nGimat

nanoEngineered Materials™

*nGimat ("**engi-mat**") is a privately-owned developer and manufacturer of nano **engineered materials**, with an extensive record of technical innovation. World-class expertise includes nanotechnology, materials science and combustion technology.*

nGimat has 24 years of technical innovation including over $40M in SBIR/STTR projects.
Active projects are underway in support of the Department of Defense and the Department of Energy.

Commercialization successes include:

- Active technology license and equipment lease with a global OEM
- Growing product sales to DOD prime contractor, fuel cell manufacturer, Spectra Sensors and others
- Providing 50 nanopowders to diverse customers through the Sigma Aldrich catalog
- Increasing revenue from sales of nanopowders for superconducting wire

Applications of nGimat's unique technical capabilities include:

Marvite™ Insulation Materials

nGimat's proprietary insulation materials **enable a 46% increase in motor power** without increasing temperature. Marvite magnet wire insulation demonstrates a **thermal index of 281°C**, compared to 240°C for polyimide.

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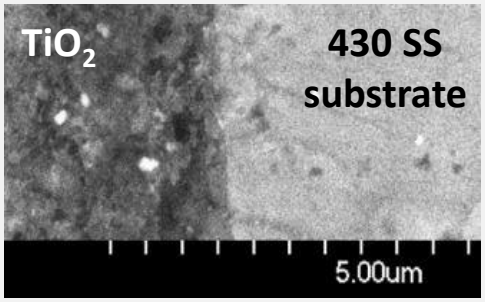
Design and Production of Nanopowders

50 high-performance nanopowders (<200 nm) are cost-effectively produced for diverse customer applications. Unique capability to tailor particle size, shape, morphology and surface characteristics.

ISO 9001:2015

See page 4

Ceramic-to-Metal Bonding



Patented solution dramatically improves ceramic-to-metal **adhesion strength,** with ~5 GPa hardness, for cutting tools, turbine blades, and heat exchangers.

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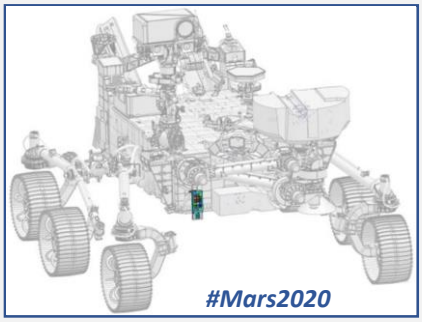
Superhydrophobic Surfaces



nGimat's proprietary coated fabric has been selected by NASA to travel to Mars in 2020 for further testing.

See tinyurl.com/ngimat2020 and tinyurl.com/ngimat2020a

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nGimat's proprietary Marvite™ insulation materials offer dramatically improved thermal conductivity

Increased power density** ● **Reduced size & weight

Lower temperatures** ● **Longer life** ● **Increased efficiency

Testing conducted by National Renewable Energy Laboratory (NREL) and Oak Ridge National Laboratory (ORNL)

Marvite Insulation and Marvite Resin

nGimat's proprietary materials incorporate both conventional polymers/resins and nanomaterials, with outstanding results:

Thermal conductivity (measured by NREL):

- **Marvite wire insulation**: 0.81 W/m·K
- **Marvite resin**: 3.0 W/m·K

Thermal modeling (NREL) indicates >900% increase in effective cross-slot thermal conductivity (20 AWG wire):

- 5.34 W/m·K with **Marvite insulation and resin**
- 0.52 W/m·K with conventional insulation and resin

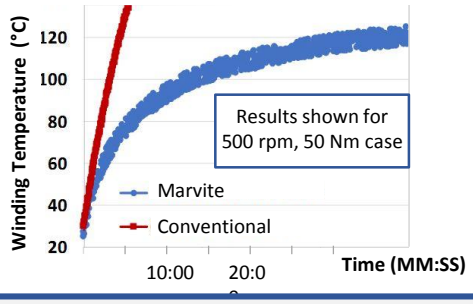
Marvite wire insulation satisfies NEMA MW1000: (using 250°C rating)

- Dielectric strength
- Flexibility; adherence
- Thermal endurance
- Scrape resistance
- Dissipation
- Continuity
- Cut-through
- Heat shock
- Spring-back
- Solubility

