Laser Based High Strain Rate Testing

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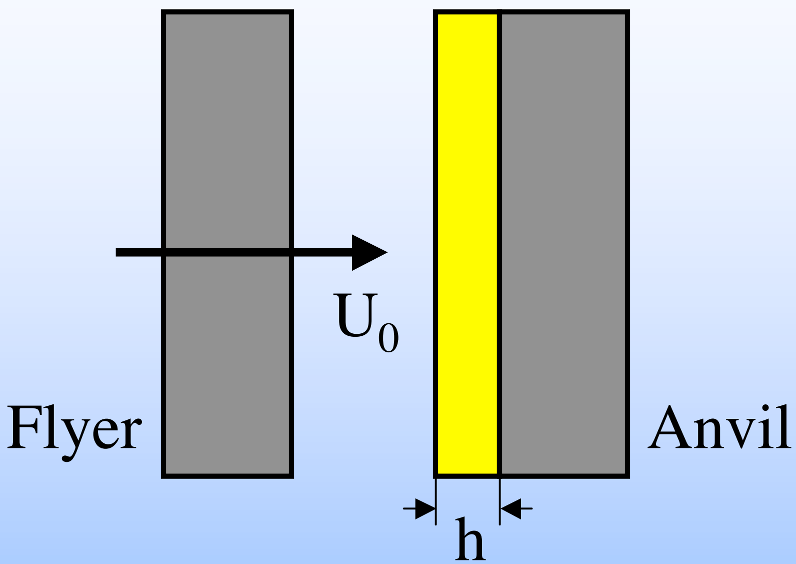
Motivation

- Research group goals
- Why high strain rates?
- Why laser based testing?
- Advantages over traditional methods
  - Higher strain rates (10^6-10^9 s^{-1})
  - Ease of setup and use
  - Small scale testing
  - Easy to modify for high and low Temp.
  - High rate but low strain levels (microscopy)

