M3OrC-502

Synthesis of $Bi_2Sr_2CaCu_2O_x$ oxide precursor from nano-oxides and its relationship with multifilamentary wire transport properties

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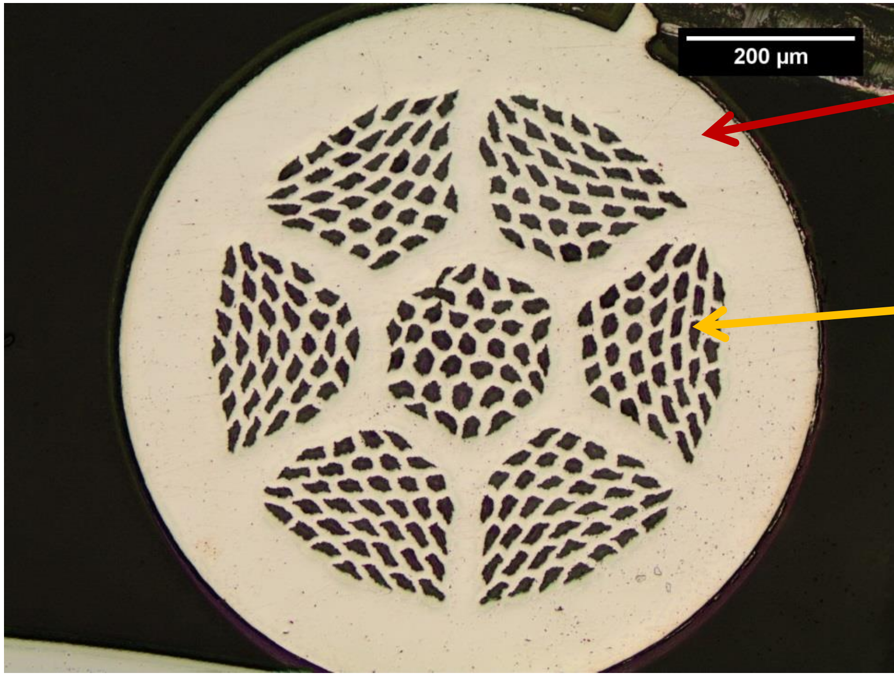
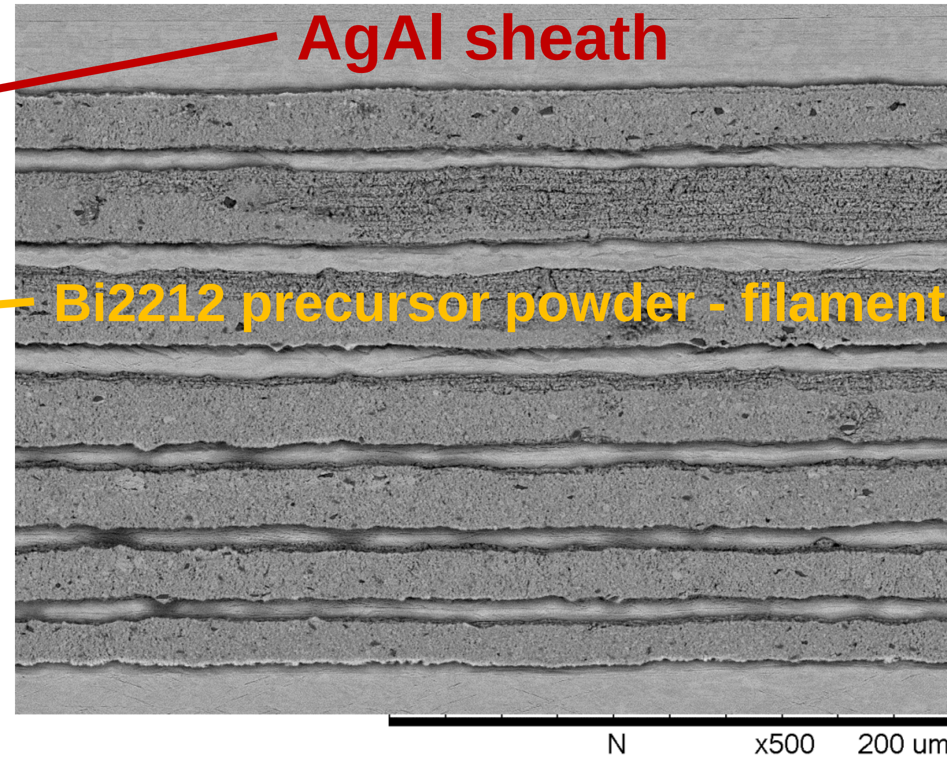
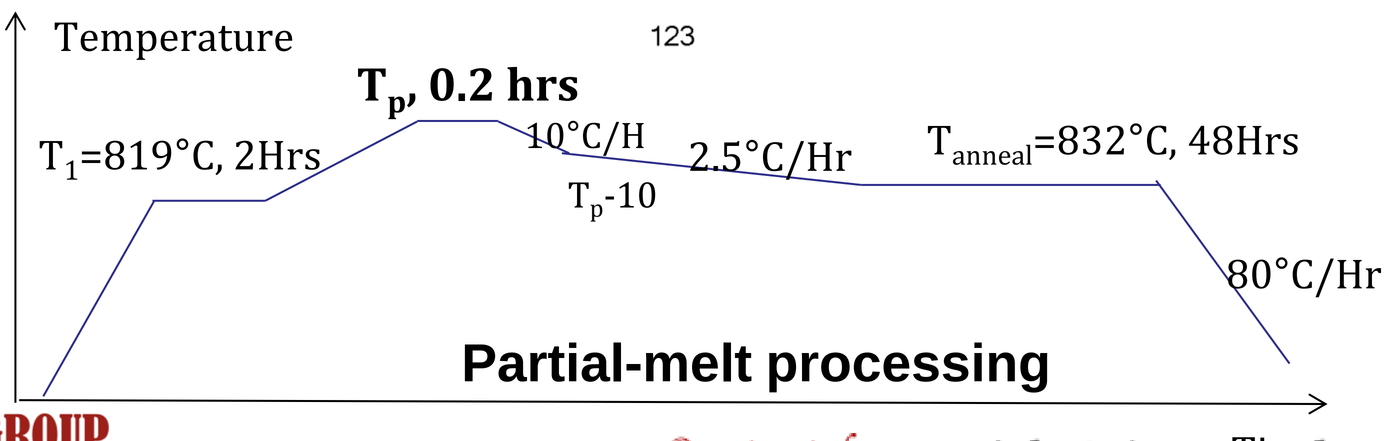
Bi2212/Ag wire before partial-melt processing







