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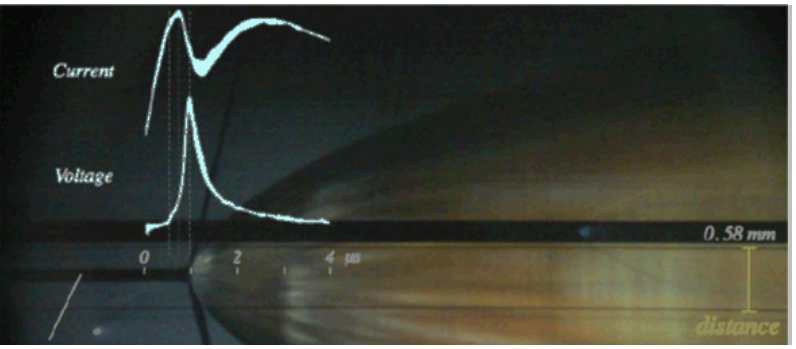

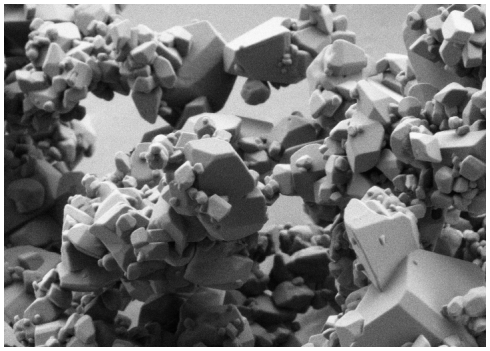

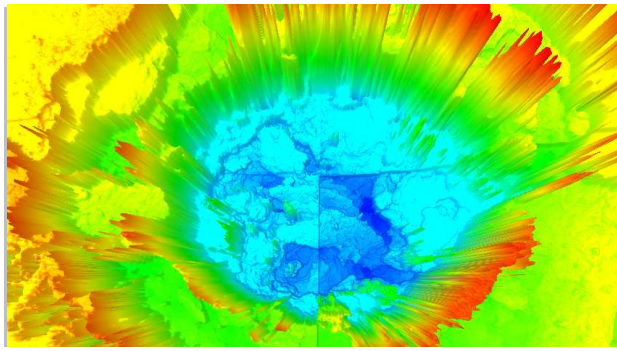

Physical and Electrical Measurements of Different Metals used in Exploding Wires

