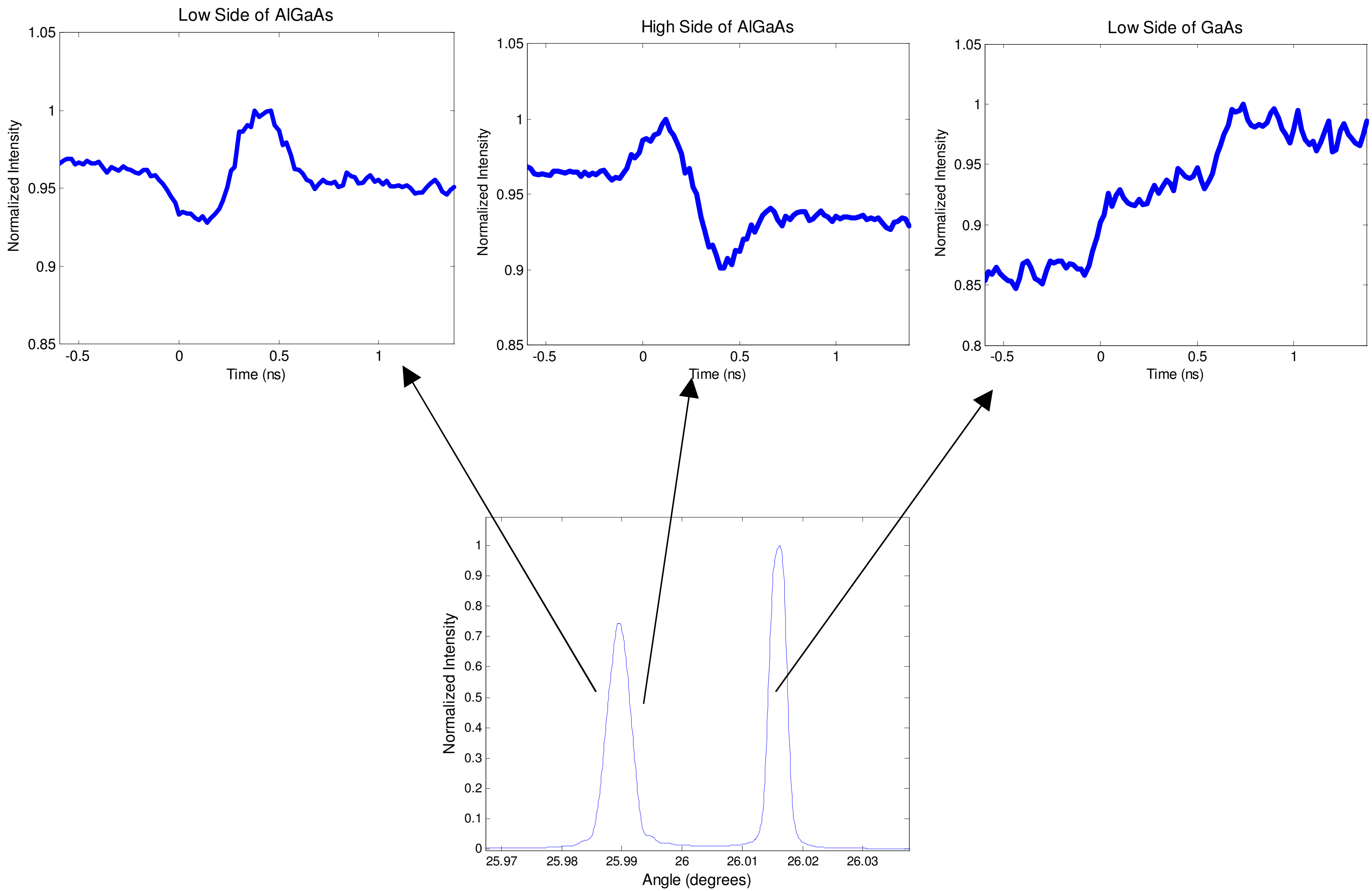
Experimental Setup





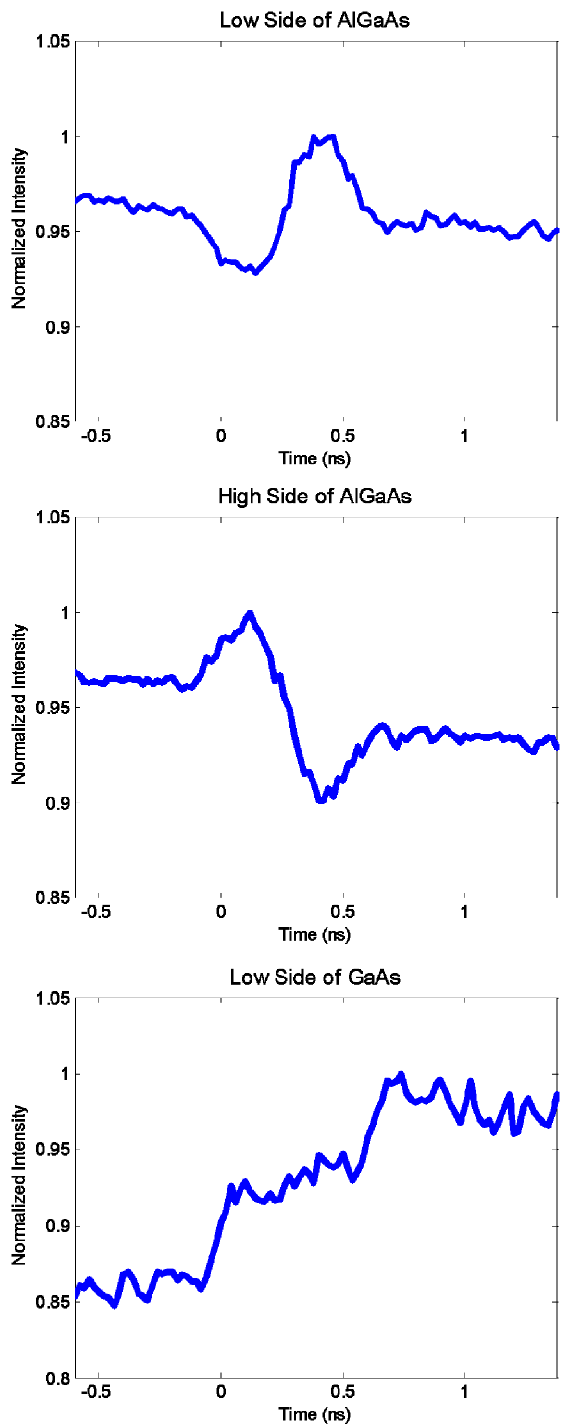
- Advanced Photon Source, MHATT-CAT X-Ray Hutch

Experimental Results

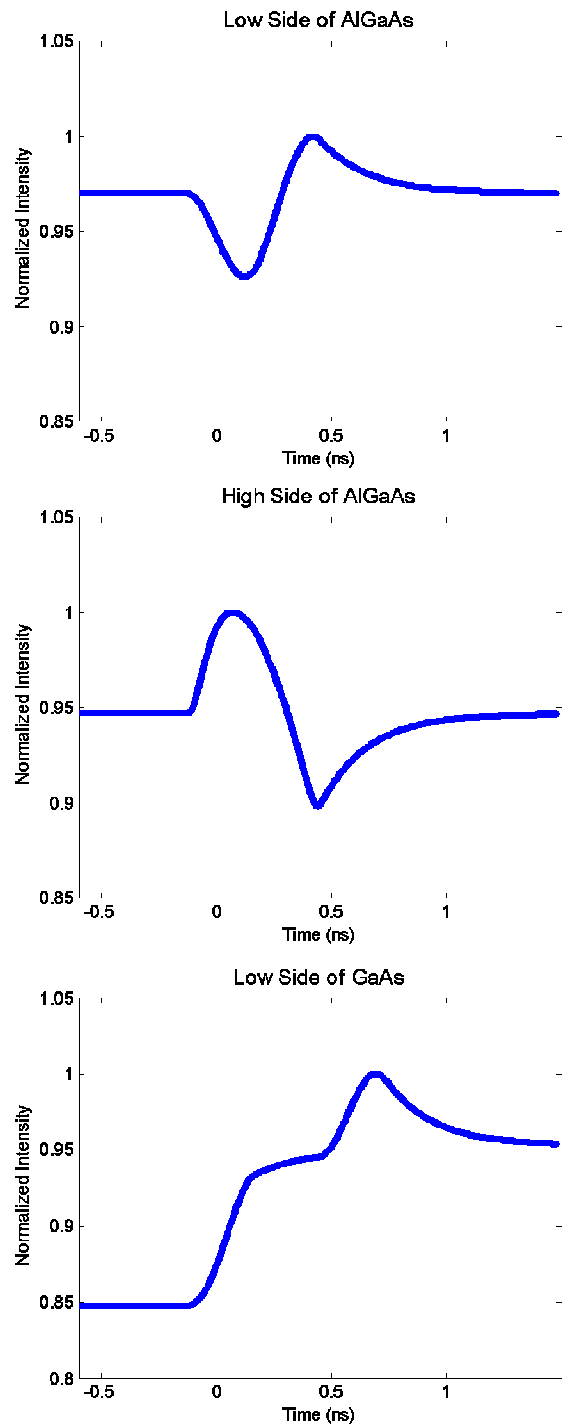


Comparison with Theoratical Model

Experiment



Simulation



Conclusion and Future Work

- ✓ We have developed techniques and numerical models to explore transient dynamics in multilayer semiconductor materials.

- ✓ Experimental data and simulations show evidence of a unipolar coherent acoustic strain pulse.

- ✓ We plan on using these techniques for exploring energy transport (phonon / electronic) across heterostructure interfaces.