SAND2017-3847PE

A cross-platform comparison of dynamic material strength for Ta

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This project addresses an NNSA Level II milestone to better understand the approaches to determining material strength

Large list of participants

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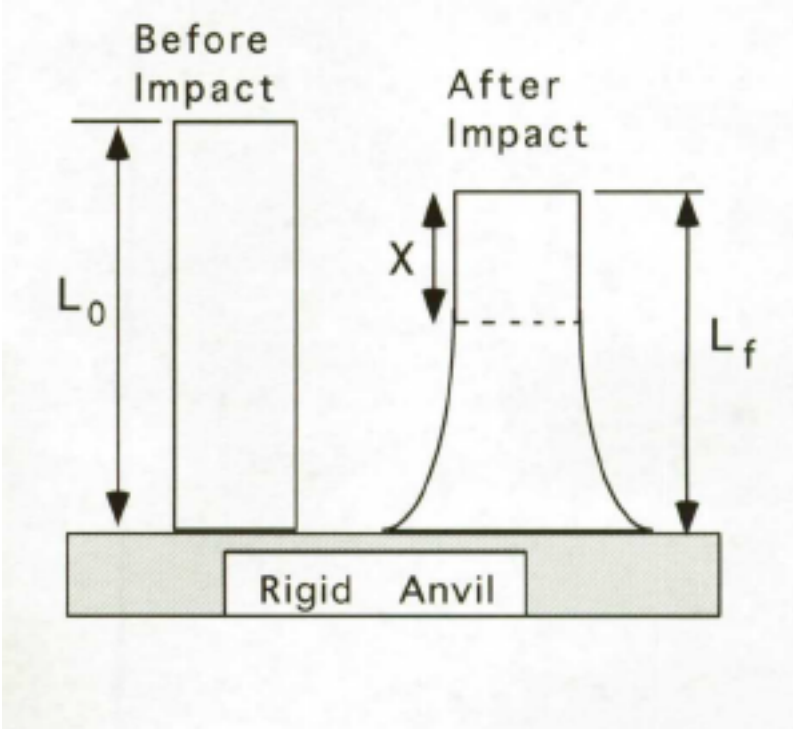
Milestone specifics

- **Discussion of the goals for the milestone/project**
  - Develop and share compendium of Ta strength experiments.
  - Conduct additional experiments to enhance data set.
  - Assess with current hydrocodes and material models the tantalum strength experiments conducted at Z, NIF, Omega, and LANL M-9 gas guns.
  - Document results of preliminary simulations and hypotheses.
  - Report out analyses and experimental results in the form of a series of presentations to a tri-lab panel

- **Specific tasks to be completed this year**
  - Set up sharepoint website as centrally located data and simulation storage site
  - Simulate results of Taylor cylinder, 1 Mbar Z ramp and release, and 3.5 Mbar NIF experiments using same models
  - Present results to Tri-lab committee