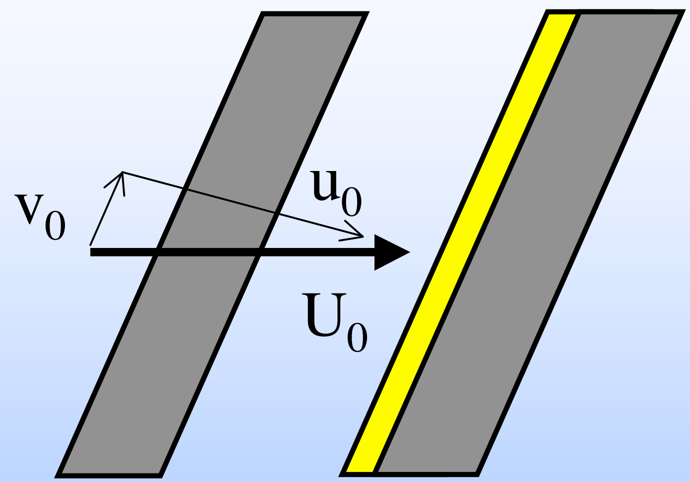
Plate Impact Experiments

Normal Impact



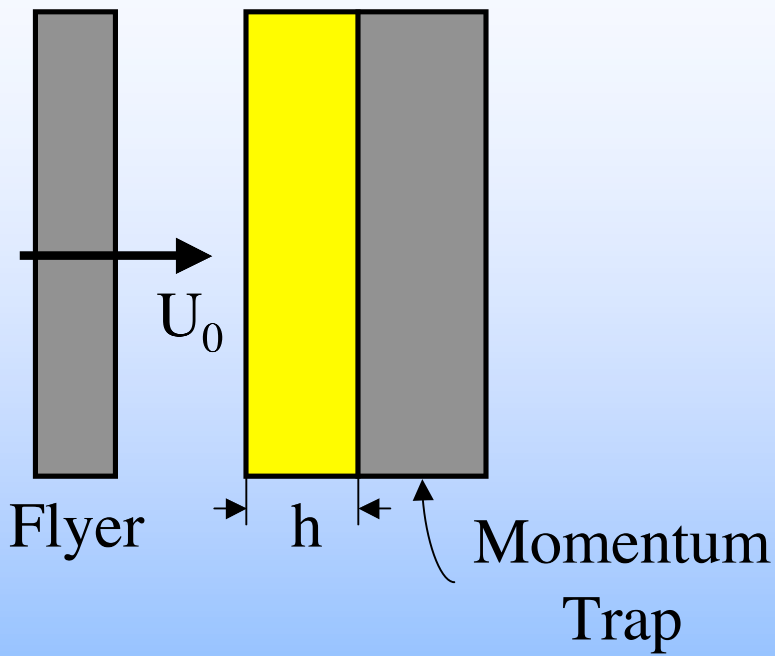
- h << other dimensions
- Flyer & anvil: Same material and remain elastic
- Measure U_0 and back face velocity
- Yields P-V relations

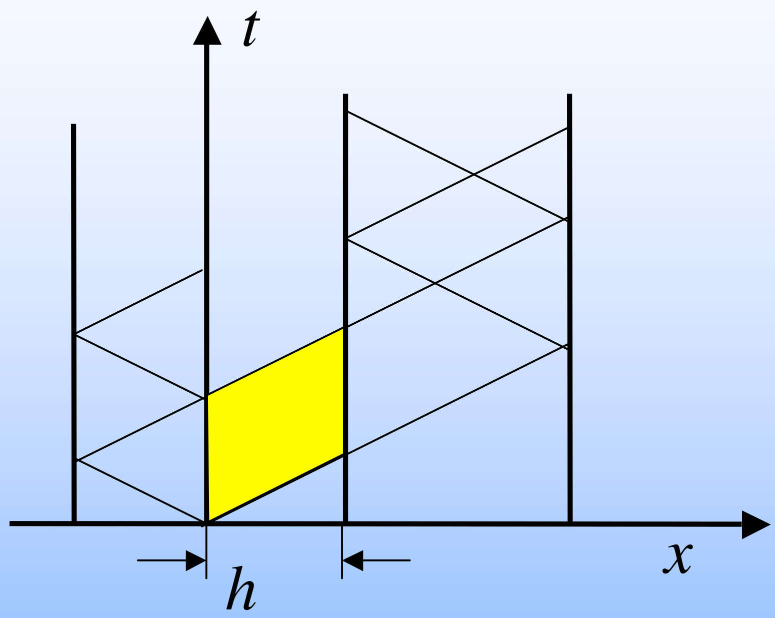
Pressure–Shear Impact



- h << other dimensions
- Flyer & anvil: Same material and remain elastic
- Measure U_0 and back face velocities ($\perp$ and $\parallel$)
- Produces shear loading under high pressures