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U.S. DEPARTMENT OF ENERGY

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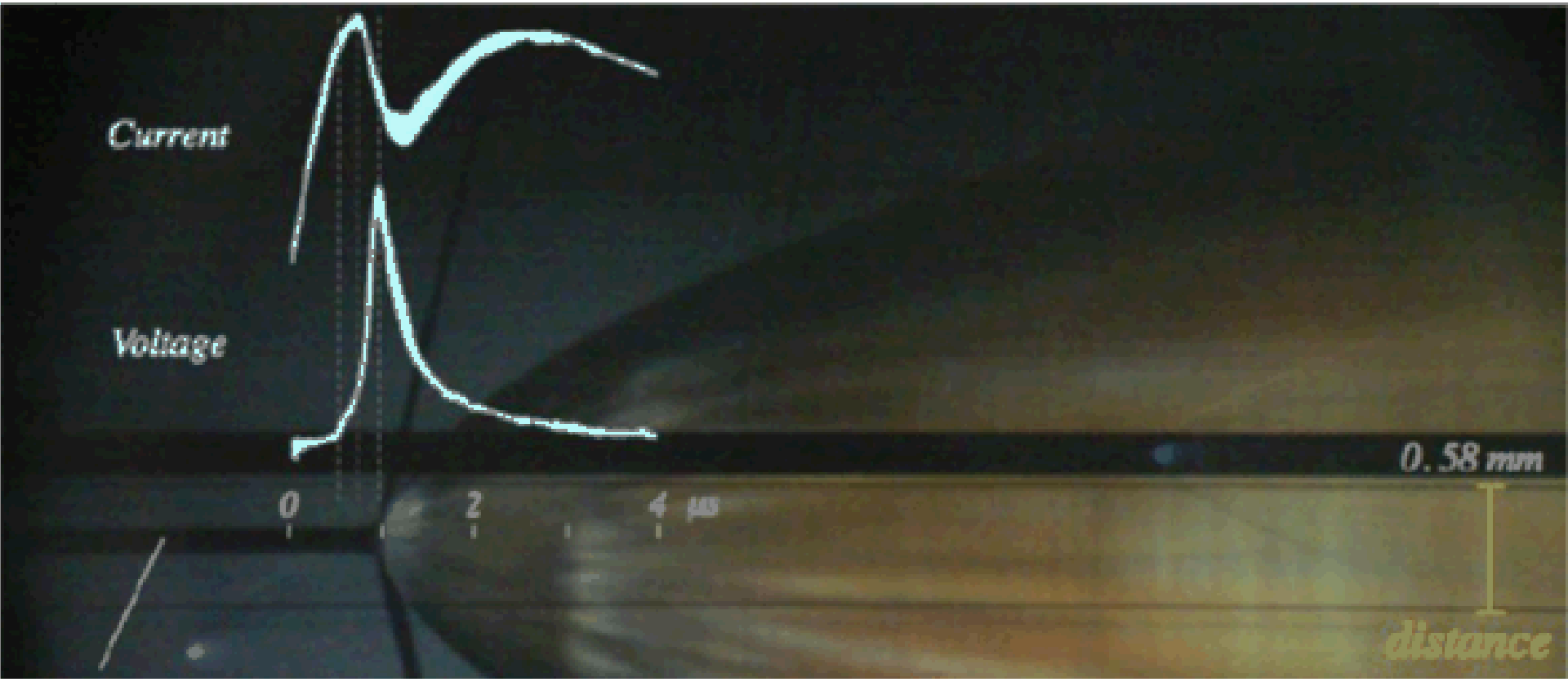
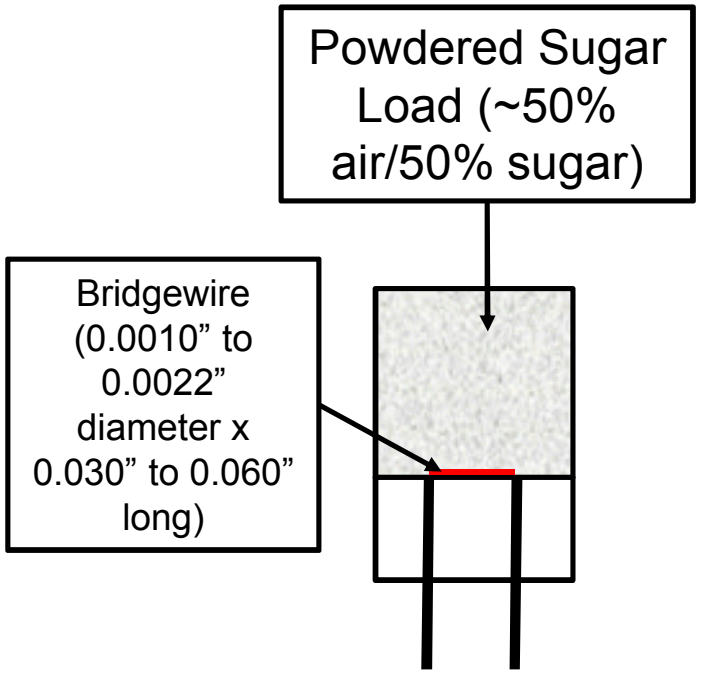
Historical Tests



