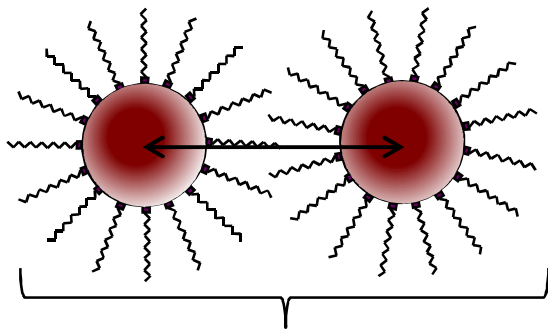


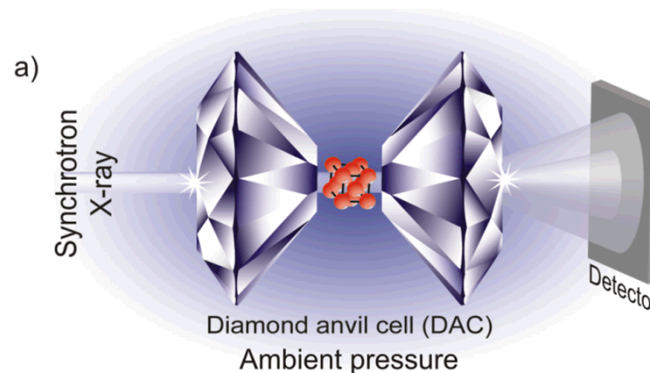
# Formation of nanostructured arrays through magnetic ramp compression

RANDY J. HICKMAN, TOMMY AO, JACK L. WISE, HONGYOU FAN

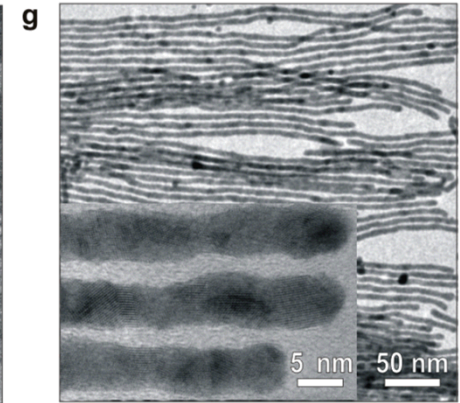
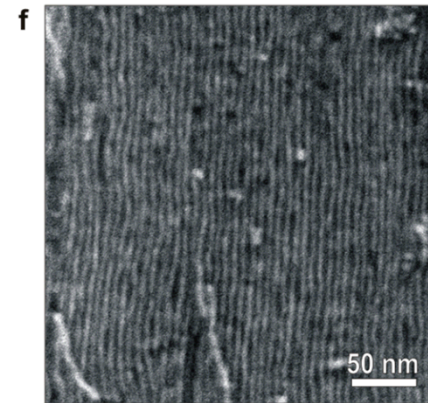
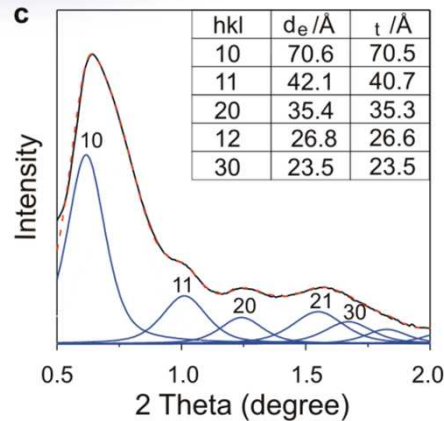
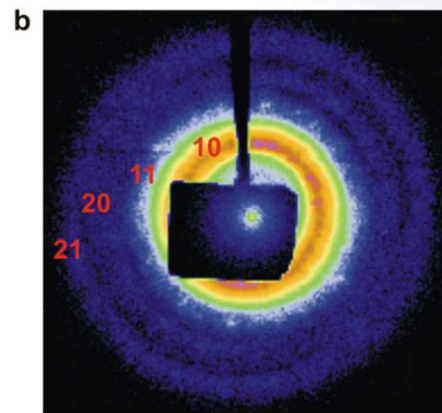
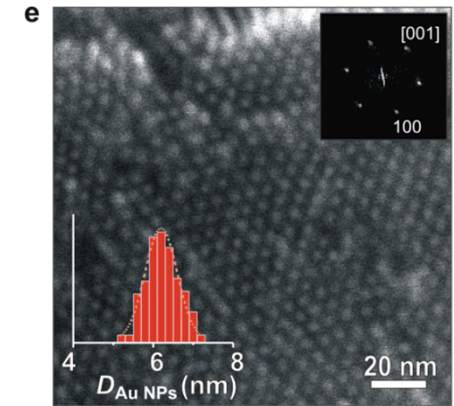
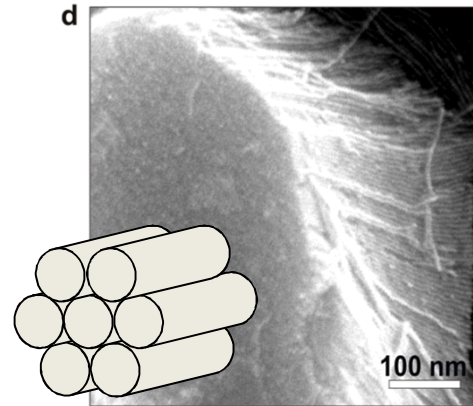
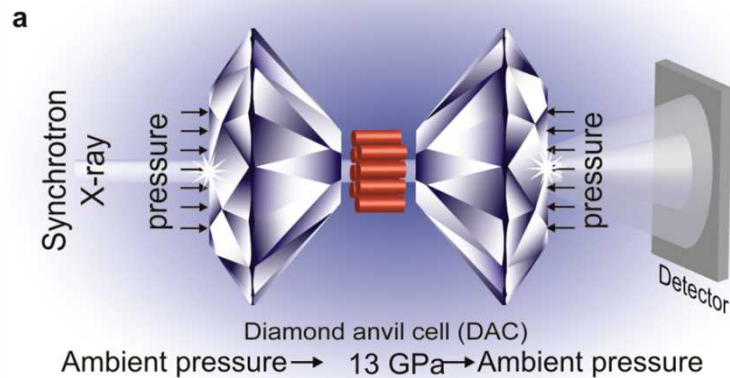
*Recently, pressure-driven assembly of spherical nanoparticles and formation of one to three dimensional, nanostructured arrays have been demonstrated using diamond anvil cells. Extending the pressure-driven assembly of nanostructured arrays from static diamond anvil cells to dynamic compression techniques has been studied.*