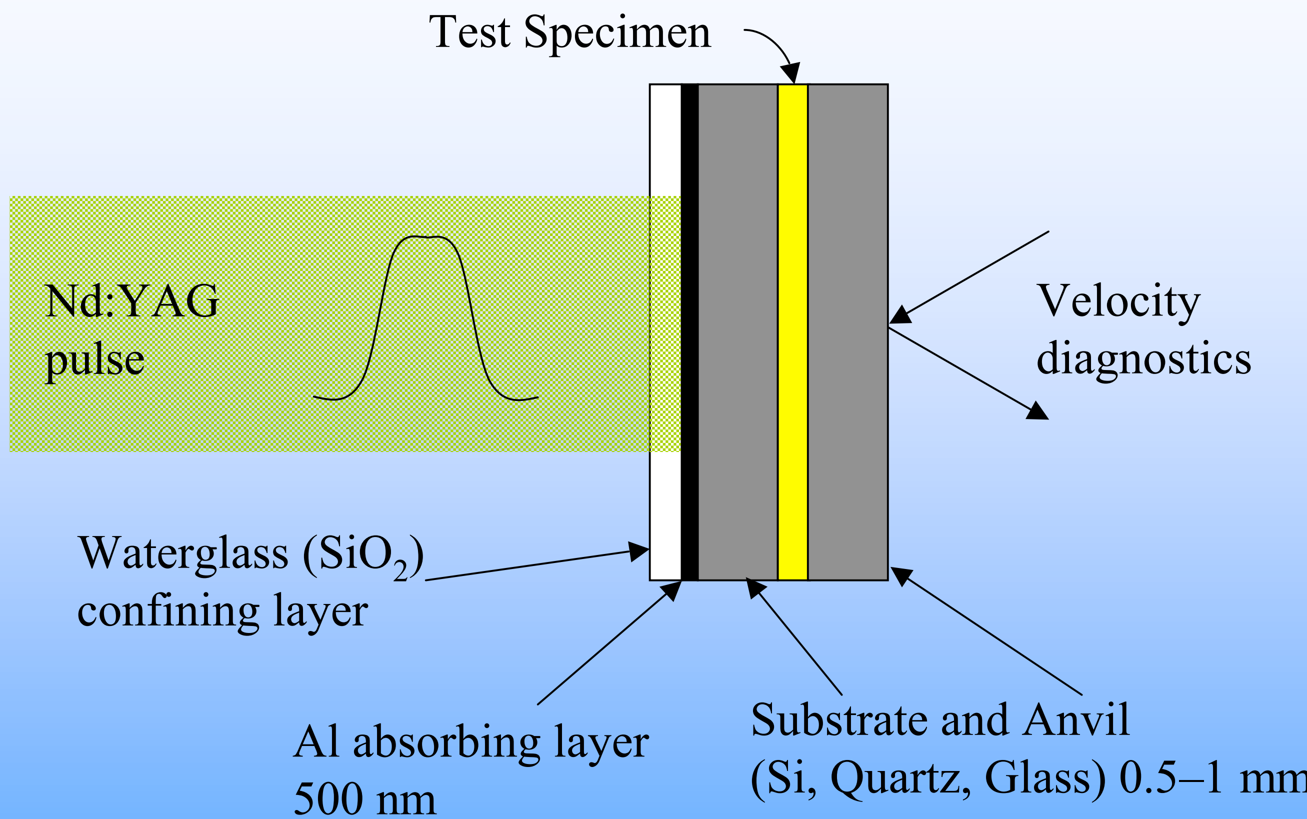
Normal Recovery Exp.





- “Thick” specimen is subjected to one loading
- Momentum trap “catches” transmitted pulse
- Produces known loading history

Proposed Experimental Set-Up



- Fusion of plate impact and laser spallation
- Used in either standard or recovery mode by changing specimen thickness