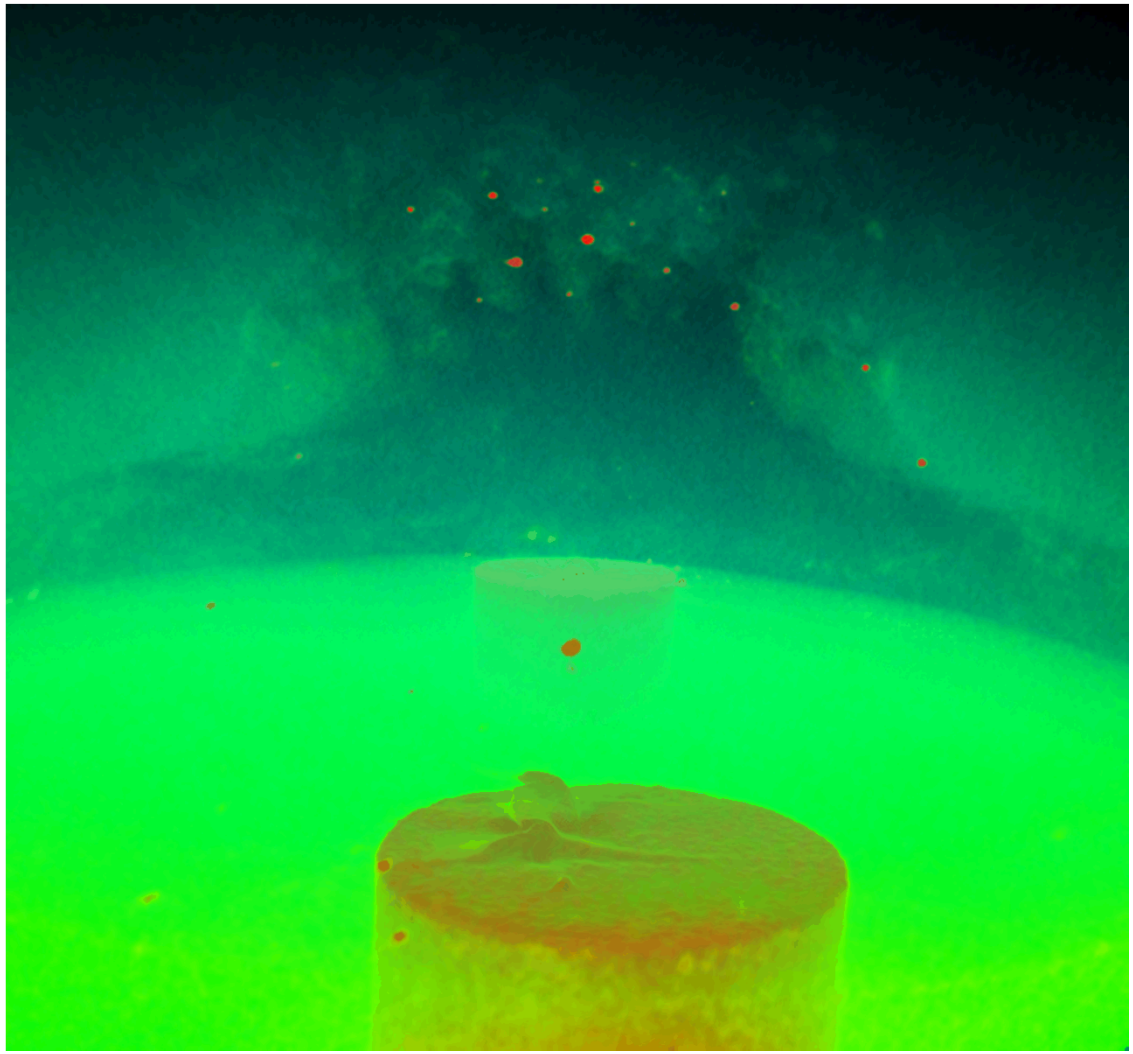
- Tests done in air or water.
- Streak done in conjunction with current measurements (sometimes voltage).
- These tests are very interesting for observing the shock velocity/wire expansion.

- However, many applications are not in air/water.

