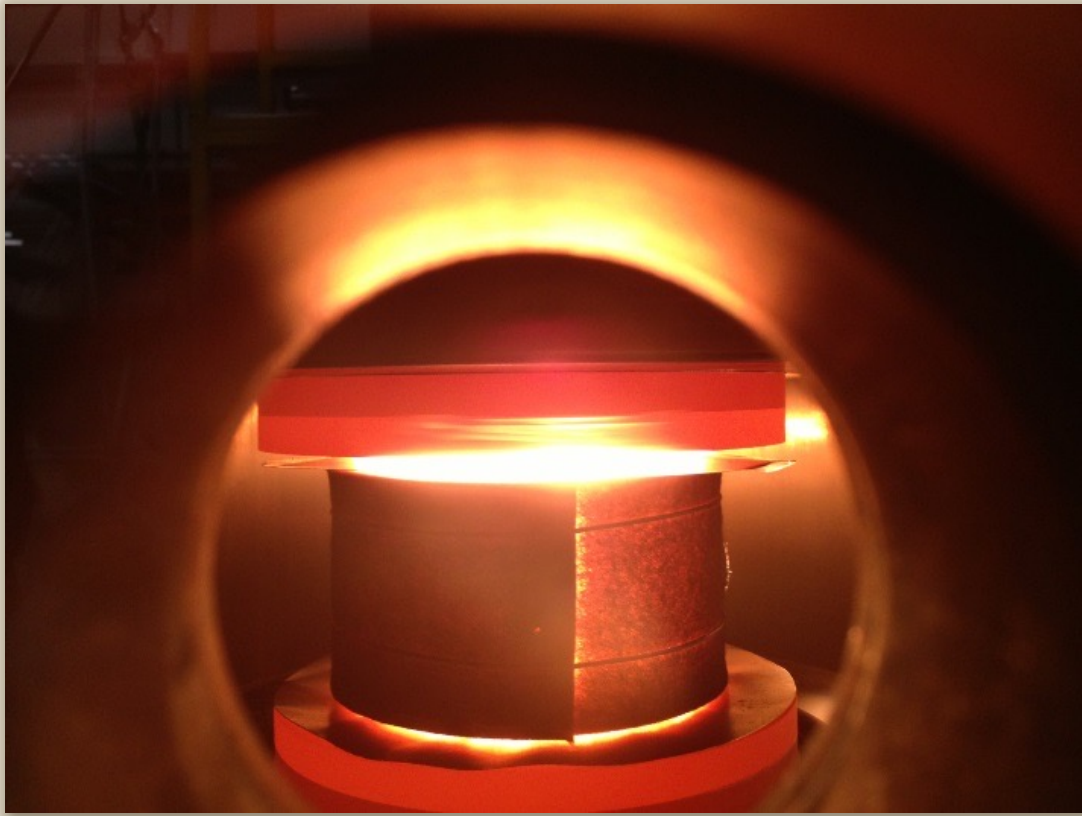


# THERMAL TECHNOLOGY LLC<sup>TM</sup>

H I G H   T E M P E R A T U R E   E X P E R T S



Direct Current Sintering



## What Is Direct Current Sintering Technology?

Thermal Technology's rapid powder consolidation technology, Direct Current Sintering (DCS), utilizes high amperage DC current to rapidly heat a conductive tooling assembly under simultaneous uniaxial pressure inside a vacuum chamber. The application of this technology enables metal and alloyed powders, ceramic powders, cermets (ceramic/metal mixtures), functionally graded materials (FGM's), carbon matrix composites (CMC's), and other advanced materials to be densified into rigid substrates for aerospace, defense, energy, industrial, and medical applications. Materials are quickly heated and quenched minimizing grain growth resulting in improved microstructure and accompanying material properties with high homogeneity at lower operating costs.