Project Task List

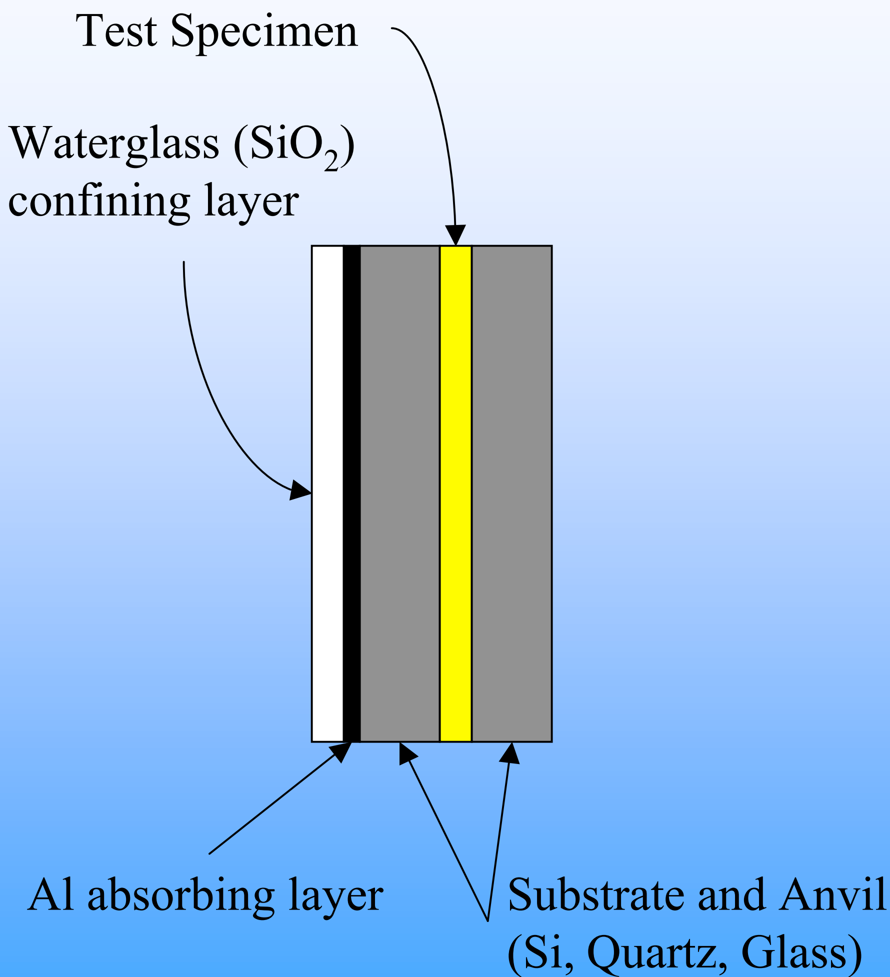
Short Term

- Specimen preparation
- Calibration experiments
  - Effect of laser power
  - Effect of substrate material
  - Transmission experiments
- Get and test metal specimens
  - Recovery specimens
  - Nanograined specimens

Long Term

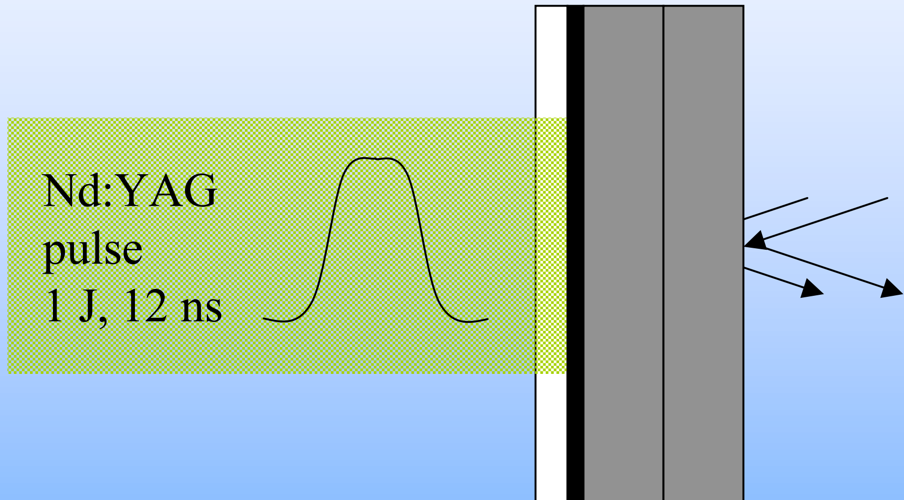
- Microscopy of deformed metal specimens
- Quartz gage experiments
- Polymer layer to “stretch” pulse
- Develop laser based pressure–shear test

