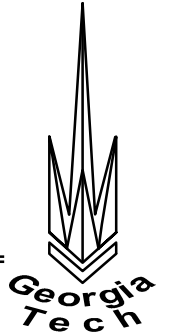


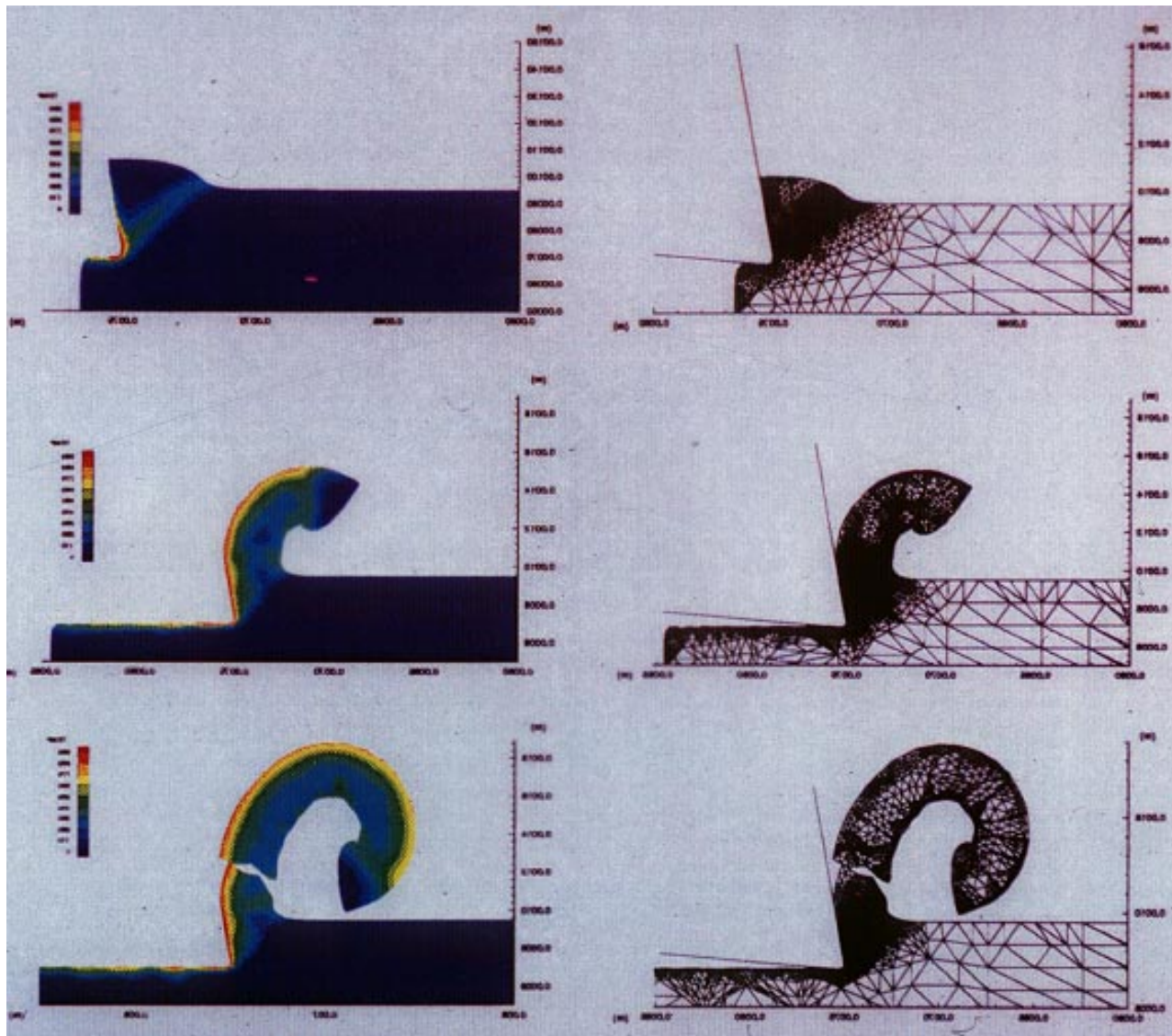
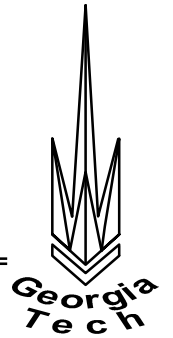
High Strain Rate Shear Failure of Metals in High-Speed Machining



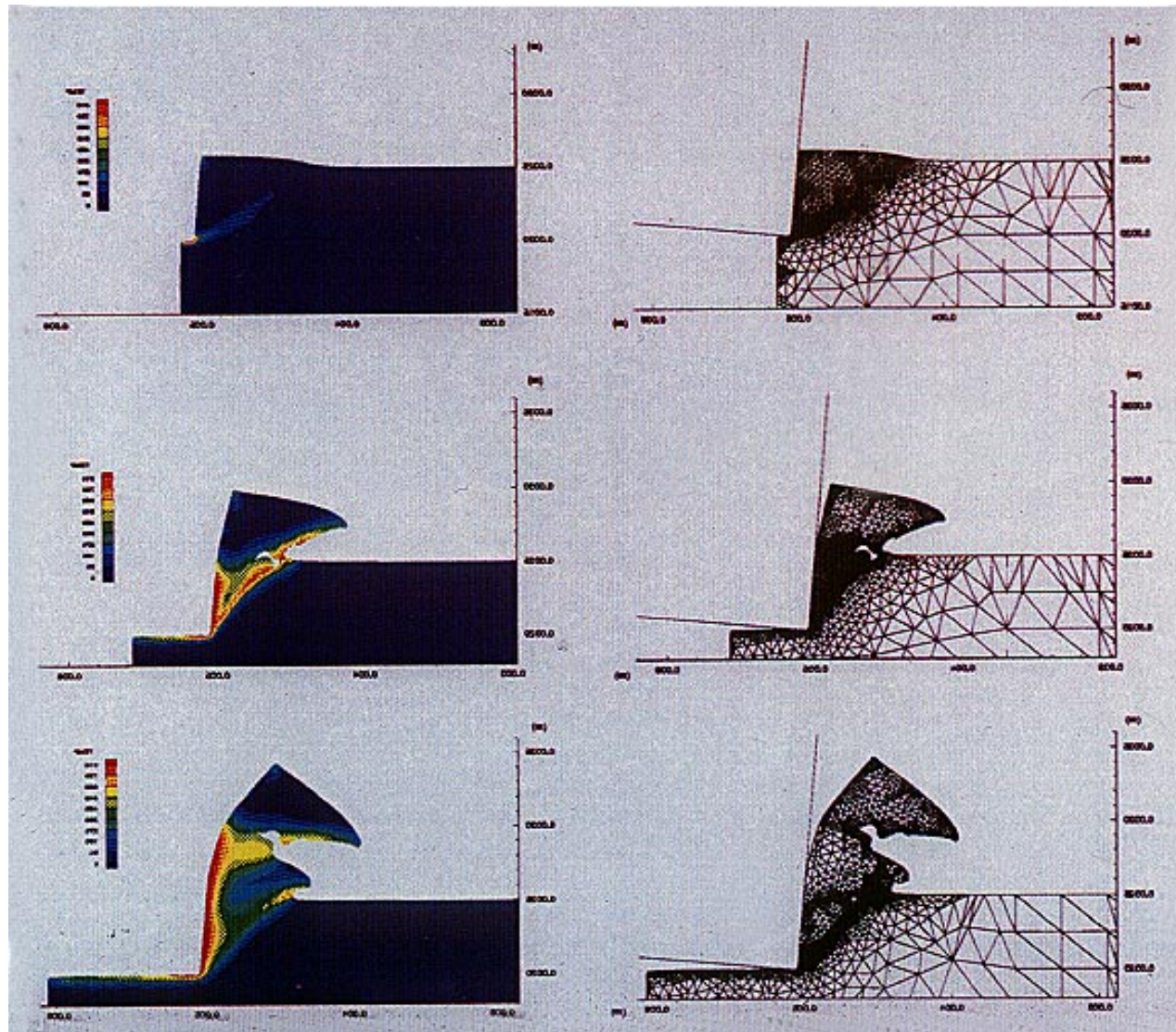
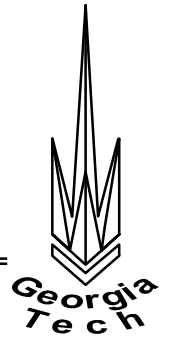
Precision Machining Research Consortium
Industrial Advisory Board
Georgia Institute of Technology
29 October 1997