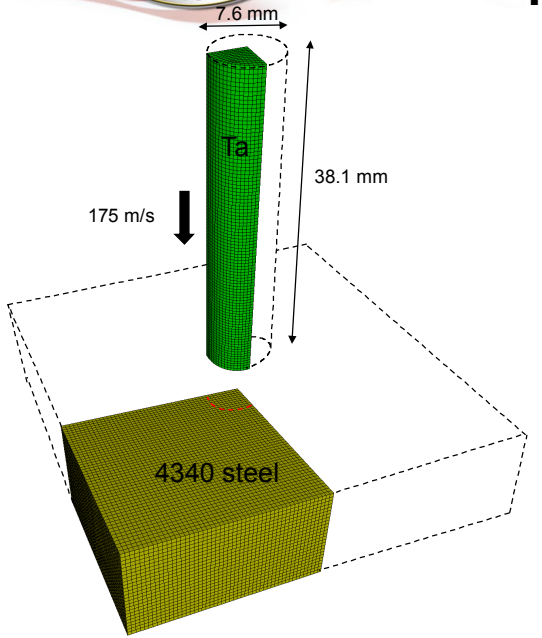
Taylor Cylinder Testing

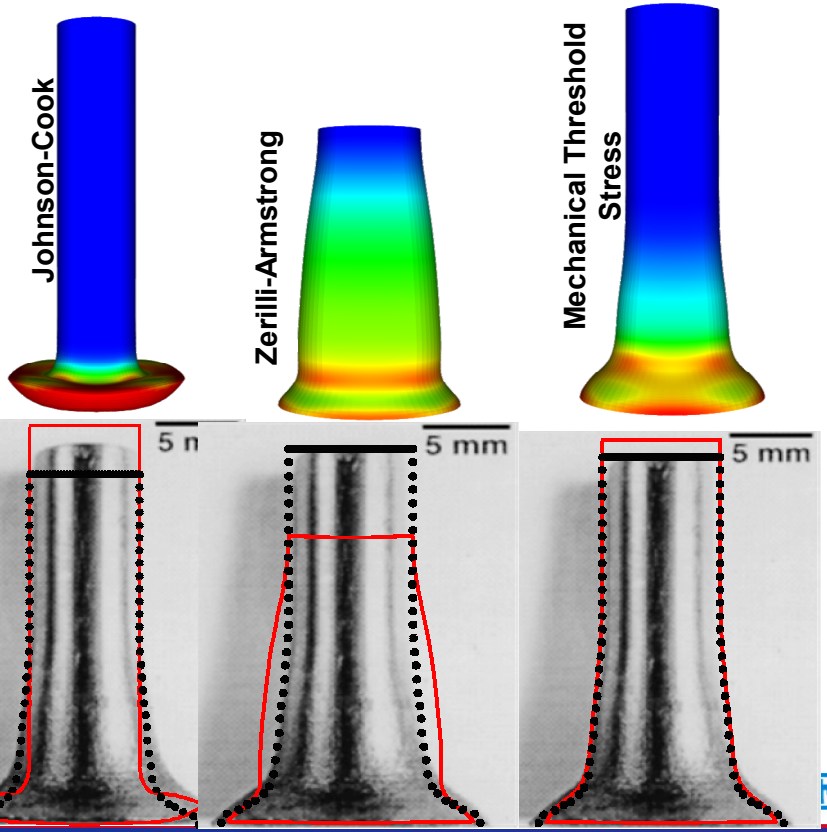
- Advantage is the sensitivity to models and simpler relationship to strength.
- The Taylor Cylinder test entails firing a cylinder rod of a material of interest at a massive and rigid object.
- The result of the collision are large gradients of stress, strain rate, and strain along the length of a cylinder.
- The final length, cylinder axial profile, and footprint allow comparison to constitutive models.



Taylor Simulation Results (ALEGRA)

Taylor cylinder impact test



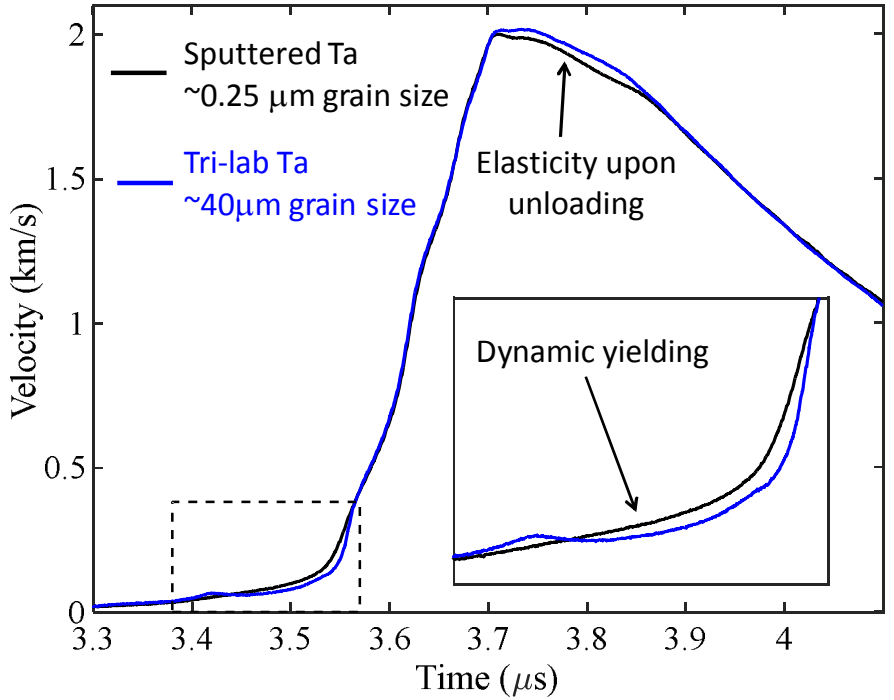


- ALEGRA solid dynamics code (Sandia)
- Kerley Mie-Grüneisen equation of state
- Strength models:
  - Kink-pair (KP) model
  - Johnson-Cook (JC) model
  - Zerilli-Armstrong (ZA) model

* Maudline et al., IJP (1999)

Ramp and Release method used at Z

- **Advantage is high pressure and strain rates are in region of interest**
- **Magnetic field from very high electrical current used to produce a ramp pressure wave in sample**
- **When material then goes through elastic release, the response is related to shear stress.**
- **Data is then used to compare to various strength models.**

