Company Presentation



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www.calnanocorp.com

Cal Nano Mission



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Bringing next generation materials to market with cutting-edge technologies

At Cal Nano, we envision a world in which our advanced technologies are used to help make the most innovative products on this planet and beyond. We are trusted by global leaders to help push the boundaries of applied material science by utilizing our unique technical expertise and vision.





What We Do

R&D & Manufacturing Toll Services

Provide toll services to universities, national labs, start-ups, and large corporations Ranging from making a few samples to fullscale R&D & production programs

SPS Equipment & Tooling Sales

- North American distributor for Japanese SPS equipment manufacturer
- We install, train and service all size SPS equipment from lab scale to full production As the experts in SPS, we supply customers that have SPS systems with the highest quality tooling to fit their sintering needs

Vertically Integrated materials R&D

One-stop shop for all of our customers We act as extension of your R&D departments SPS Tooling & Sample Pre & post work/analysis



Cryogenic Milling is a specialized grinding process conducted in a cryogenic liquid environment of -190 C used for reducing particle size, creating nano-materials & mechanical alloying

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R&D and Pilot Scale Cryomills at our facility

- ✓ 500 gram 1 kg powder capacity
- ✓ 7-10 kg powder capacity







Cryogenic Milling Benefits

Particle Size Reduction

Rapidly reduces particle size in materials that otherwise smear (polymers, low density metals, water soluble materials, etc.)

Custom Alloys & MMCs

Cal Nano has produced high value, custom engineered material alloys of five elements or more. We can achieve this safely and in 1/5 the time of standard milling processes.



Material Properties Improvement

Cal Nano took a commercially available Aluminum aerospace alloy and doubled it's strength with cryomilling due to creating nanocrystalline material

Moisture/Oxygen/Heat Sensitive Materials

Materials remain fully protected by inert cryogenic liquid or gas throughout the cryomilling process. This makes the process perfect for materials sensitive to environmental & high temp conditions.



Cryogenic Milling Powder morphology



Metallic powders generally become flake like before layering and coldwelding into larger, more irregular shapes.





8 hrs Aluminum (6061+ Dia)

8 hrs Co Super Alloy

Cryogenic Milling

Powder morphologies

Material	Al 6061 + 0.3 wt% DIAM
Break-in Wt.	800 g
Charge Weight	1000 g
Gas used	Liquid Nitrogen
Milling time	8 hrs
Mill RPM	180 rpm
Ball Dia., Material	¹ / ₄ inch, stainless steel, 30 kg
Ball to Powder Wt.	30:1
Stearic Acid	0.5 g



COMPO 10.0kV X25.000



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SPARK PLASMA SINTERING "SPS" (aka Field Assisted Sintering Technique "FAST")

- ✓ SPS allows for the rapid application of temperature and pressure via high-density pulsed current within a controlled atmosphere.
- SPS is the ideal consolidation and bonding method for all of your materials including magnetic materials, metals, refractory alloys, nanomaterials, ultra-high temp ceramics, and more.





SPS Benefits

Extremely Versatile

Low to ultra high temperature capabilities (100-2200+°C) make SPS ideal for all metallic and ceramic applications. Can sinter 100% dense parts or controlled porosity

Shorter Cycle Times

Rapid and repeatable sample production ensuring R&D efforts lead to commercial programs, 10-100x faster standard furnace, retain smaller grain size of materials



Cost Effective

Due to the method and speed of heating, SPS is more cost effective than traditional sintering methods with energy savings exceeding 90% in some cases

Bonding & Functionally Graded Materials

Diffusion bonding of dissimilar materials and the ability to create functionally graded materials adds to SPS capabilities