Karel Minnaar
Advisor: Dr. Min Zhou

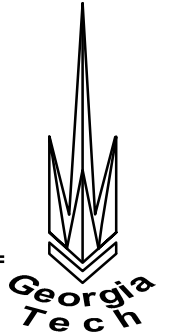
Chip Formation Contour



Chip Formation Contour

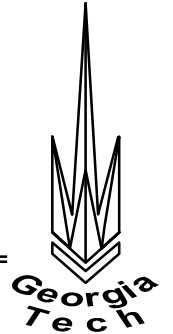


Applications



- ❖ Manufacturing: machining, metal forming & welding
- ❖ Structure integrity: vehicle crash-worthiness
- ❖ Material processing: consolidation
- ❖ Tribology: wear and lubrication
- ❖ Composites: MMC's and IMC's
- ❖ Armor & Armor penetration

Dynamic Deformation and Failure: Issues



Ductile Plastic Flow

- Shear Banding



Ductile rupture and failure

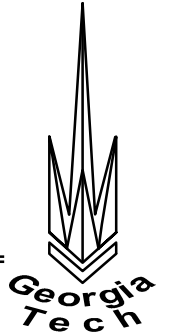
Brittle Failure

- Rapid Crack Growth



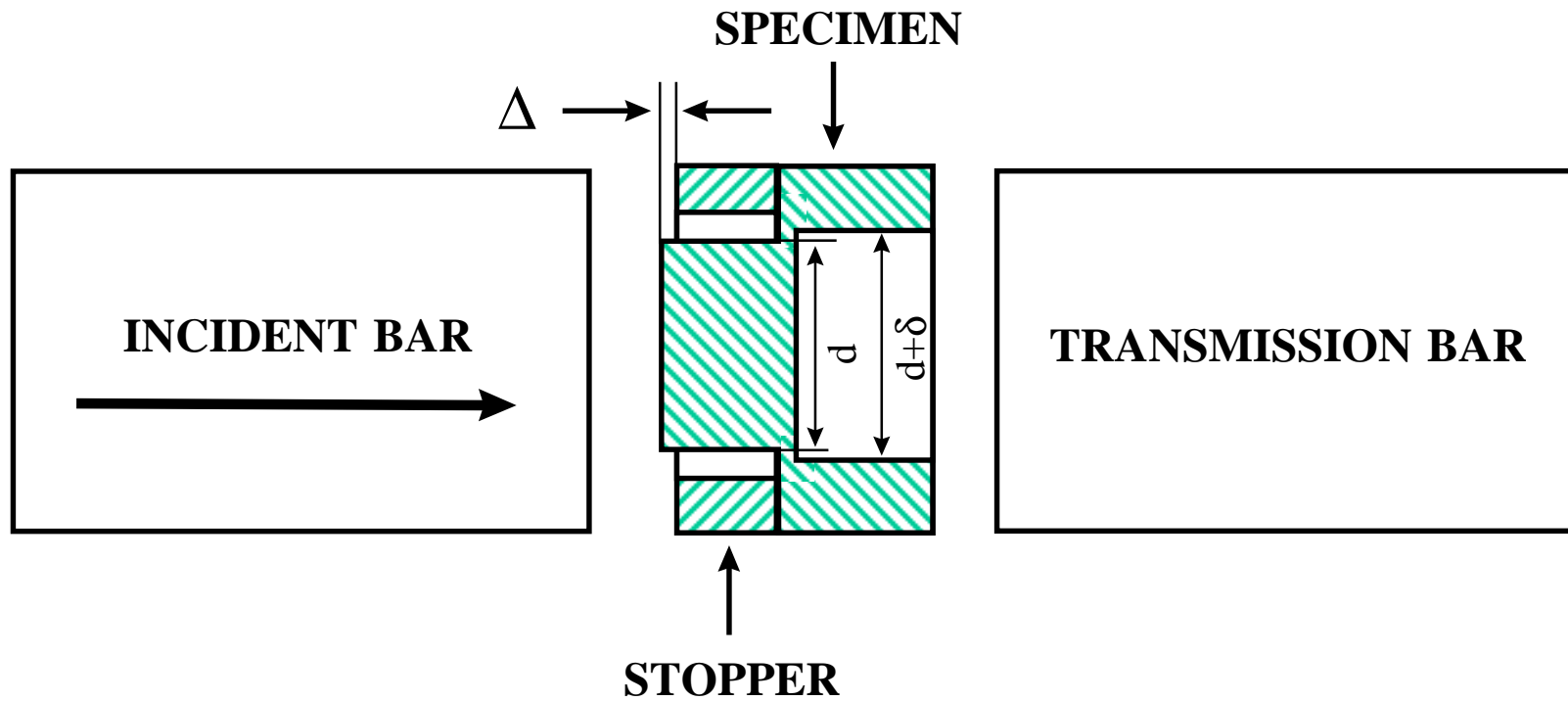
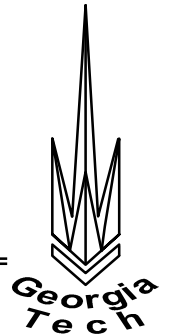
Brittle fracture, fragmentation, and pulverization