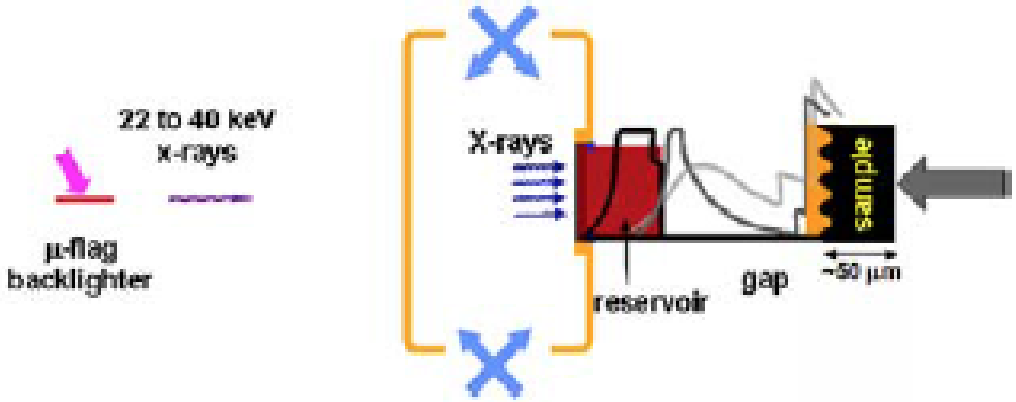


Velocity profiles from 1 Mbar Ta strength experiment on Z

Rayleigh-Taylor strength experiments

- Advantage is very high pressures and very fast strain rates
- Laser/Holraum ablation is used to generate pressure wave in material
- Drive side of material has rippled surface interface with strengthless material.
- X-ray radiography is used to measure the growth in amplitude of the ripples
- Results can be related to strength of the rippled material

Schematic description of RT strength experiment on NIF



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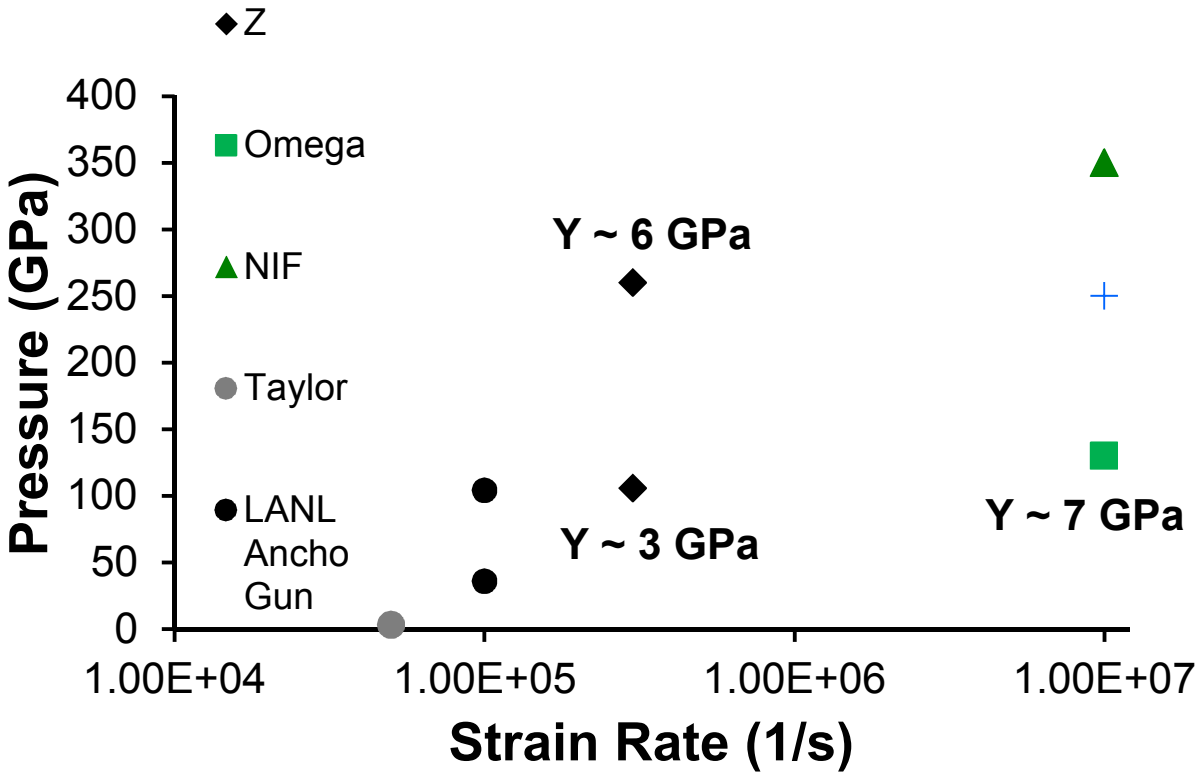
Material conditions covered by the experiments