SPS – Sinter almost any material

Classification		Materials for SPS processing
Metals		Fe, Cu, Al, Au, Ag, Ni Virtually any metals possib Cr, Mo, Sn, Ti, W, Be
C	Oxides	Al_2O_3 , Mulite, ZrO ₂ , MgO, SiO ₂ , TiO ₂ , HfO ₂
r (a 1 m 1 c 5	Carbides	SiC, B₄C, TaC, TiC, WC, ZrC, VC
	Nitrides	Si ₃ N ₄ , TaN, TiN, AlN, ZrN, VN
	Borides	TiB ₂ , HfB ₂ , LaB ₆ , ZrB ₂ , VB ₂
	Flourides	LiF, CaF ₂ , MgF ₂
Cermets		Si ₃ N ₄ +Ni, Al ₂ O ₃ +Ni, ZrO ₂ +Ni
		Al ₂ O ₃ +TiC, SUS+ZrO ₂ , Al ₂ O ₃ +SUS
		SUS+WC/Co, BN+Fe, WC+Co+Fe
Intermetalic compounds		TiAl, MoSi ₂ , Si ₃ Zr ₅ , NiAl
		NbCo, NbAl, LaBaCuSO ₄ , Sm ₂ Co ₁₇
Other materials		Organic materials (polyimide, etc.), compositematerials





Spark Plasma Sintering – Multi-sample



Cost Effective NNS



Collaboration sintering for SDSU

Large scales and Near Net Shape Sintering is Achieved via Engineered Tooling or Selective Powder Deposition



Spark Plasma Sintering – Functionally Graded Materials

ZrO2(3Y)/Stainless Steel FGM





Spark Plasma Sintering – Large Ceramics





Material: SiC (with additives) R.D : 99-100%



Current Max Size SPS part made – 620 mm OD (~ 2ft OD)



Spark Plasma Sintering Capabilities



SPS-515 Specs - 1500 A/50 kN

- Max size- 1" OD
- Max Temp 2400 C
- Has been used for R&D at Cal Nano for 10+ years
- Over 7,000 SPS trials performed
- Vacuum/N/Ar atmosphere



SPS 7.40 Mk IV Specs – 10000 A/1000 kN

- Max size ~ 6" OD
- Max Temp 2400 C
- Installed in Fall 2017 for larger R&D and pilot scale SPS programs
- Over 2,500 SPS trials performed
- Vacuum/N/Ar atmosphere

Inert Glove Box Handling Available For Materials That Require It (Ar/N)

Cal Nano – Offering Custom Machining for SPS Tooling & Samples

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Cal Nano offers a variety of post-SPS processing capabilities including machining & Wire EDM. We will often cut out specimens for customers after SPS for testing such as tensile, fatigue, compression, gleeble, CTE, and much



Cal Nano Innovation

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Commercialization SPS'd 1000+ wafers in <2 months

The successful commercialization of an advanced thermoelectric material via SPS resulting in significantly greater performance



Innovative Solutions

Collaboration

HEAs and Refractory alloys

In collaboration with key partners in the Nuclear & Oil & gas industry, Cal Nano cryomilled, SPS'd, & analyzed dozens of new advanced powder systems for next-gen materials

> Cal Nano's engineering team developed a complicated component with internal features via SPS for a multi-national semiconductor company

- **Energy** high performance thermoelectric materials, nuclear reactor components
- **Aerospace/Space** ultra-high temp ceramics for shielding/engine components/hypersonics
- **Defense** transparent ceramics like Spinel for high temperature applications, Ultra-hard Ballistic Armor
- **Next-gen Batteries -** Cathode Materials, Nd-Fe-B, Soft Magnetic Materials
- **Automotive** High volume disc brakes, Cubased & composites, brake rotors – specialty applications
- **Specialized Parts Repair via Bonding**

 \checkmark













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Transition from R&D to Production – Cryomilling Production Capabilities

Cal Nano has patented key techniques allowing for safe and cost effective large scale commercial cryomilling. Hundreds to tens of thousands of kg per week are achievable with cryomilling process.

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Transition from R&D to Production -SPS Production Capabilities

Using an automated SPS tunnel-type system, SPS is capable of manufacturing high volumes of parts.

Throughput Capability – 15 min or less per cycle, tens to hundreds of parts per cycle depending on part size







Top view - multi-sample SPS die

Stay in Touch

For further information, please contact info@calnanocorp.com (562)-991-5211