Balanced interparticle interactions



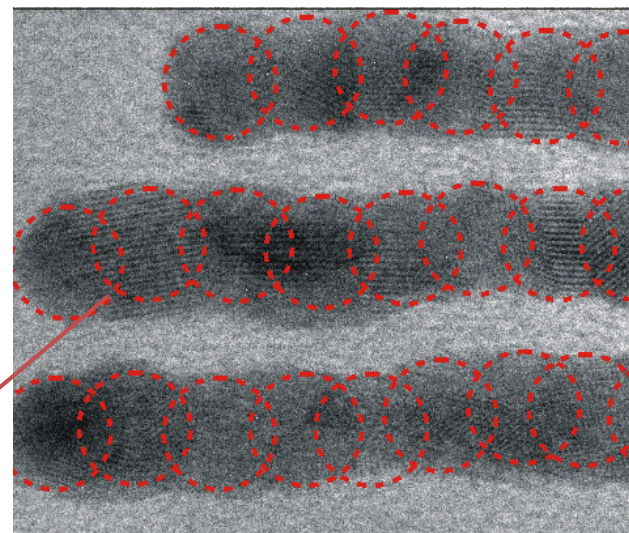
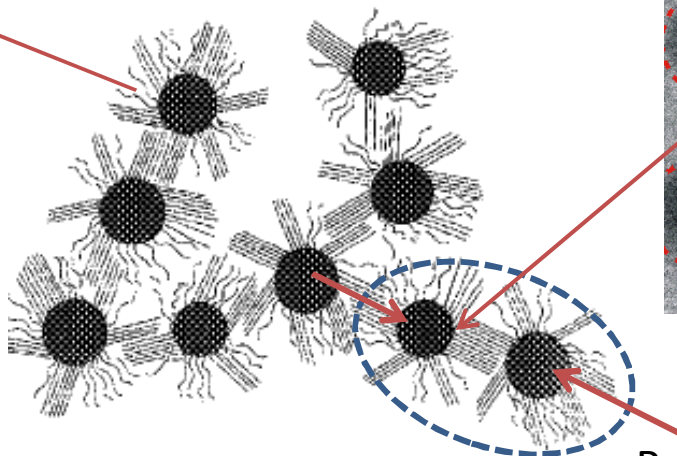
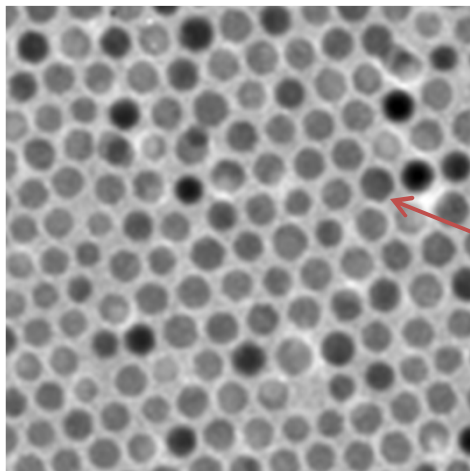
# High Pressure Driven Formation of 1D Nanowires