CT Scans of EBW in Porous Media

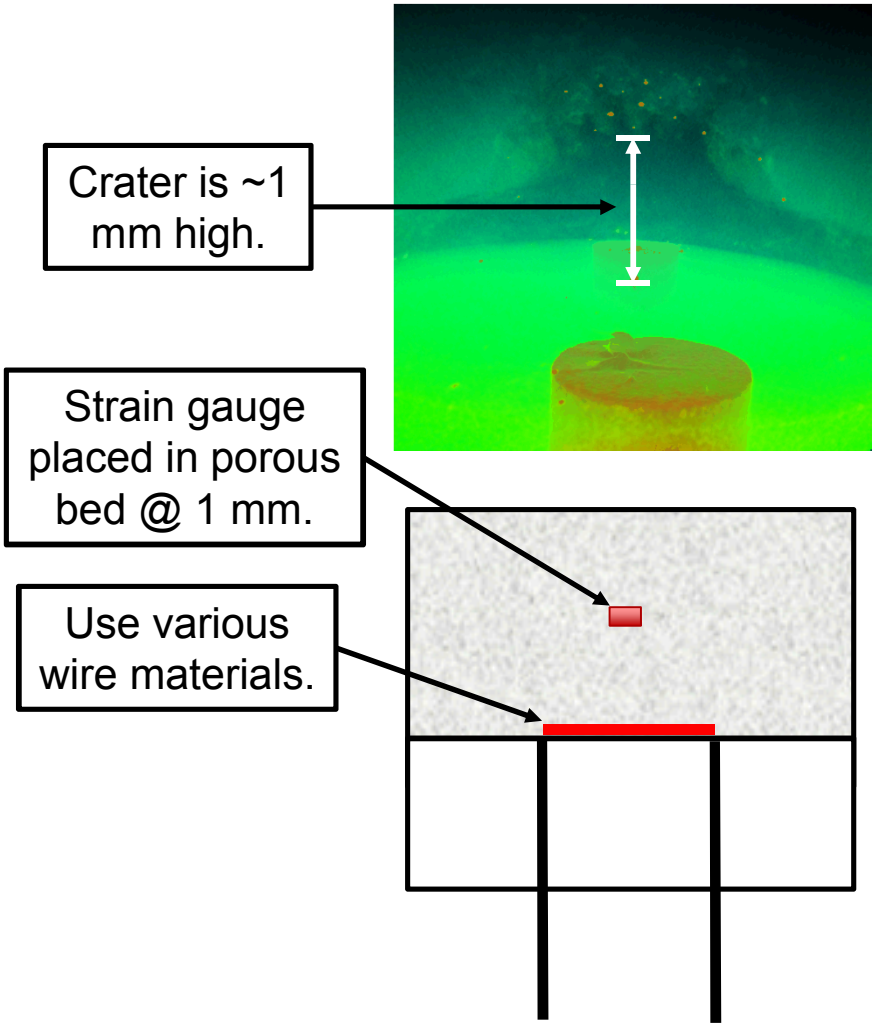


- High current is applied to the wire.
- The wire explodes.
- Result is work done on porous media.
- Porous media are interesting because shockwaves are quickly attenuated.
- Is work done due to gas expansion, or Rayleigh-Taylor type flow?