Specimen Preparation



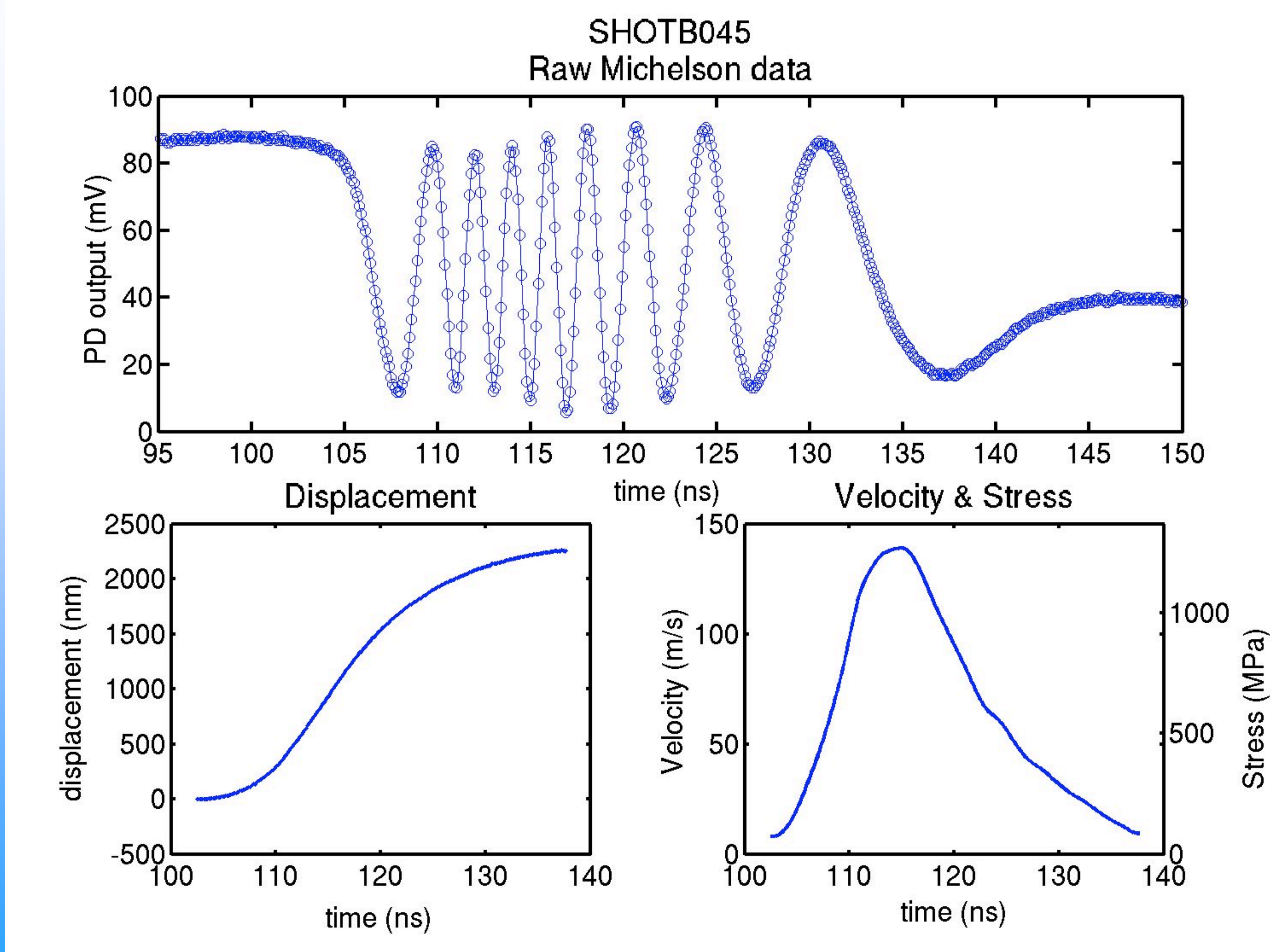
- Al absorbing layer is deposited (E-beam)
- 5mm circular specimens are cut out
- Waterglass is painted on
- Specimen is "sandwiched" between substrate and anvil