# PRESSURE DRIVEN ASSEMBLY OF PARTICLES



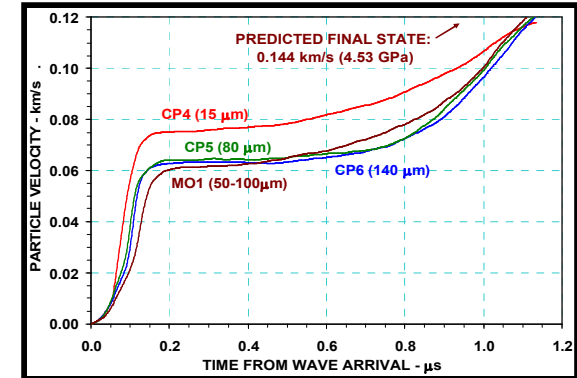
- *At ambient pressure, 'fibers' keep particles separated*
- *As pressure increases, the 'fibers' begin to interleave and allow the gold particles to sinter into structured arrays and then completely bound wires*



Pressure applied

# DICE FACILITY CAPABILITIES

## 3" BORE AIR GUN



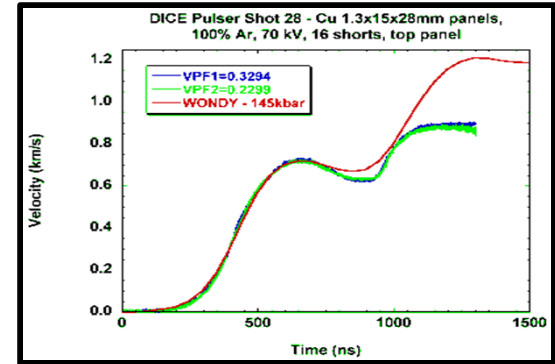
- 76mm Bore
- 240-540 gm projectile mass
- 80-450 meters/second velocity
- .3-6 GPA (60Kbar)
- VISAR, Line ORVIS, X-Ray diffraction



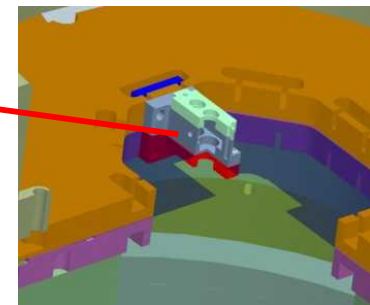
Sandia National Laboratories is a multi program laboratory managed and operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation, for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

# DICE FACILITY CAPABILITIES

## VELOCE ISENTROPIC COMPRESSION DRIVER



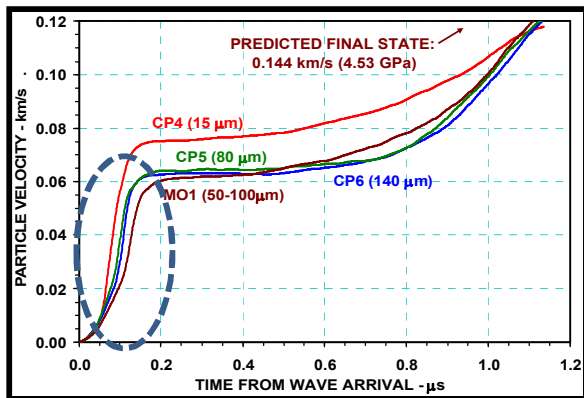
- **PRESSURES OF 5-14 GPA**
- **RAMP TIMES OF 430-540ns**



# WHY RAMP COMPRESSION?

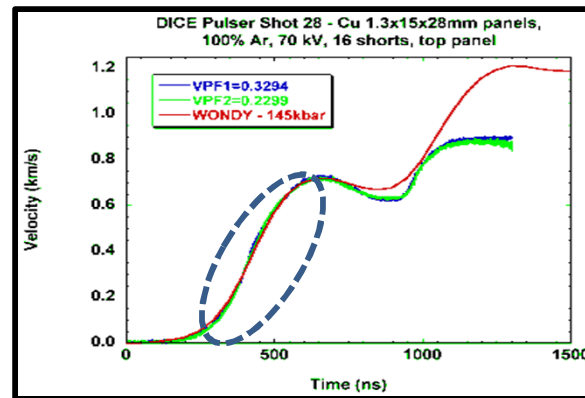
- Shock compression would be unsuitable for synthesis of nanostructures because the elevated temperatures of shock states would induce melting of nanoparticles.
- However, magnetic ramp compression has been demonstrated to produce smooth, shockless loading with low temperature states suitable for nanostructure synthesis.