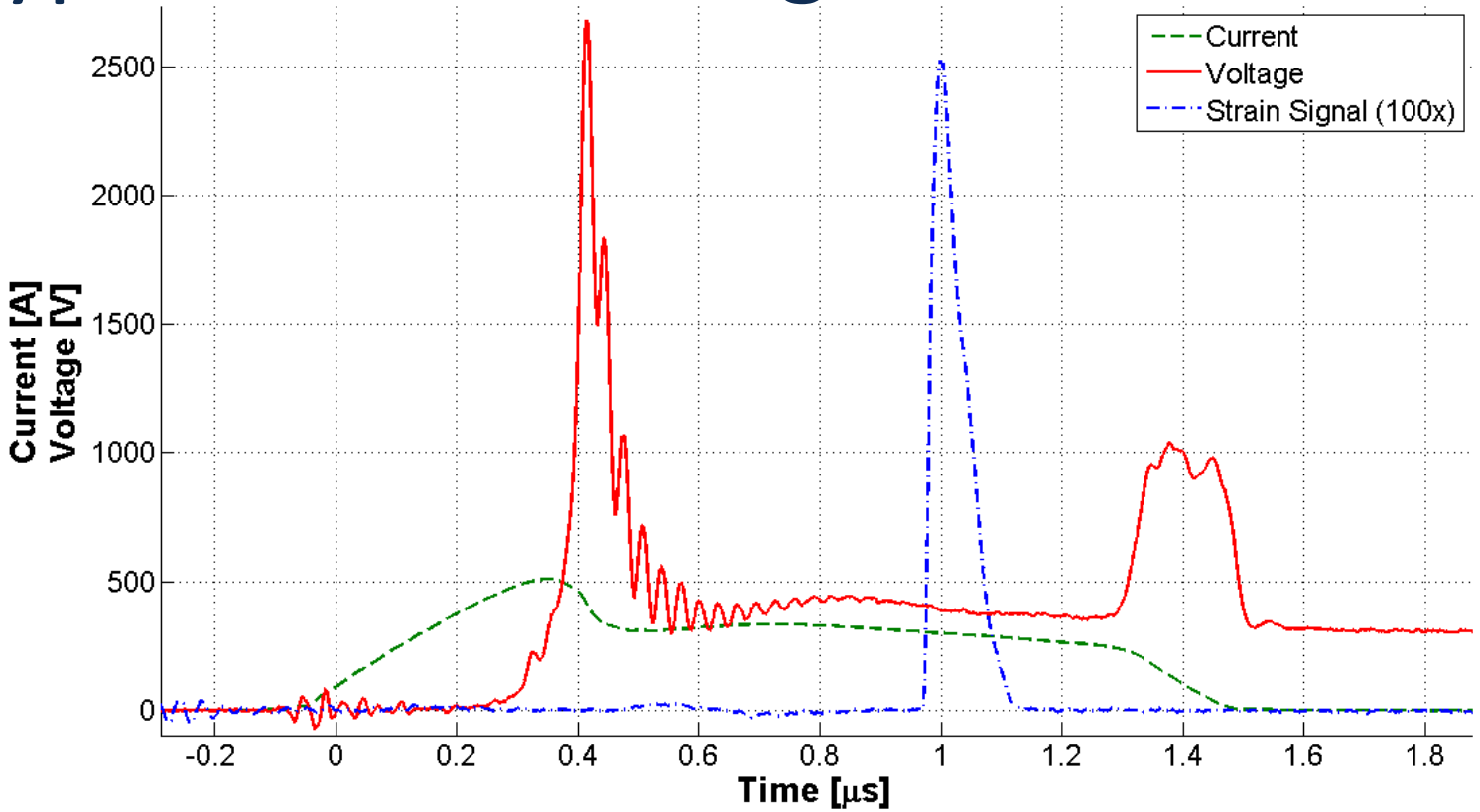


Test Setup

- CT scans indicate the crater in the material is roughly 1 mm high off the header surface.
- A strain gauge is placed at 1 mm off the surface inside the porous media.
- A 1 uF capacitor is charged to various voltages and discharged through the wire.
- The time it takes until a strain signal is observed is recorded.
- If no strain signal is recorded, it is assumed the media was not compressed to the 1 mm mark.
- This is repeated for multiple bridgewire materials (Au, Ag, Cu, Ni, Pt, Fe, Ti, Bi).