Calibration Experiments

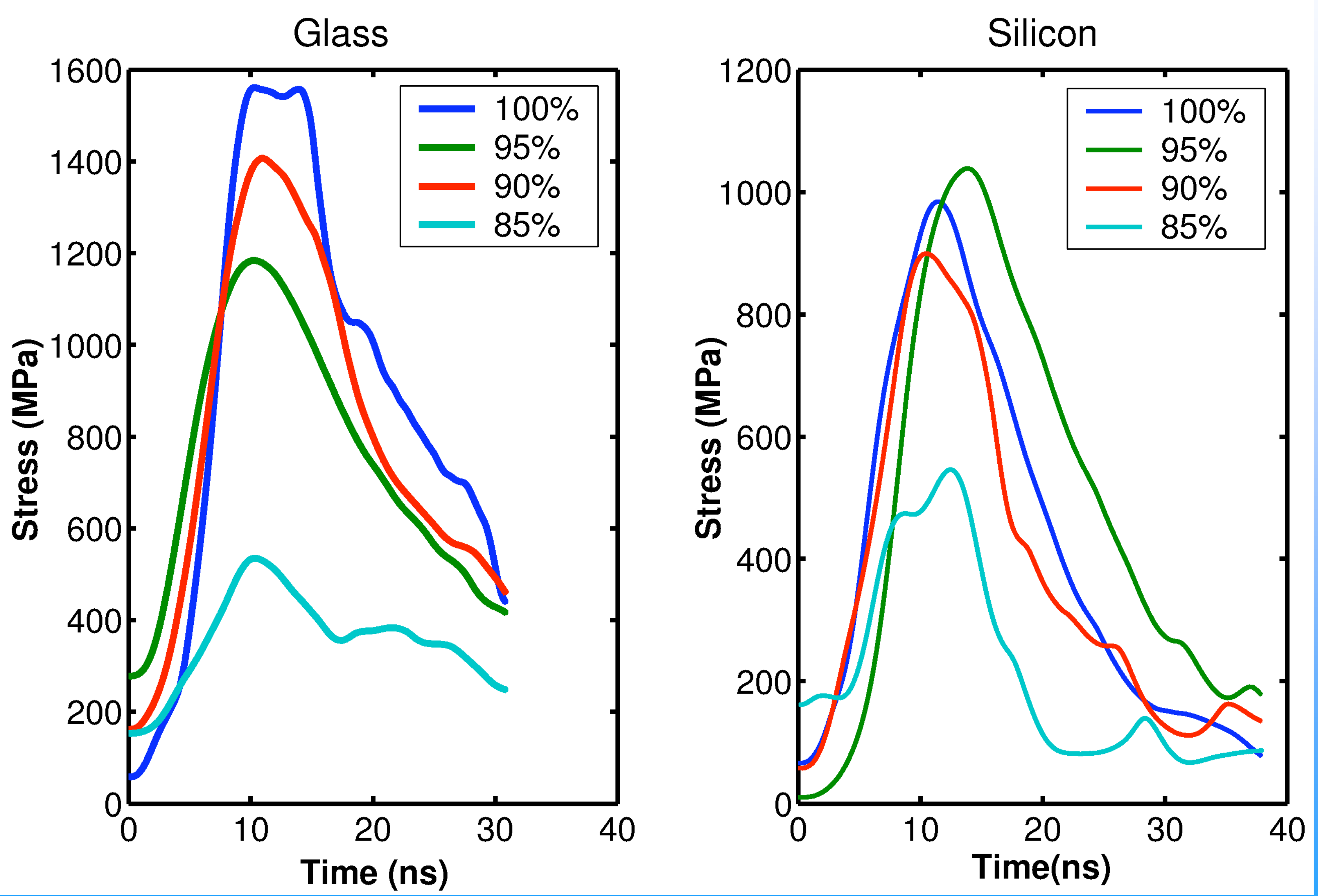


- Use front substrate only
- Michelson interferometer for back face diagnostics
- Vary laser intensity and substrate material
- Si-Si sandwich test