Dynamic Response vs. Quasi-Static Response

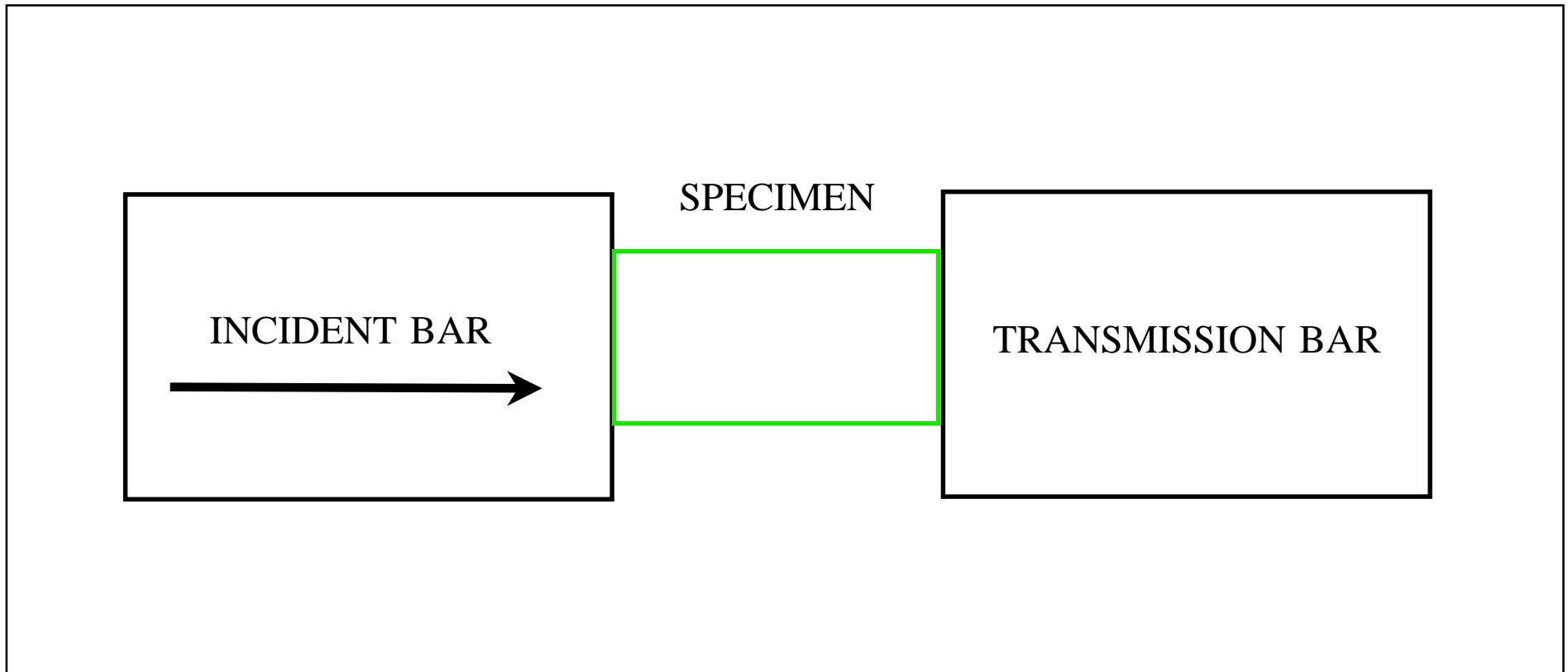
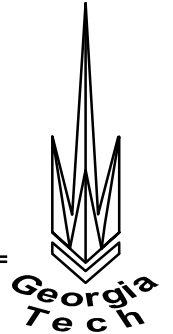


- ❖ Strain Rate Sensitivity
- ❖ Transition from thermally activated mechanism to a linear viscous mechanism-high dislocation velocities
- ❖ Inertia Effect
- ❖ Time-Dependent
- ❖ Highly Nonlinear
- ❖ Heat Generation
- ❖ Thermal Softening
- ❖ Phase Transition

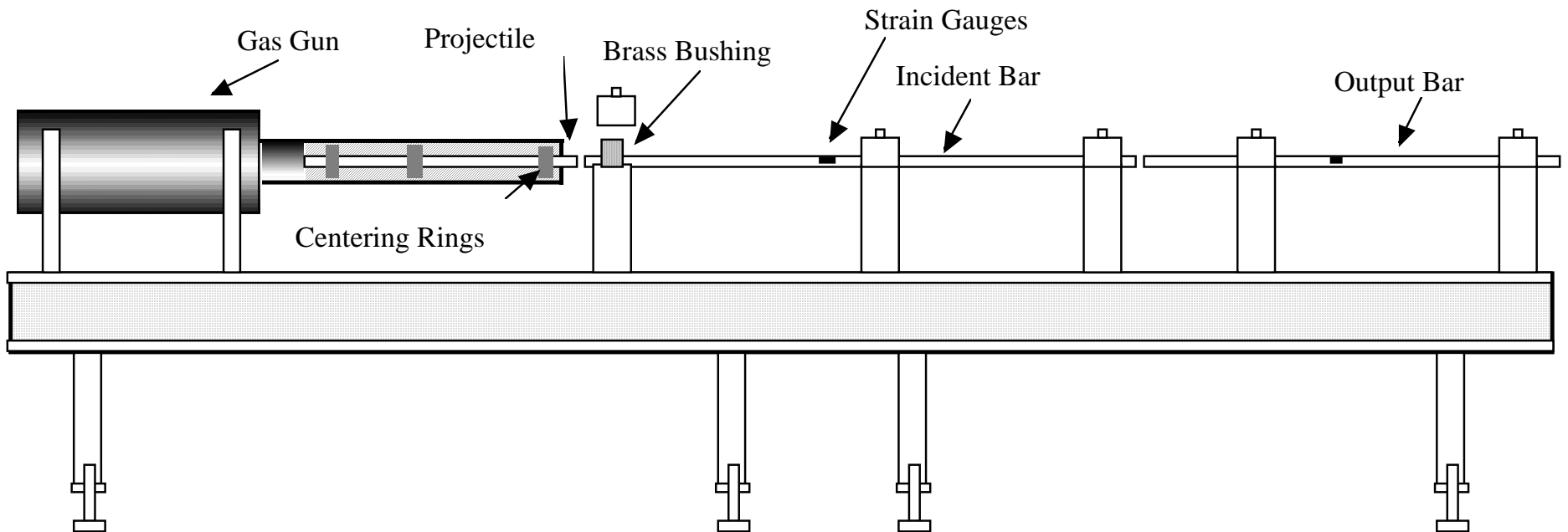
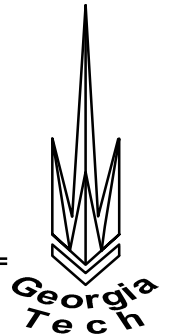
Dynamic Shear Failure Experiment