Typical Recorded Signals

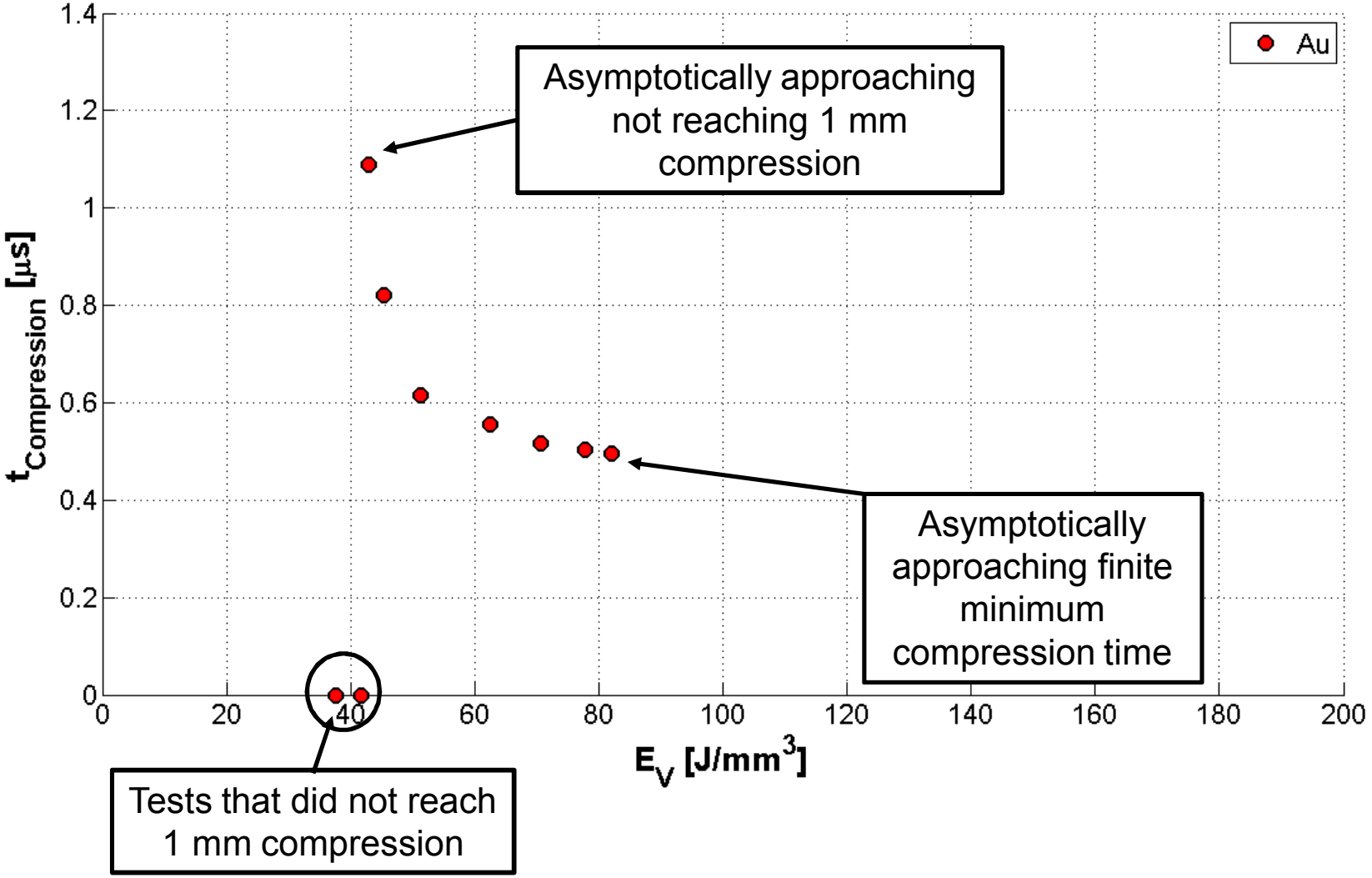


- Current, differential voltage, and strain are recorded on an oscilloscope.
- Peak Power until strain signal start is noted as the time it takes for compression to reach 1 mm.
- Energy Density[1] is calculated and compared to compression time.