Superior Thermal Performance

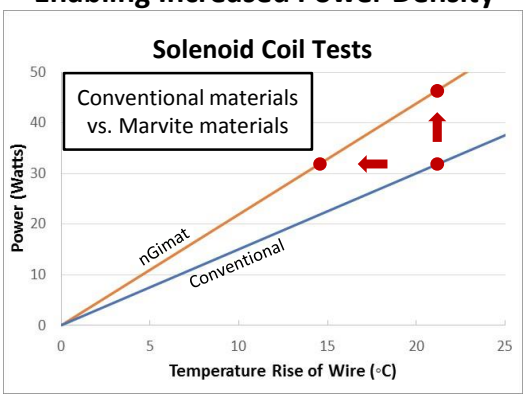
ORNL tested two nearly-identical motors:

- Adapted from the 2010 Toyota Prius
- "Marvite" = with Marvite insulation and resin
- "Conventional" = with conventional materials



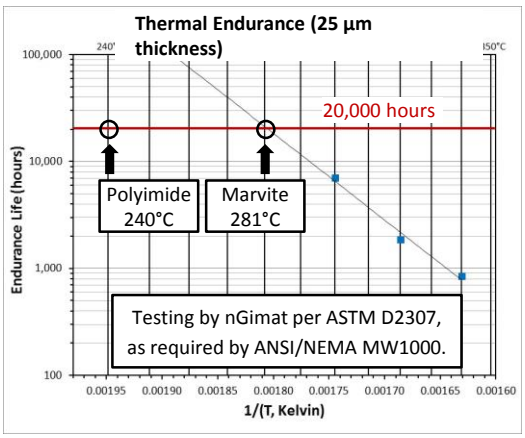
Conventional motor: reaches 130°C in 5:20
Marvite: approaches steady state of ~125°C

Enabling Increased Power Density



Marvite materials enable 46% more power without increasing wire temperature (or 31% lower temperature rise at same power)

Higher Thermal Index for Extended Endurance



Thermal Index of Marvite wire insulation (281°C) is dramatically higher than polyimide's (240°C)

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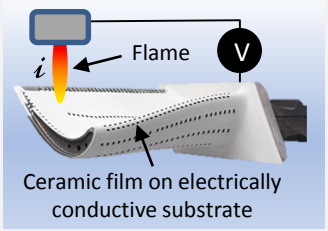
Page 3: Flame Assisted Flash Sintering

for ceramic-on-metal surfaces

"FAFS" is a breakthrough technology enabling rapid sintering of ceramic to metal with dramatically improved adhesion and hardness

The Unique FAFS Process

- A ceramic coating (<5-100 µm) is placed onto an electrically conductive substrate
- The flame, acting as a conformal top electrode, moves over the area to be sintered
- Voltage generates an electric plasma within the flame, resulting in powder-substrate bonding
- A highly-uniform sintered area is produced

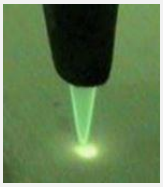


Simplified process diagram

nGimat's novel FAFS process enables control of:

Density • Adhesion • Porosity • Hardness

- Patented non-contact procedure allows for sintering of complex 3D parts at reduced cost
- Scalable, rapid manufacturing process
- Performed under ambient conditions, enabling applications not suited for vacuum chambers
- Capable of production at lower temperatures
- Tight control of sintered area

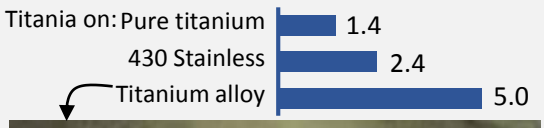


Flame tip

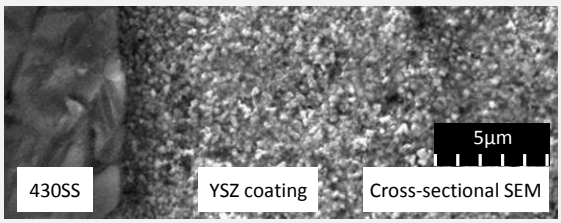
Increased Hardness and Adhesion

FAFS' high ceramic-to-metal adhesion far exceeds that of thermal spray techniques

Vickers hardness estimates (GPa):