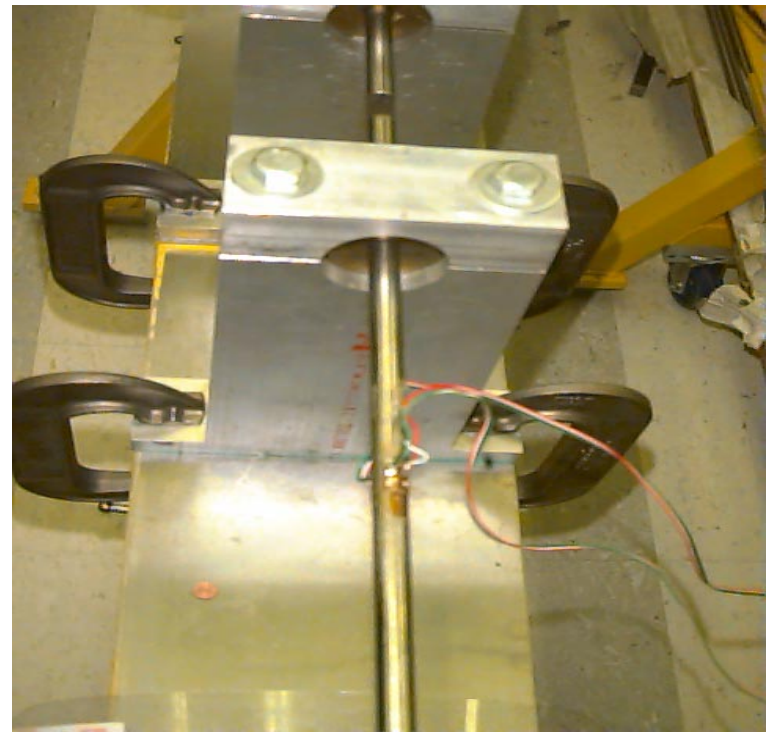
Constitutive Dynamic Response



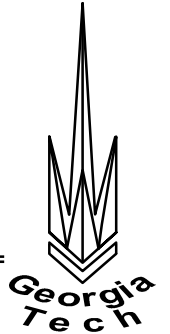
Split Hopkinson Pressure Bar



Split Hopkinson Pressure Bar

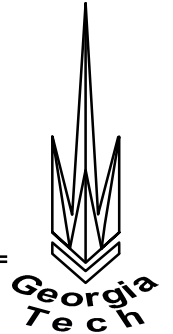


Current Research (supported by ONR)



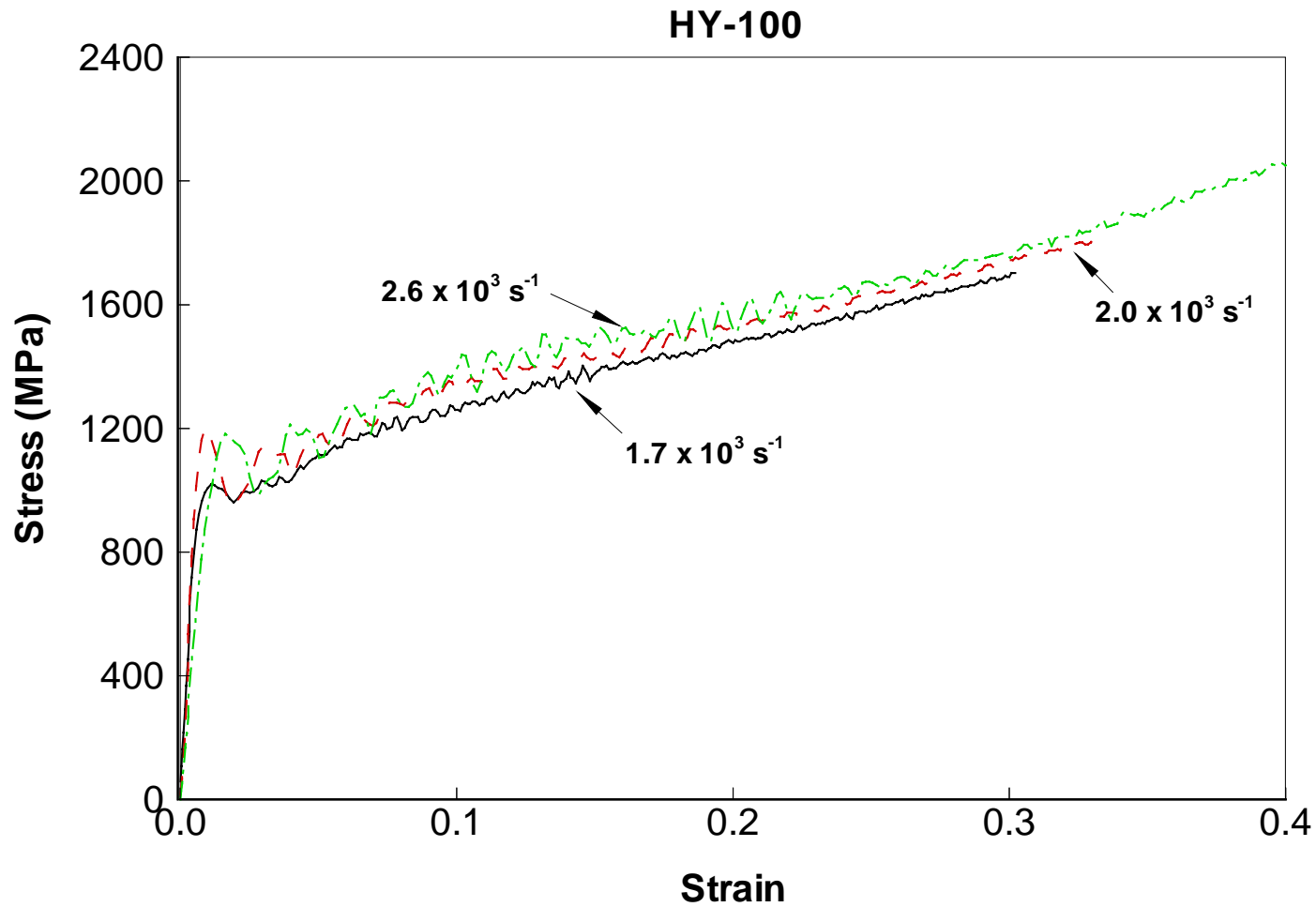
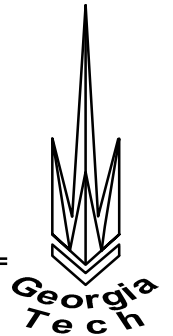
- ❖ Objectives:
- ❖ Characterize evolution of load-carrying capacities of structural metals under predominantly shear conditions.
- ❖ Quantify the shear failure resistance of
- ❖ the materials