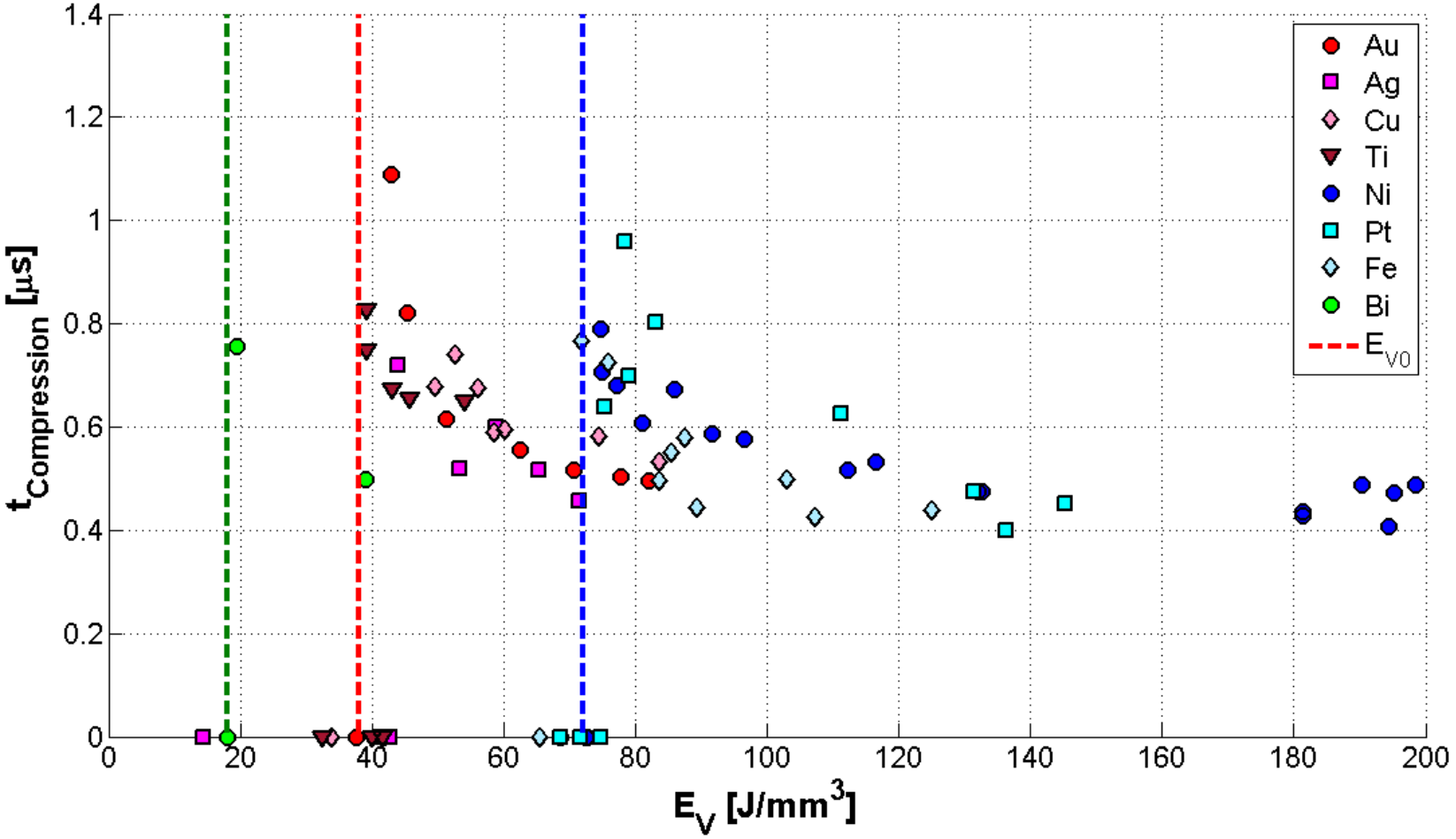
$$P = I(t)\,V(t) \qquad E_V = \frac{Energy\ from\ Current\ Start\ to\ Peak\ Power}{Initial\ Bridgewire\ Volume} = \frac{\int_{t_{current\ start}}^{t_{Peak\ Power}} I(t)\,V(t)\,dt}{\pi l r^2}$$