Even at 25N loading, the tester tip does not penetrate the substrate. (TiO2 on Ti-6Al-4V)



- Coating fully adherent to the SS430 substrate
- Uniform densification throughout ceramic layer

Applications and Materials

Applicable wherever ceramic coatings are applied to metals:

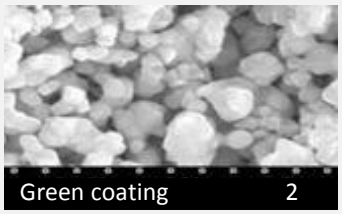
Wear surfaces, engines, heat exchangers, biomedical implants, thermal barrier coatings, exhaust shields, fuel cells, battery-electrode coatings, and aerospace applications

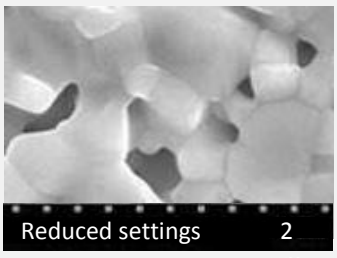
Proven broad material capability:

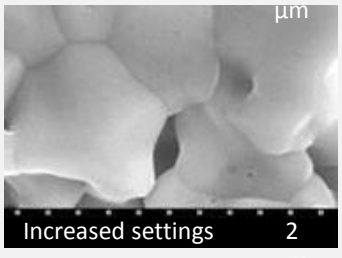
- Coatings used include YSZ, YAG, LSM, TiO2, HAP, various composites
- Substrates include Titanium, SS, Aluminum, and Nickel 625

Optimization of Thermal Conductivity

FAFS allows coatings to be tailored as desired







Density/porosity closely controlled to maximize or minimize heat transfer as required. SEM images of YSZ on SST shown above.

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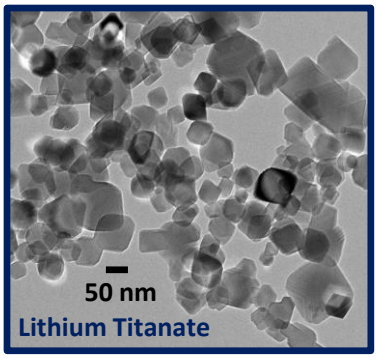
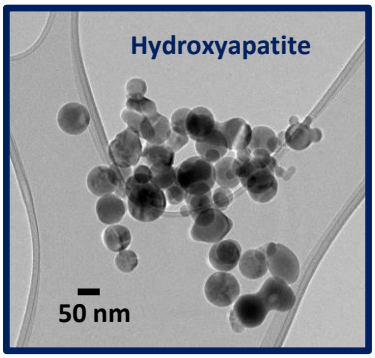
Page 4: Nanopowders

nGimat's proprietary process enables cost-effective production of the highest-performing nanopowders. Particle size is tunable from ~ 10-200 nm.

nGimat's proprietary process enables control of particle properties to satisfy the most demanding requirements, including shape, distribution, morphology, composition, and surface characteristics.

Established in 1994, nGimat provides diverse manufacturers with volume and custom nanopowders for numerous applications, from packaging and industrial sensors to fuel cells and superconducting wire. Additionally, approximately 50 standard nanopowders are provided in research quantities through distribution partner Sigma Aldrich. nGimat's strong internal analytical capabilities include XRD, XRF, BET and ICP.





nGimat Offers a Variety of Nanopowders, Including:

- ***Binary Metal Oxides***
  - Calcium Oxide, Cerium Oxide, Copper Oxide, Erbium Oxide, Tin Oxide
- ***Doped Metal Oxides***
  - Aluminum-doped Zinc Oxide, Manganese-Doped Titanium Oxide
- ***Complex Metal Oxides***
  - Barium Ferrite, Lithium Nickel Oxide, Yttrium Aluminum Garnet
- ***Phosphates/Silicates***
  - Amorphous Calcium Phosphate, Hydroxyapatite, Lithium Iron Phosphate
- ***Metals***
  - Gold, Palladium, Platinum, Silver, Silver-Copper Alloy

Product list is representative; other products are also available, including dispersions.

Specialty packaging available upon request.

Contact us at contact@ngimat.com to discuss custom product requirements.

nGimat is ISO 9001:2015 certified for the design and production of nanopowders.

ISO 9001:2015