Materials

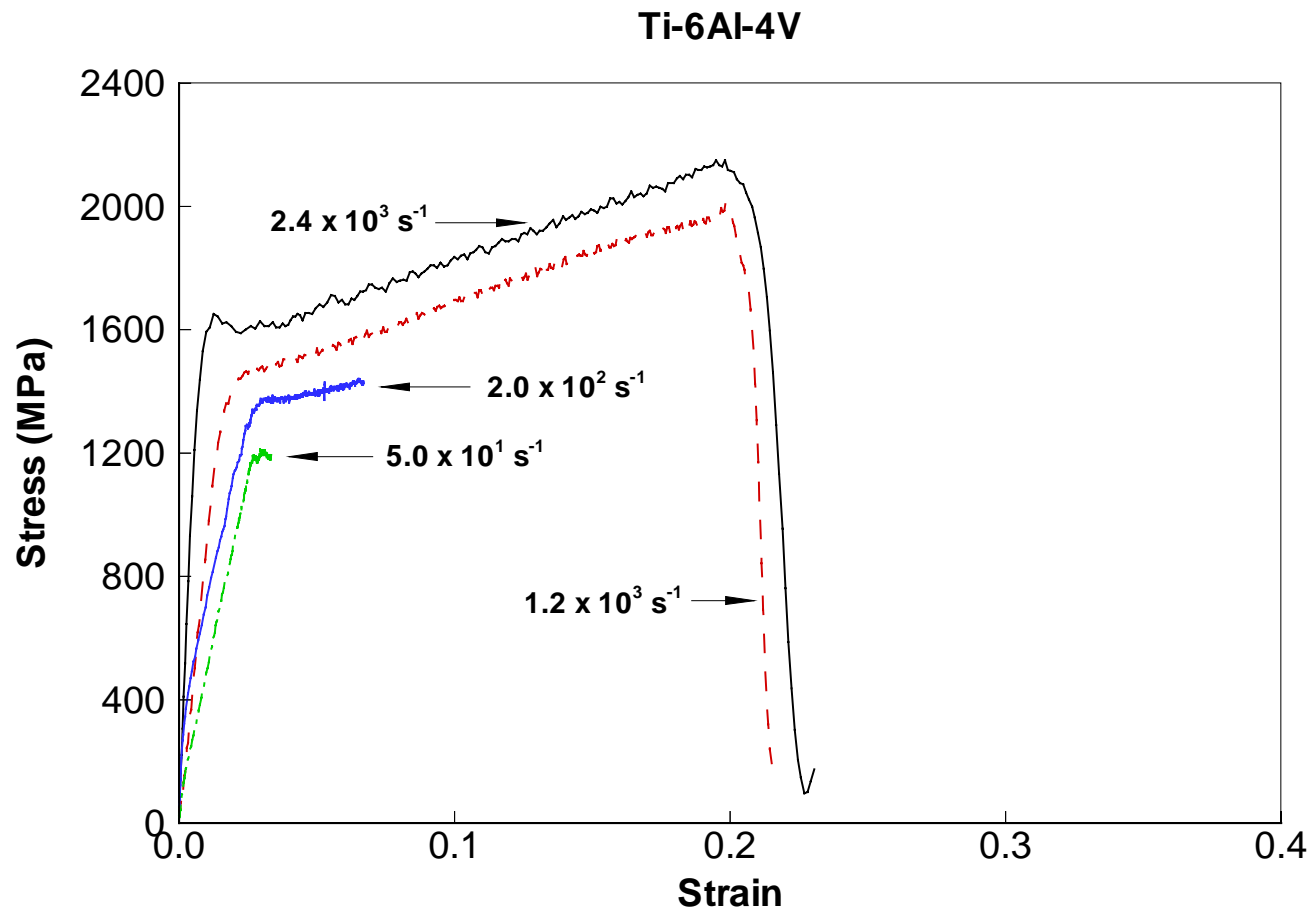
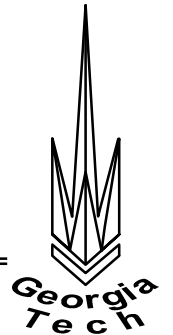


- ❖ High Yield 80 (HY-80)
- ❖ High Yield 100 (HY-100)
- ❖ High Strength Low Alloy 80 (HSLA-80)
- ❖ Al 4340 VAR
- ❖ Ti-6Al-4V

