Bi2212 Powder Development in Support of the HTS Community

Daniel E. Bugaris

ENGI·Mat
NANO ENGINEERED MATERIALS

U.S. MAGNET DEVELOPMENT PROGRAM

US-MDP Collaboration Meeting 2021
SC Strand and Cables (Materials)
March 3, 2021

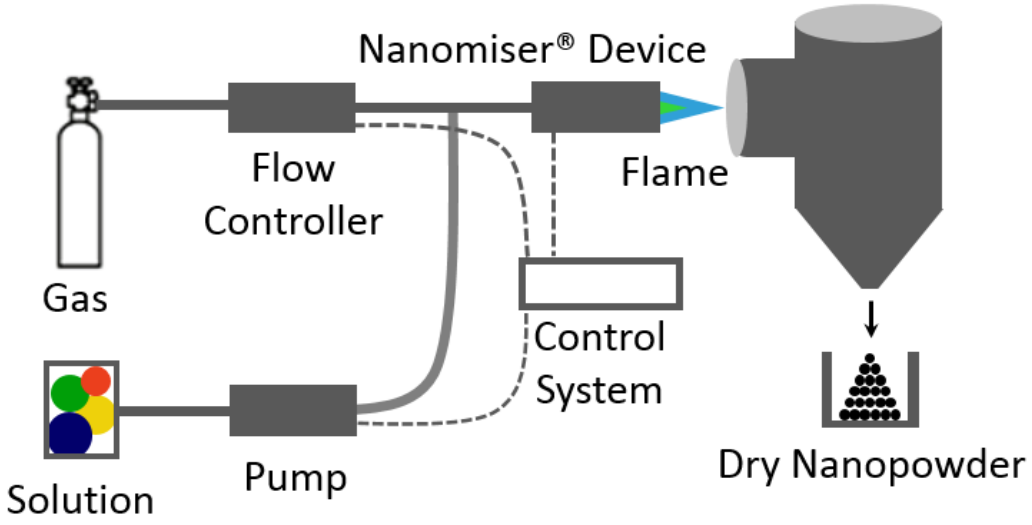
Who is Engi-Mat? (Formerly nGimat)

- For 25+ years, a developer and manufacturer of **nano-engineered materials**
- Opened new facility in **Lexington, KY** in 2010 with a focus on nanopowders
- New management team in early 2018
- Closed our Atlanta facility in 2018 and consolidated operations in Lexington to focus on the company's capabilities related to nanopowders
- In mid-2018, our quality management system was certified to the **ISO 9001:2015** standard for the design and production of nanopowders

- We are the preferred provider of dozens of standard nanomaterials for the Sigma-Aldrich catalog
- We deliver more than 40 high purity nanopowders to diverse customers, in volumes from **a few grams to hundreds of kilograms**
- **Continued optimization and production of Bi2212 powder** is closely aligned with Engi-Mat's core competency: the development and production of high-performance powders

Bi2212 Powder Production

Engi-Mat produces Bi2212 powder with a proprietary chemical combustion process that utilizes the innovative Nanomiser® atomization system.



Control	Impact to Powder
Precursor solution	▪ Composition & Stoichiometry
“Combustion” settings	▪ Particle Size ▪ Particle Morphology
Post-processing	▪ Particle Size ▪ Particle Morphology ▪ Phase Assemblage

With funding from the Department of Energy (beginning in 2013) and support from the HTS community, we have demonstrated the ability to **provide the highest performance Bi2212 powder available.**

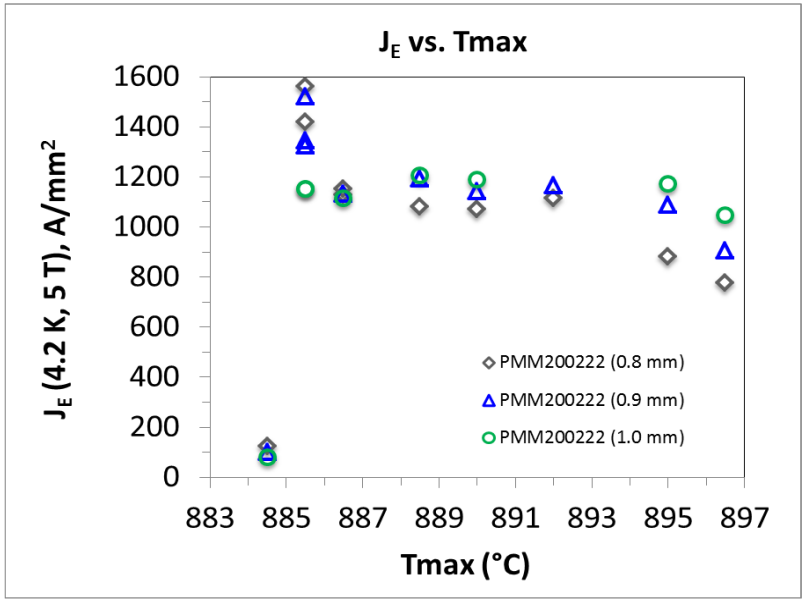
Chemical and Physical Specifications for Bi2212 Powder