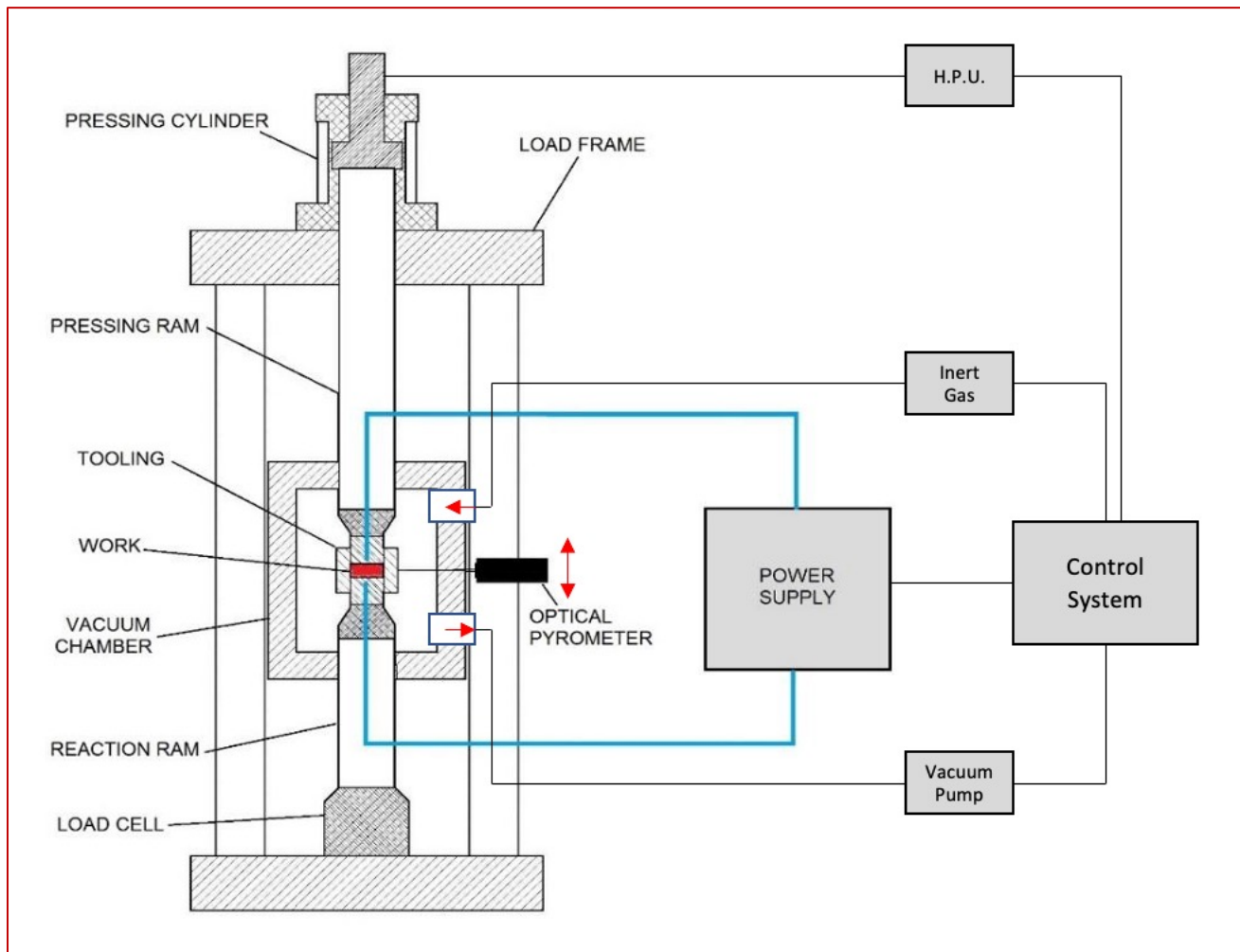
Conductive materials that can pass current through their bulk see significant benefits from the DCS process. Non-conductive materials are also heated and cooled faster resulting in less grain growth as the temperature differential across the part is much lower in the DCS process.

Products such as Sputtering Targets of refractory metals and metalloid compositions, substrates for nuclear fuel pellets, ultra-high temperature ceramics (UHTC's) for hypersonic flight vehicles, high entropy alloys, FGM's, and diffusion bonding are but a few of the many applications for which the DCS process is utilized. National Labs and corporate R&D facilities alike are securing their next generation IP using this technology.

Today, Direct Current Sintering technology is growing into full-scale commercialization with Thermal Technology producing the largest manufacturing systems available globally.

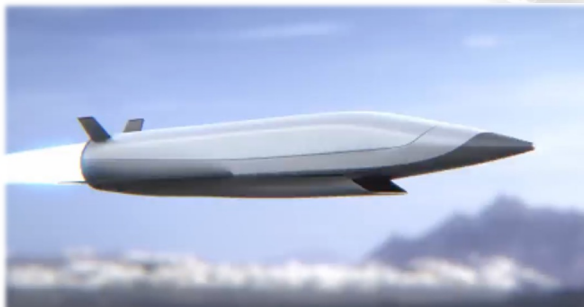
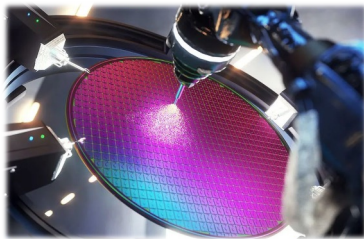


# The Fundamentals Of Direct Current Sintering Technology...



The Direct Current Sintering furnace is Thermal Technology's product offering for the process also known as Spark Plasma Sintering (SPS), or the Field Assisted Sintering Technique (FAST). The process uses high electrical current to rapidly heat a conductive tooling assembly under simultaneous uniaxial pressure inside of a vacuum chamber. With no heating elements, extremely rapid heating and cooling of the sample is possible, enabling high-density materials to be sintered with ultra-fine or even nano-sized grain structures.