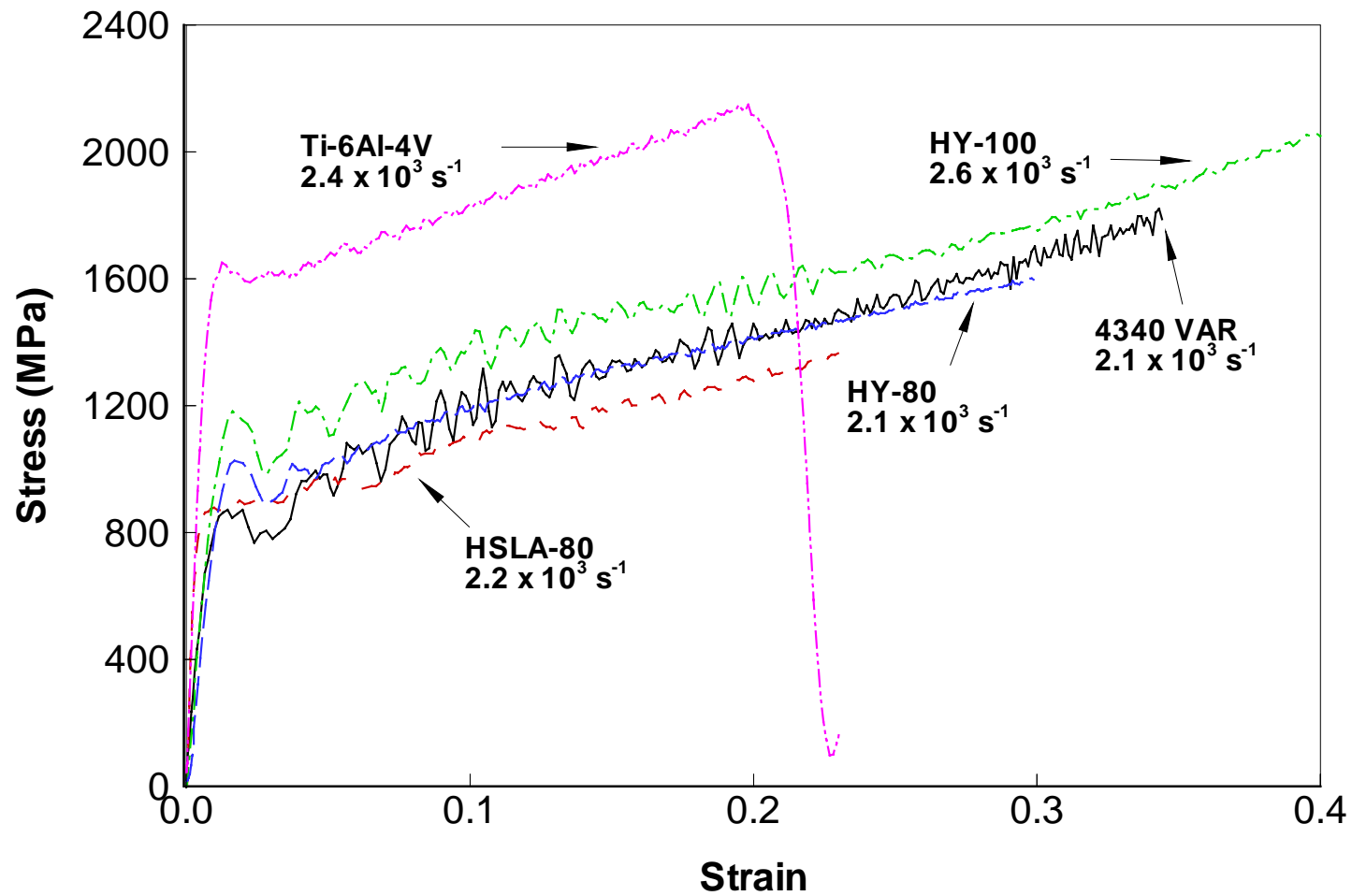
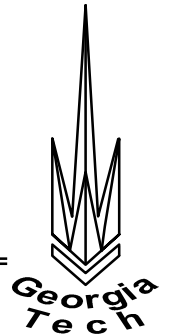
Dynamic Constitutive Response



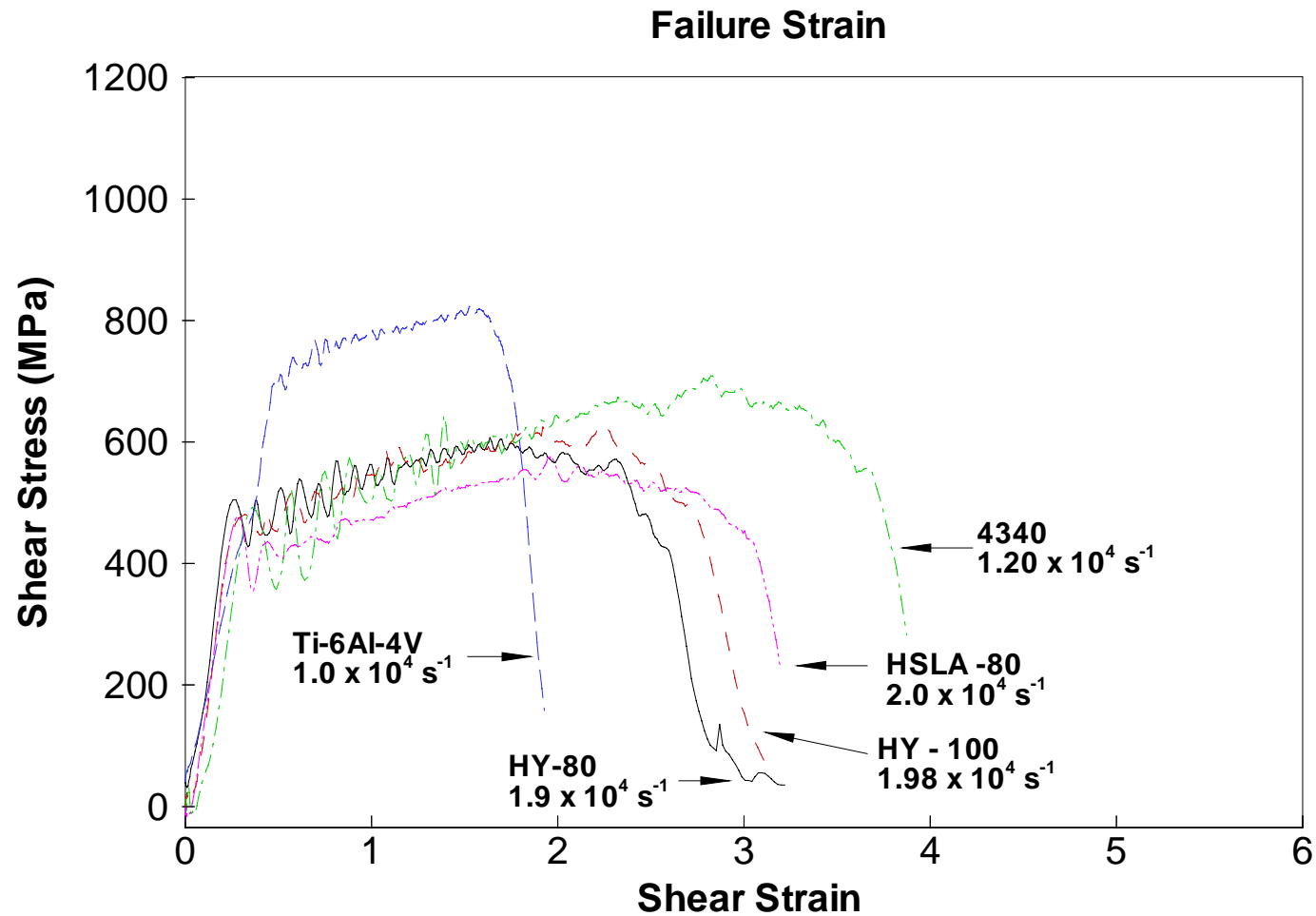
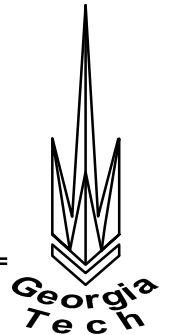
Dynamic Constitutive Response