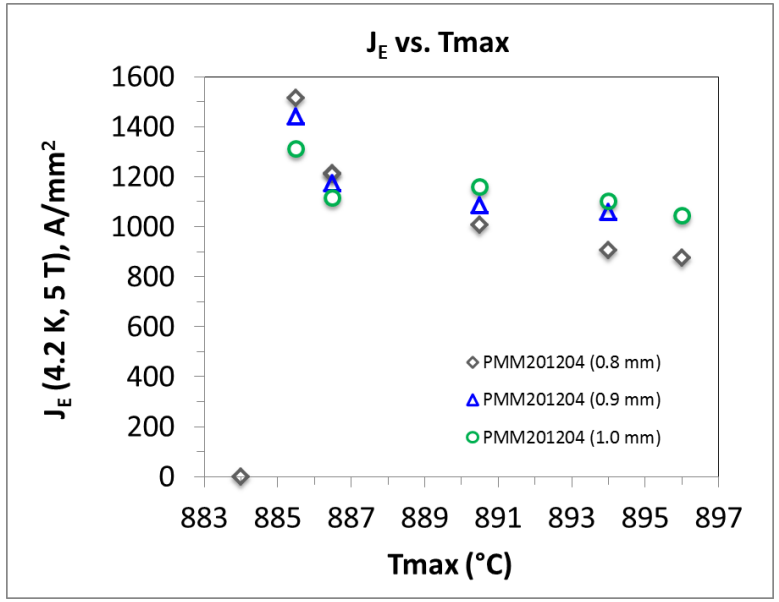
Property	Analytical Technique
Elemental Composition (Majors)	X-ray Fluorescence (XRF)
Overall Purity (Trace Element Analysis)	Inductively Coupled Plasma Optical Emission Spectroscopy (ICP-OES)
Phase Purity	Powder X-ray Diffraction
Secondary Phases	Scanning Electron Microscopy (SEM)
Microstructure	SEM
Specific Surface Area	BET Gas Adsorption
Bulk Tap Density	Tap Density Measurement
Carbon Content	Combustion Infrared Detection
Hydrogen Content	Inert Gas Fusion

Various quality control measures ensure that Engi-Mat consistently delivers Bi2212 powder to meet target specifications!

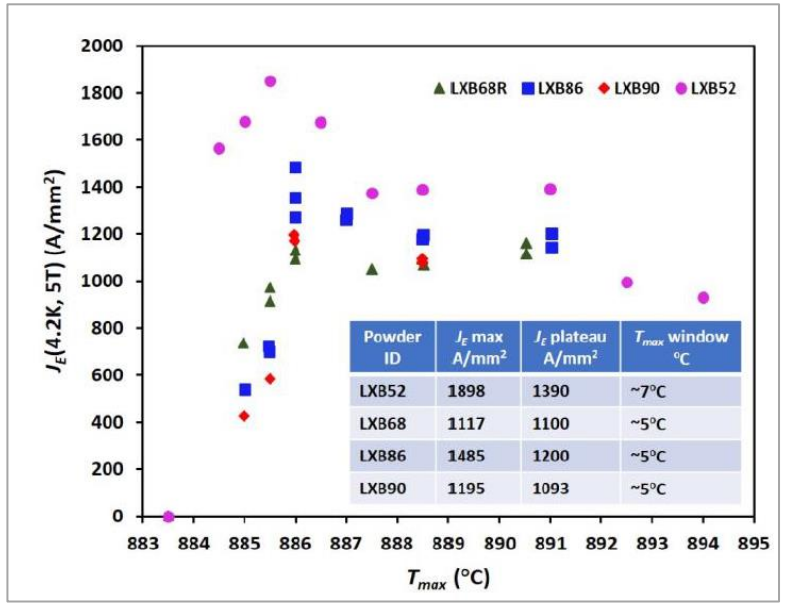
Wire Results from Current Phase II DoE SBIR Project

Goal: To widen T_{max} window (for ease of processing)





Past Results



- Wire performance is dependent on powder, wire fabrication, and wire processing
- With regards to 1.0 mm diameter wire, T_{max} window is ~ 9°C (PMM20022) and ~ 8°C (PMM201204), respectively. The typical T_{max} window for previous wires was ~ 4-6°C.
- The J_e plateau (T_{max} window) appears wider in the 1.0 mm diameter wire than in 0.8 or 0.9 mm diameter wires. This is consistent with cross-sectional imaging showing the 1.0 mm diameter to be more uniform.

Funding for current work is provided by the U.S. Department of Energy under SBIR Contract DE-SC0018666

BRUKER

NATIONAL MAGLAB

The Bi2212 Ecosystem

ENGI·Mat
NANO ENGINEERED MATERIALS

Bi2212 Powder Production → Bi2212 Wire Fabrication → OPHT → High Performance Bi2212 Wire → High Field Magnets (≥ 16 T)

Engi-Mat is committed to delivering the highest quality Bi2212 powder, which is compliant with certain chemical and physical specifications.

High-performance Bi2212 wire that supports the goals of the HTS community is the result of a series of complex and distinct processes.

Each has unique and challenging specifications, and each provides an opportunity to introduce variability.

Continued close collaboration is required!

Discussion

ENGI·Mat
NANO ENGINEERED MATERIALS

Daniel E. Bugaris
dbugaris@engi-mat.com