# Technological Material Benefits For Many Industries...





## THERMAL TECHNOLOGY IS THE ONLY U.S. BASED MANUFACTURER OF DIRECT CURRENT SINTERING SYSTEMS

### DCS Technology Benefits

- Fast Cycle Times
- Pre-forming and binders NOT necessary
- Uniform sintering of like and dissimilar materials
- Vaporization of pre-existing contamination
- Ease of use
- Full density and controlled porosity
- Low Operating costs
- Powder-to-part and near-net shapes
- Minimal grain growth

### All DCS Systems Include:

- Remote PC based programming station
- State-of-the-art clean wave, high efficiency power supply
- Proportional valve controlled hydraulics for ultra-fine control
- Process data acquisition
- Fully programmable power supply, including mid-process adjustability
- Front-load access – entire front wall of chamber opens

### Vacuum System Options:

- High-Performance Mid-Range Vacuum Package
- Diffusion Pump High-Vacuum Package
- Turbo-Molecular High-Vacuum Package
- Cryo-Pump High-Vacuum Package

### Standard DCS System Features

- ✓ Maximum temperature of \*2500°C.
- ✓ Vacuum ( $10^{-3}$  Torr Range)
- ✓ Inert gas (Ar, He) and Process Gas ( $N_2$ ). Combustible Gas Safety System for use with combustible gases.
- ✓ 10 Volts heating power.
- ✓ Fully automatic operation by PLC and touchscreen HMI.
- ✓ Programmable, variable heating and ramp rates.
- ✓ Thermocouple and Pyrometer based Temperature control.
- ✓ On the fly switching between current and temperature control.
- ✓ Rapid vacuum cycling; typical <10 min.
- ✓ Water flow and pressing ram overtemperature system protection.

\*Power Supply, Rams, and Sensors allow for up to 2500°C, however, this is dependent on the cooling water quality, tooling design, size, and material.

### Additional System Options:

- Particle Vapor Trap
- Gas Heat Exchanger System
- Glove Box Integration
- Material Handling



# Laboratory & Small Parts Production Systems...



## Model DCS 10

- 100kN (10.2 Ton)
- 5,000 Amp\* Heating Current
- Typical Part Size: 10 – 38mm (0.4 – 1.5")

\*Available w/ Pulse DC power supply - this model only.

## Model DCS 25

- 250kN (25.4 Ton)
- 10,000 Amp Heating Current
- Typical Part Size: 10 – 100mm (0.4 – 4")



# Medium & Large Parts Production Systems...



## Model DCS 50

- 500kN (51 Ton)
- 20,000 Amp Heating Current
- Typical Part Size: 38 – 152mm (1.5 – 6")

## Model DCS 200

- 2,000kN (204 Ton)
- 50,000 Amp Heating Current
- Typical Part Size: 76 – 304mm (3 – 12")



# Large & Extra Large Parts Production System...

## Model DCS 800

- 8,000kN (815.8 Ton)
- 150,000 Amp Heating Current
- Typical Part Size: 254 – 609mm (10 – 24")

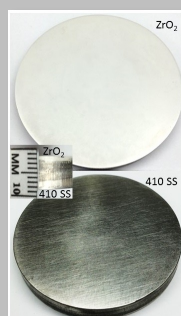
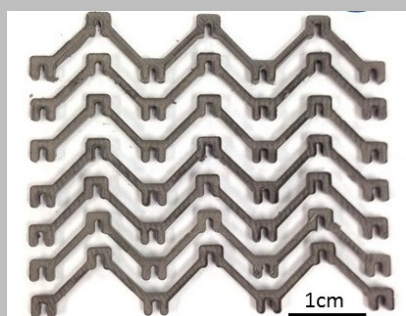
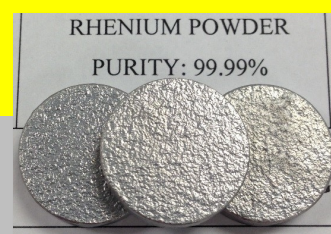






## Thermal Technology LLC R&D Engineering Laboratory...

The TT R&D Engineering Laboratory is home to two of our manufacturing systems; a Model DCS 200 and a Model DCS 25. Both systems are available for process development, proof of concept runs, and toll processing. For years TT has been working with nearly every segment of industry to further the development of both the DCS platform and our customers' advanced material projects. Contact us at [Sales@ThermalTechnology.com](mailto:Sales@ThermalTechnology.com) to discuss how we can assist you in your development projects and how we can help with the transition to manufacturing.



# **THERMAL TECHNOLOGY LLC<sup>TM</sup>**

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