GUN=SHOCK



Rapid pressure increase-  
Great heating effect

VELOCE=RAMP

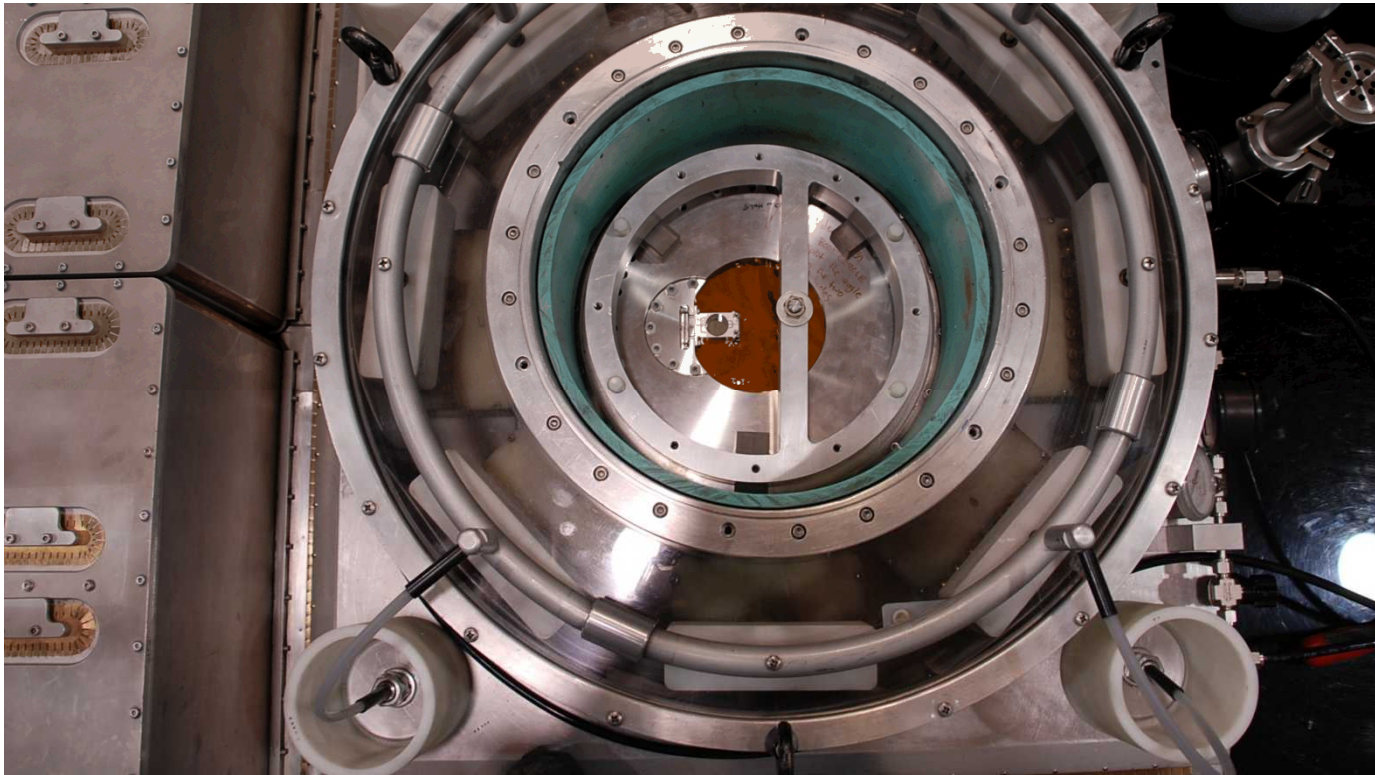


“Slow” pressure increase-  
Very little heating effect

# SOFT RECOVERY SYSTEM-VELOCE

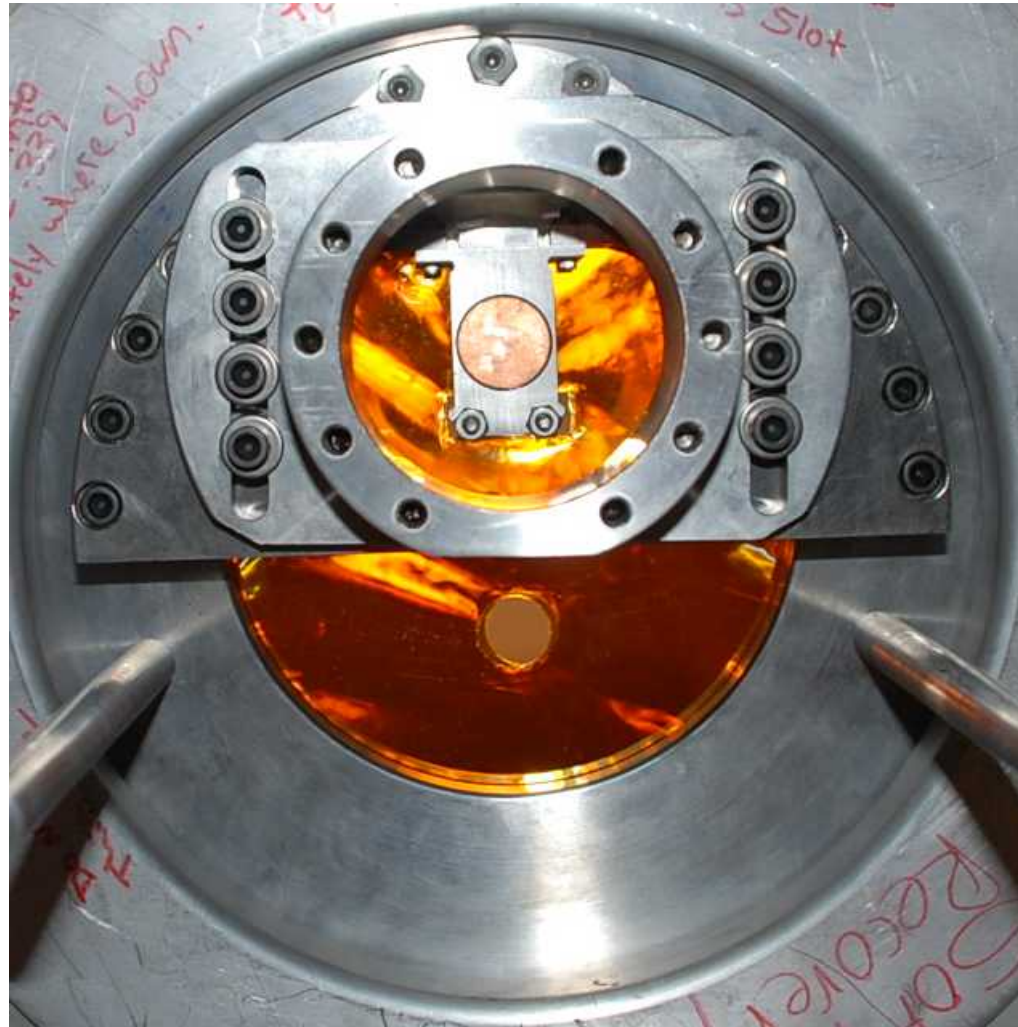


Top plate for drive measurement



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# SOFT RECOVERY SYSTEM-VELOCE



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# SOFT RECOVERY SYSTEM-VELOCE