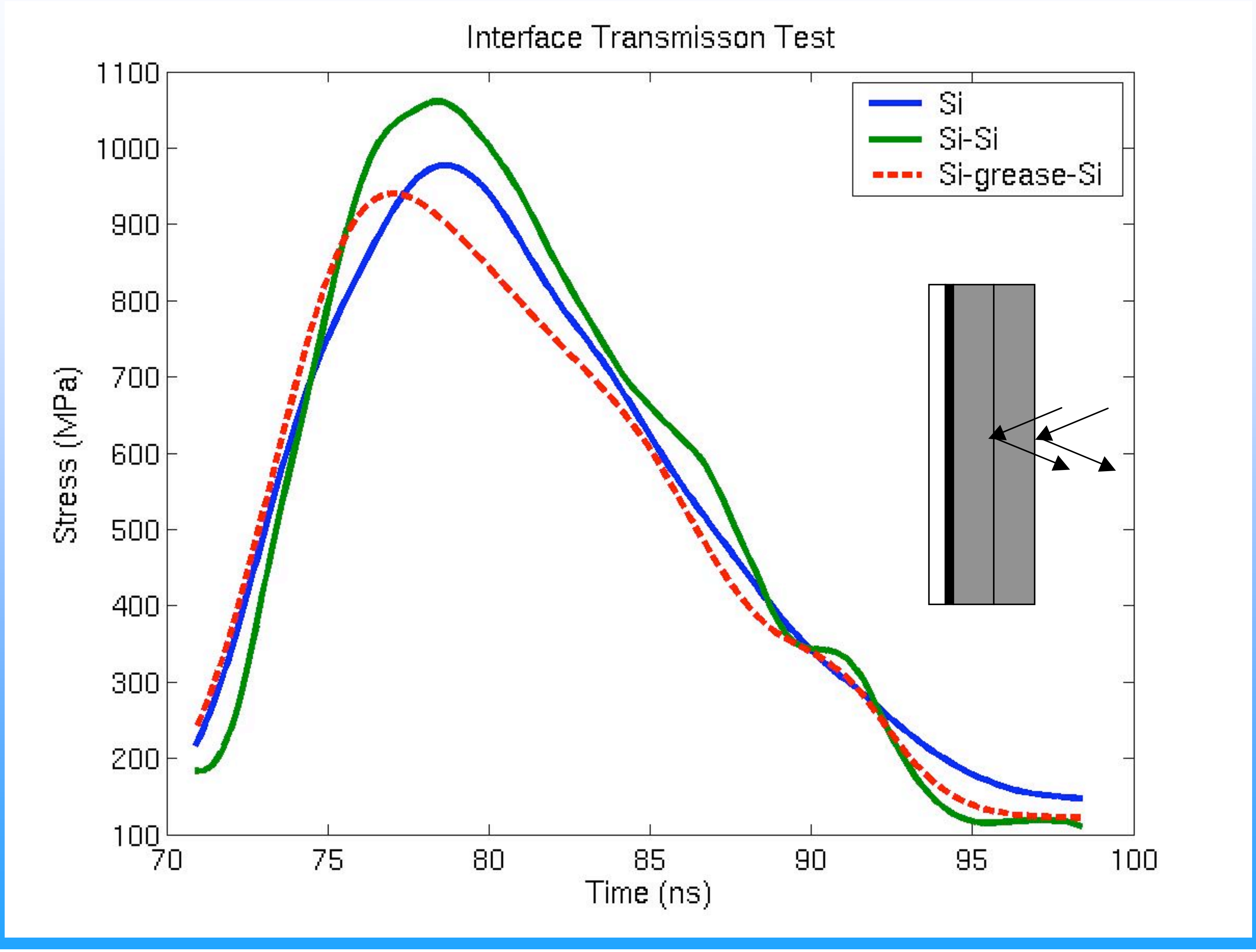
Typical Data



Stress Wave Profiles



Wave Transmission Study



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Future Work

- Si-Si-Si transmission test
- Add metal specimen
- Develop laser based pressure-shear test
  - Laser pulses can only generate dilatational waves
  - Some form of mode conversion needed
  - Diagnostics will also be a challenge