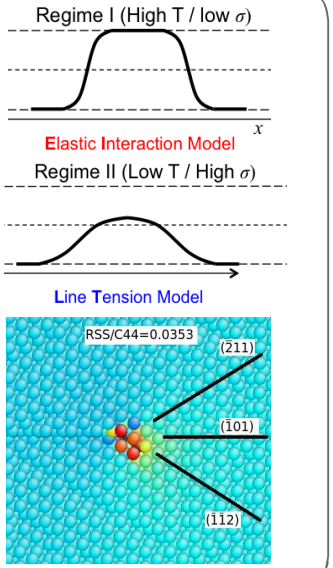
- Graph at right summarizes the experimental types, conditions, and approximate results of experiments being compared
- The results cover a range of pressures and strain rates
- All these experiments are done with the same Ta material

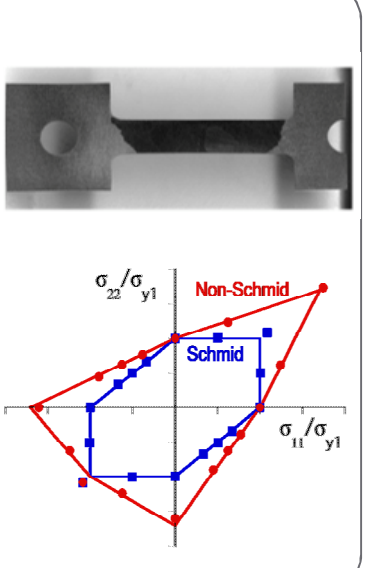


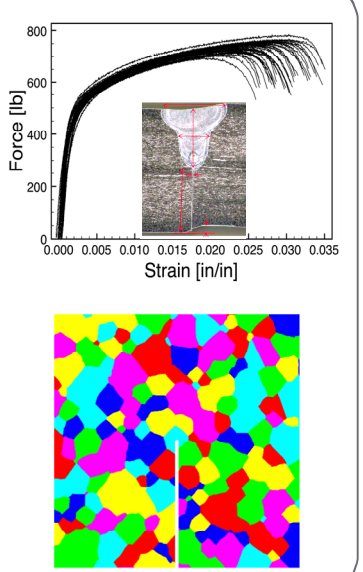
Sandia Theoretical Overview: Multi-scale Approach

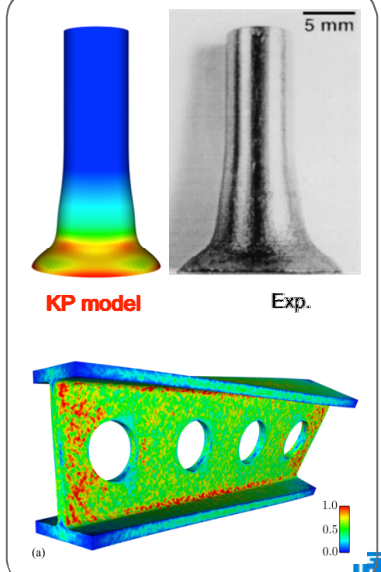
Multi-scale simulations & experiments to predict material's reliability

Atomic scale phenomena	Single crystal behavior	Microstructural effects	Material Performance
10^{-9} m	10^{-6} m	10^{-3} m	10^{0} m









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Progress to date and path forward

- **Accomplishments**
  - Modeling of Taylor impact and Z compression experiments are nearing completion.
  - Third experiment (NIF/Omega) drive has been successfully initialized on two of the three hydrocodes.
  - Cross code comparisons, as well as “best model” comparisons are being prepared.
  - The Tri-Lab committee has been chartered and will gather in April and August.
    - Consists of nine members, three suggested by each lab
    - Panels role is advisory

- **Path forward for the rest of this year**
  - Two more Ta strength shots will be carried out on Z (one to reach equivalent conditions to the laser experiments)
  - Monthly telecons will track progress between quarterly in-person Milestone meetings
  - Present results of comparative modeling of experiments to Tri-lab committee in August

Summary

- **Milestone is on track to reach goals for this year**
  - **Modeling of the experiments is going forward successfully using the same strength model**
  - **Additional experiments are being carried out to support the overall goals**
- **Once initial comparisons are made, modeling to identify differences in strength models and "best model" for the various experiments will move forward**
- **In FY18, the second part of the milestone will be carried out**
  - After material response results from a variety of simulation tools have been collected, we will assess the results, identify processes and conditions that could explain apparent discrepancies, and identify experimental or theoretical gaps.