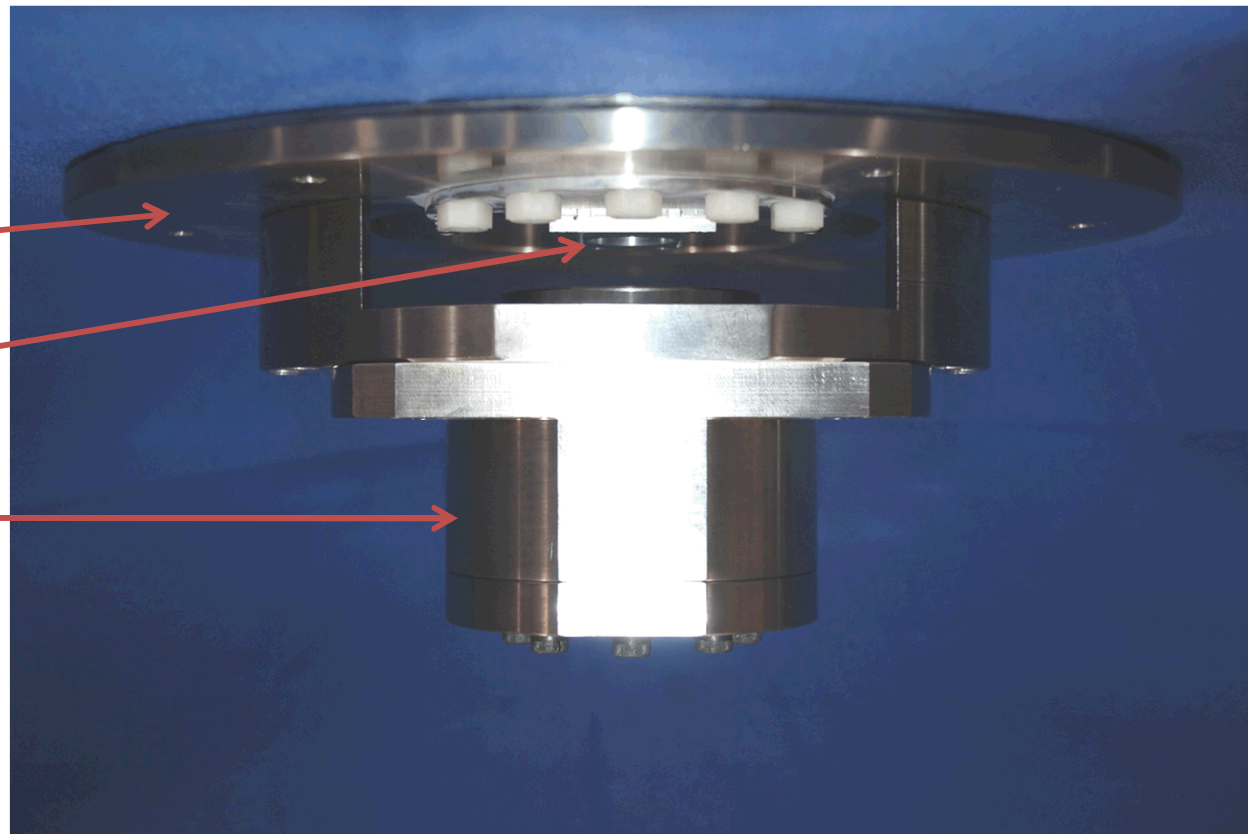


*Soft recovery system previously developed for gun and veloce to enable post experiment sample grain structure analysis*

**HEX PLATE**

**PANEL/SAMPLES**