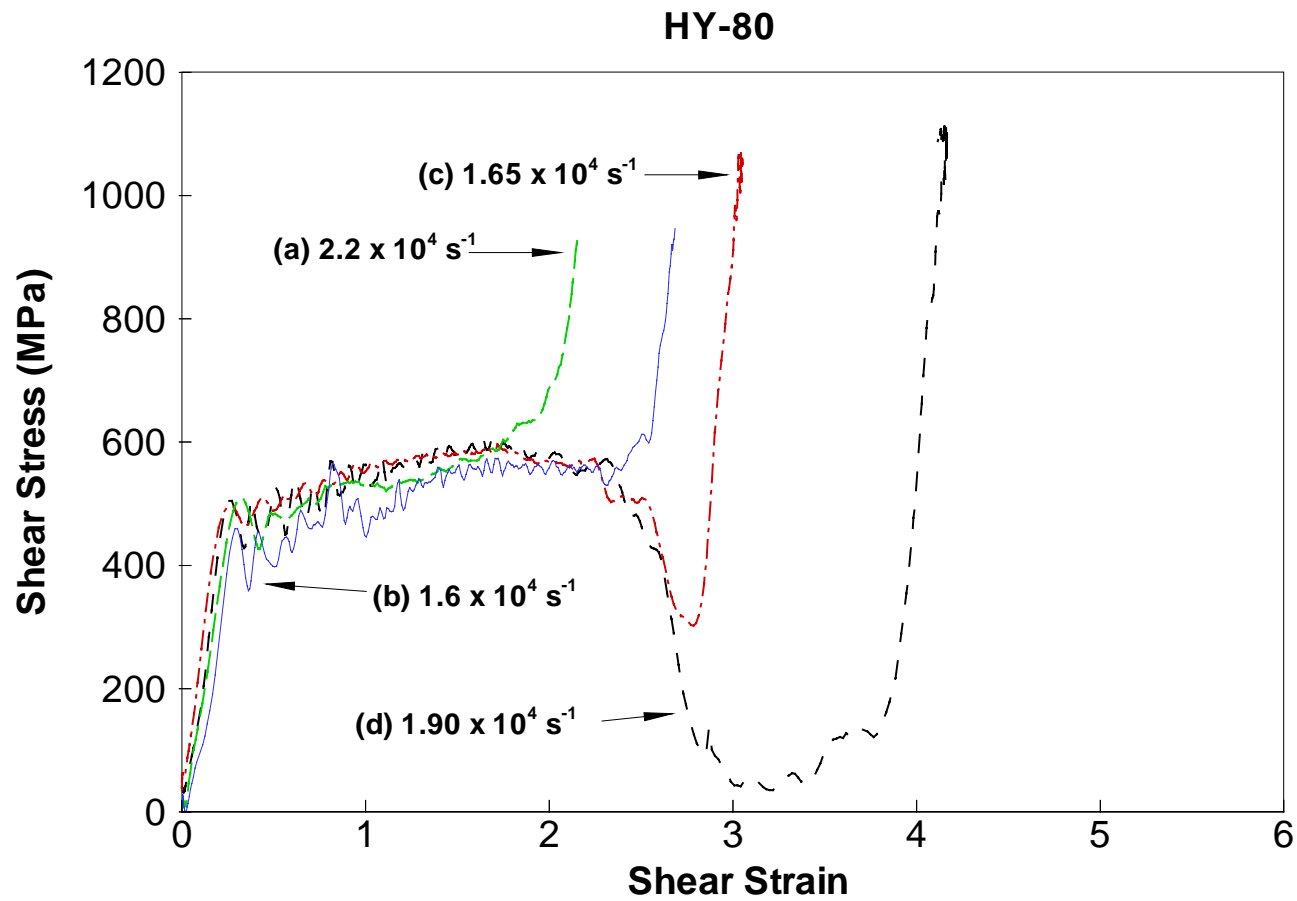
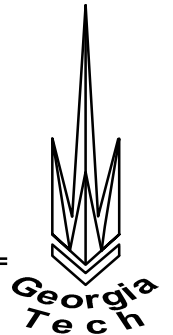
Dynamic Constitutive Response