1. Valancius, Garasi, O'Malley, "Power and Energy of Exploding Wires," Conference Proceedings of APS-SCCM, 2015-07.

Single Data Set

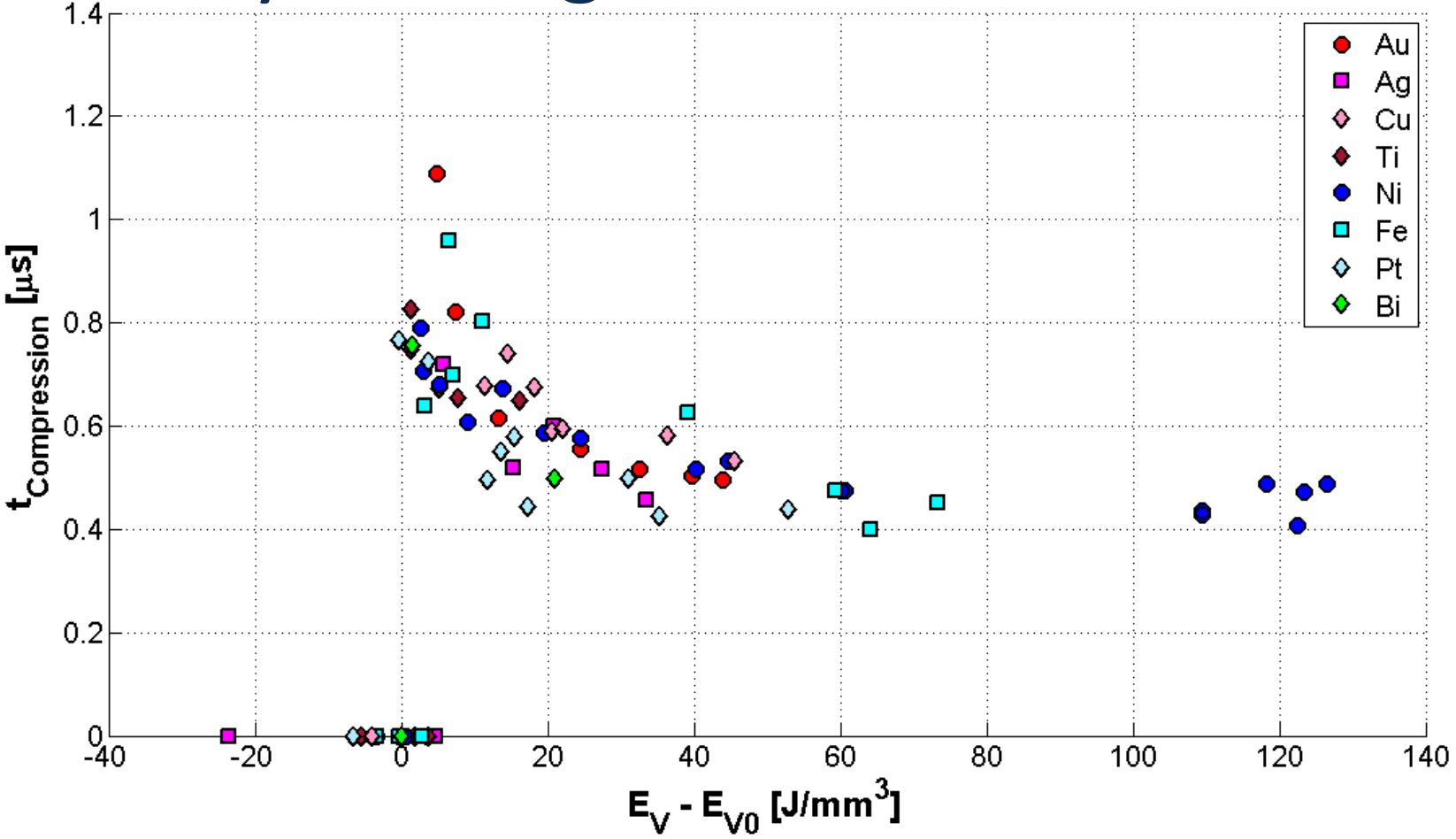


Different Metals Compressing the Bed



- Appear to be 3 categories in Energy Density compared to compressive potential.
- Historical groupings have been [Au Ag Cu], [Ni Fe Pt Ti], [Bi] based on shocks in air/water.
- We are seeing groupings of [Au Ag Cu Ti], [Ni Fe Pt], [Bi] based on porous media compression.

Linearly Shifting Curves



- Appears time to compress decreases similarly for each metal as energy is added beyond E_{V0}.
- Suggests all metals doing same work on bed.
- Suggests cannot be related to gas phase expansion of wire (if it were, each metal would be at a different vapor pressure, applying a different force, and compress at different rates).
- This leaves the shock as doing work on the bed (Richtmeyer-Meshkov interaction?).

Summary and Conclusions

- Strain gauges were placed inside a porous bed of powdered sugar.
- Different wire materials were exploded into the powder bed.
- The time to compress to 1 mm was recorded for different Energy Density inputs into the wires.
- Three groupings appear which are similar, but slightly different from historical studies:
  - Au, Cu, Ag, Ti
  - Ni, Fe, PT (historically, Ti is placed in this group)
  - Bi
- It appears that all metals compress the media at similar rates once Energy Density is above a minimum.
- It appears gas phase expansion cannot be responsible for the work done to the porous bed.