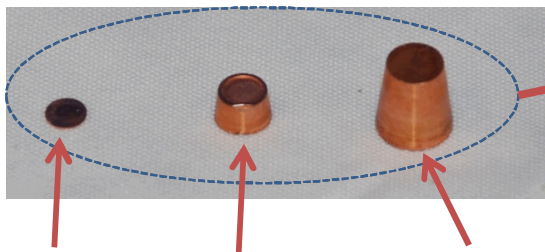
**FOAM FILLED  
CAPTURE  
CYLINDER**



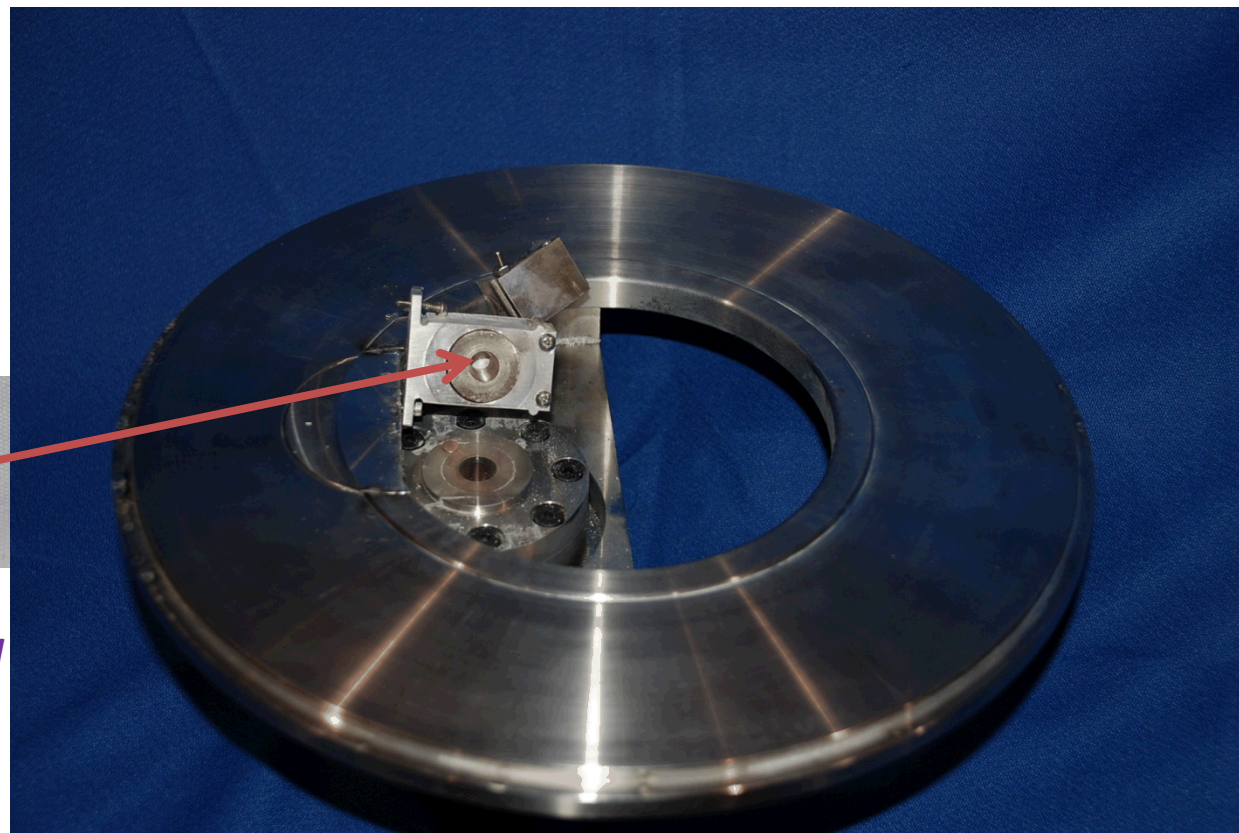
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# SOFT RECOVERY SYSTEM-VELOCE