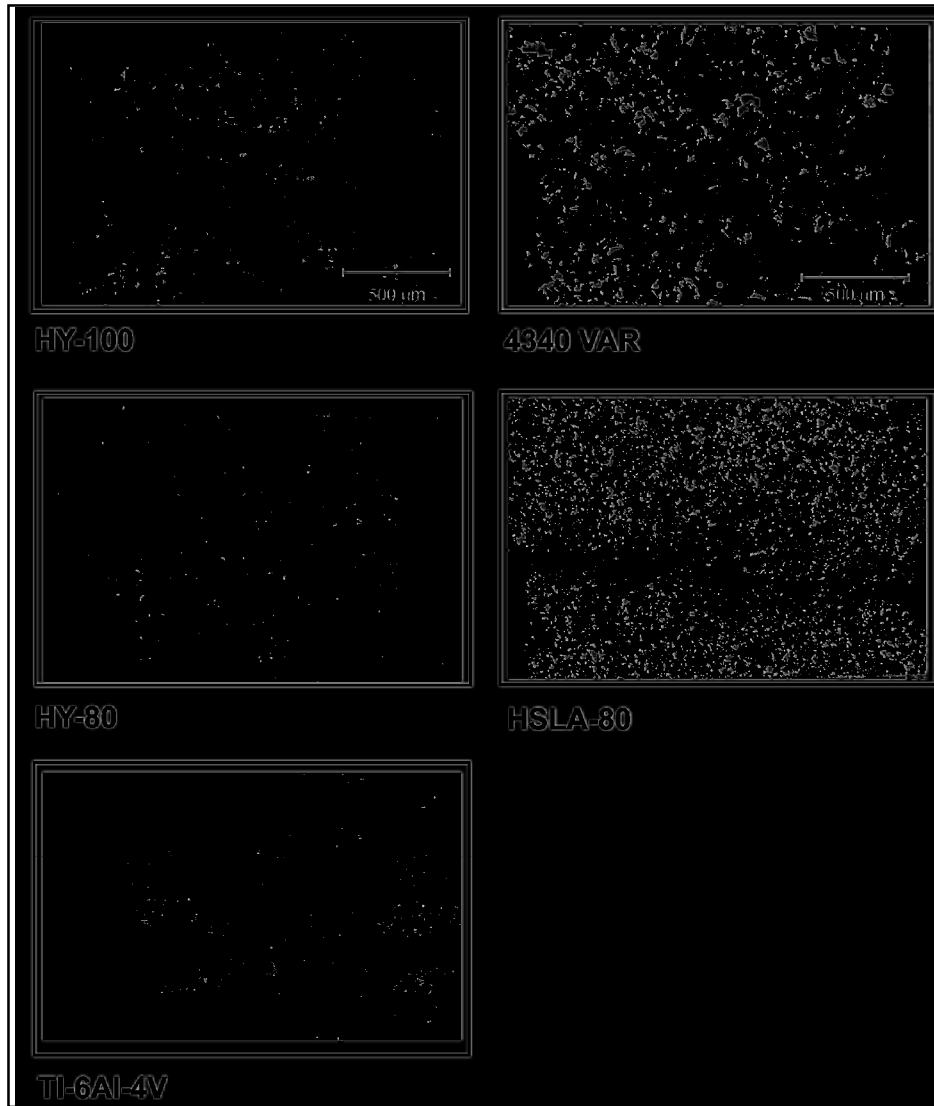
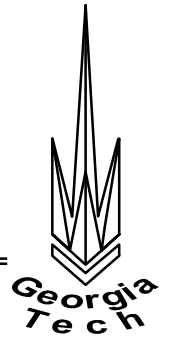
Shear Failure



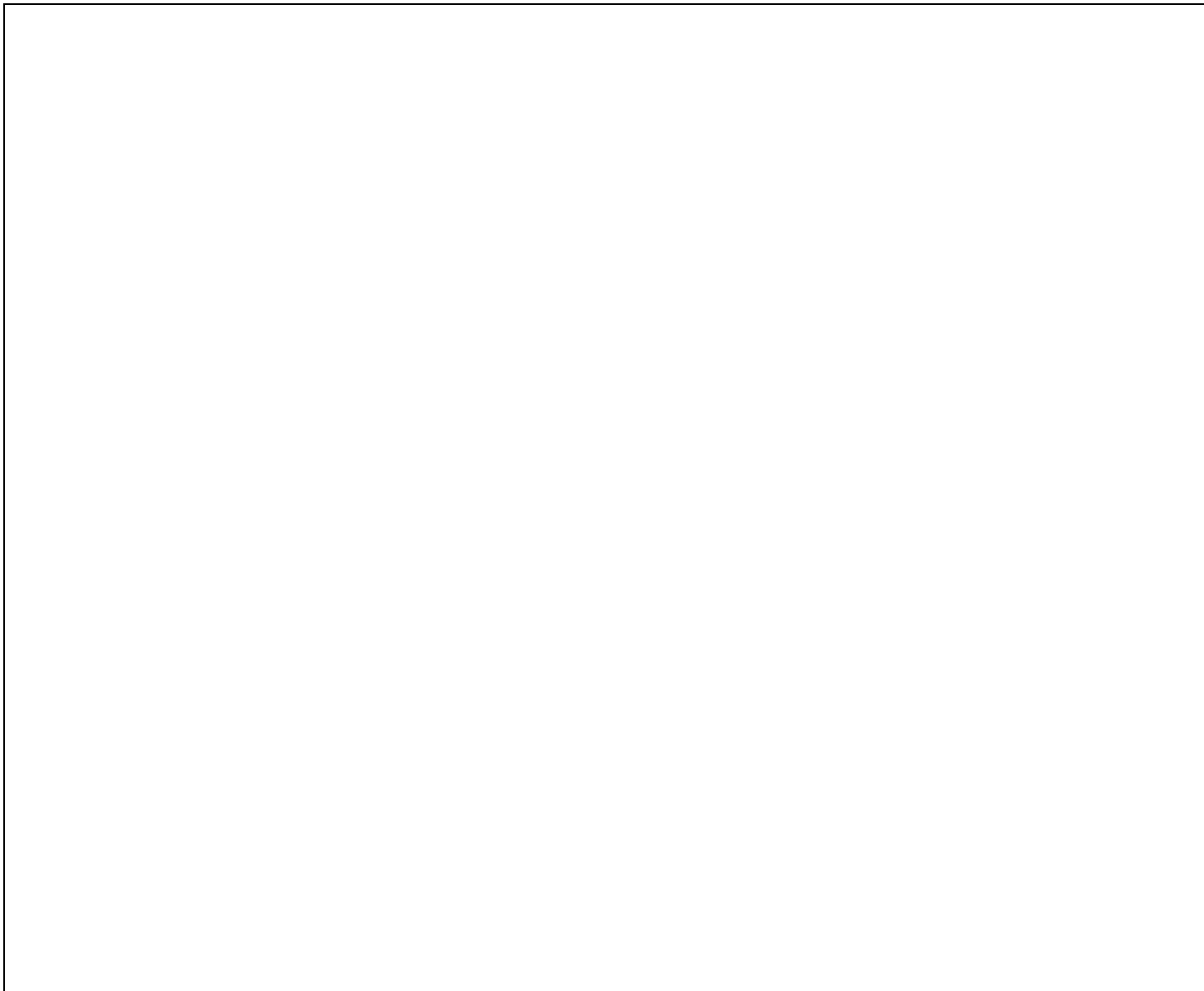
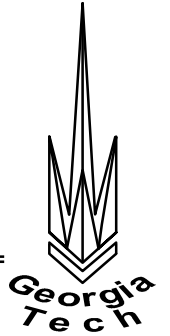
Shear Failure



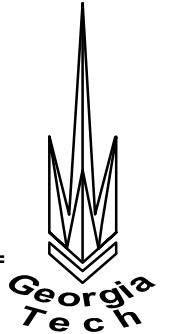
Maximum Strain 2.0



Maximum Strain 2.5



Summary and Work Ahead



1. Steels vs. Titanium

2. Rupture mechanism

3. Void coalescence

1. Constitutive model

2. Numerical simulation

3. Void damage model

4. Shear band toughness