*Cover    Sample holder    Anvil*

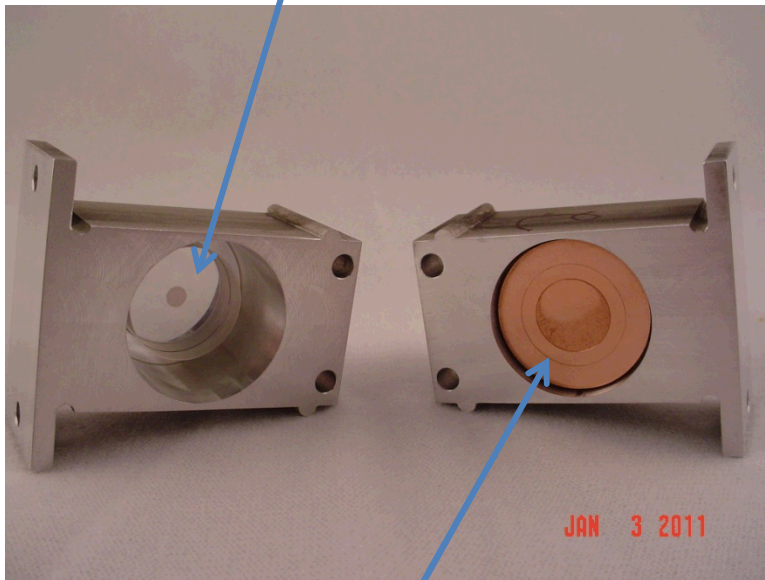




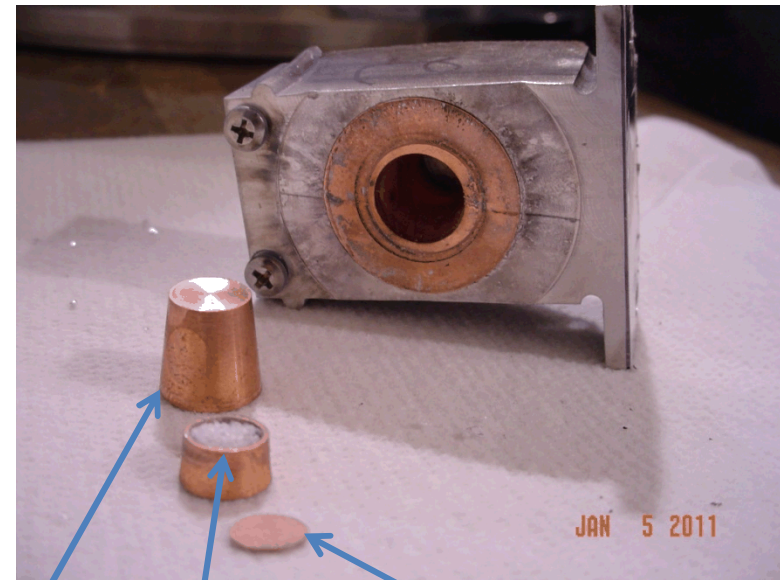
# SOFT RECOVERY SYSTEM

*Samples are recovered in foam for post mortem analysis*

*Drive measurement panel*



*Panel with complete recovery capsule*



*Anvil*

*Sample holder*

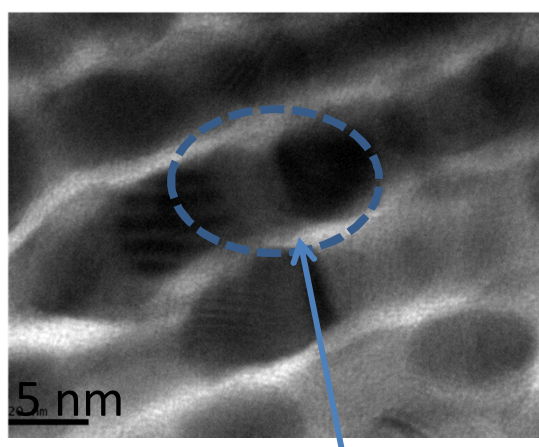
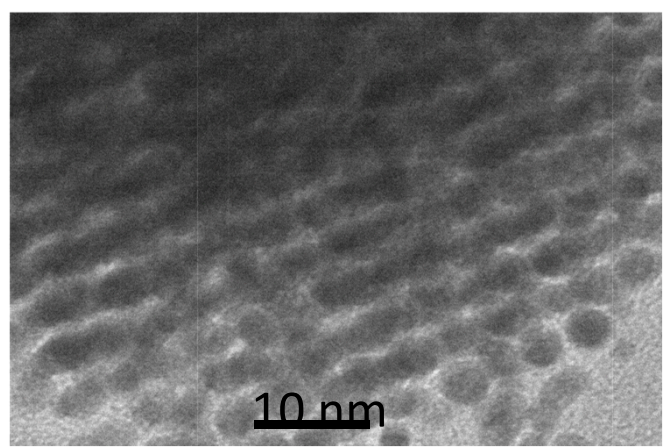
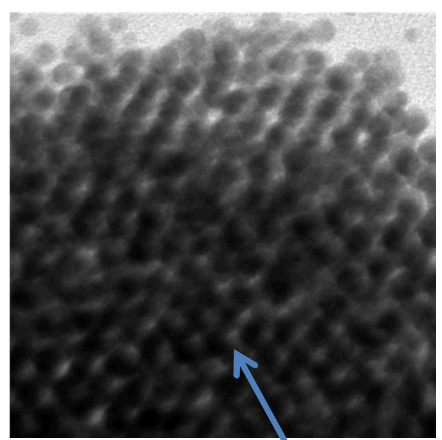
*Cover*



# EXPERIMENTAL RESULTS

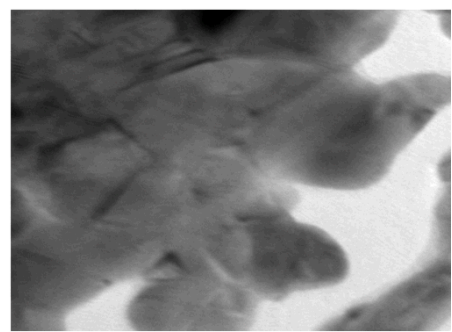
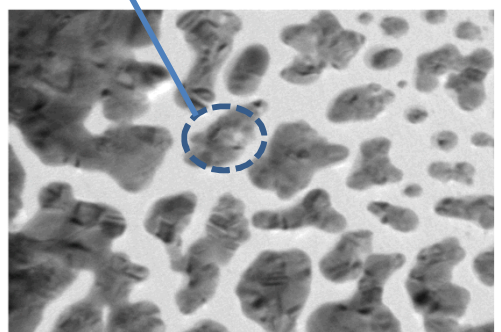
## 3D ordered gold network formed @ 7GPA

*Given uncertainties in correlation between semi-static and dynamic pressure interactions, we started at lower pressure on Veloce (6 GPA)*



Thin layer of gold sheet

*Bond not completely formed-need higher pressure-(9-11 GPA)*





# PRESSURE DRIVEN ASSEMBLY



- **New capability using Sandia's existing facilities for fabrication of new nanostructures with controlled functionality, impossible to current bottom-up and top-down methods.**
  - **The PDA method opens a new arena for production of functional nanostructures with unprecedented levels of control and facility of fabrication.**
  - **The PDA method offers the capability to explore previously uncharted domains in the collective optical and physical behavior of nanostructures.**
- **New tools for evaluation and correlation of property and structure of nanomaterials at extreme conditions.**
- **Some semiconductor manufacturing currently uses similar pressures in micro-processor fabrication**