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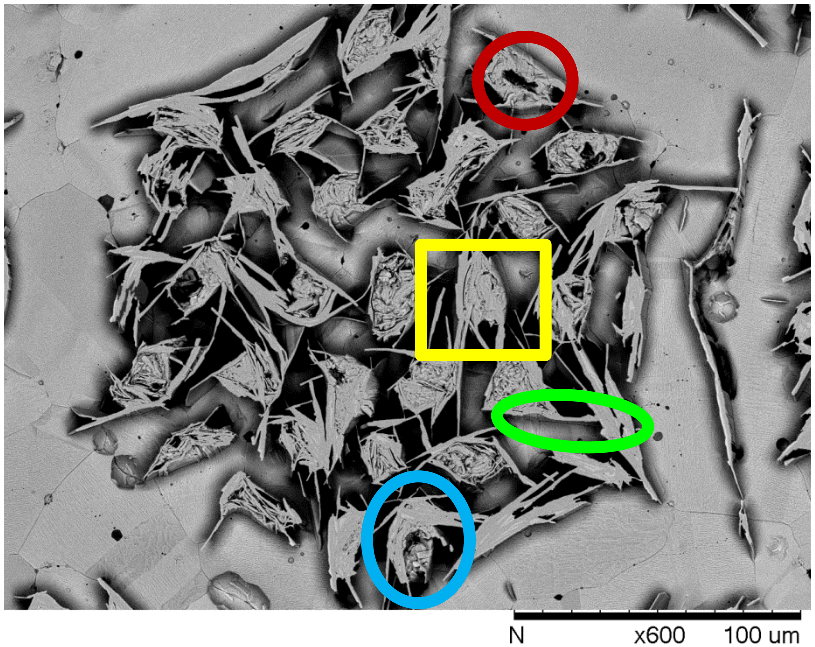
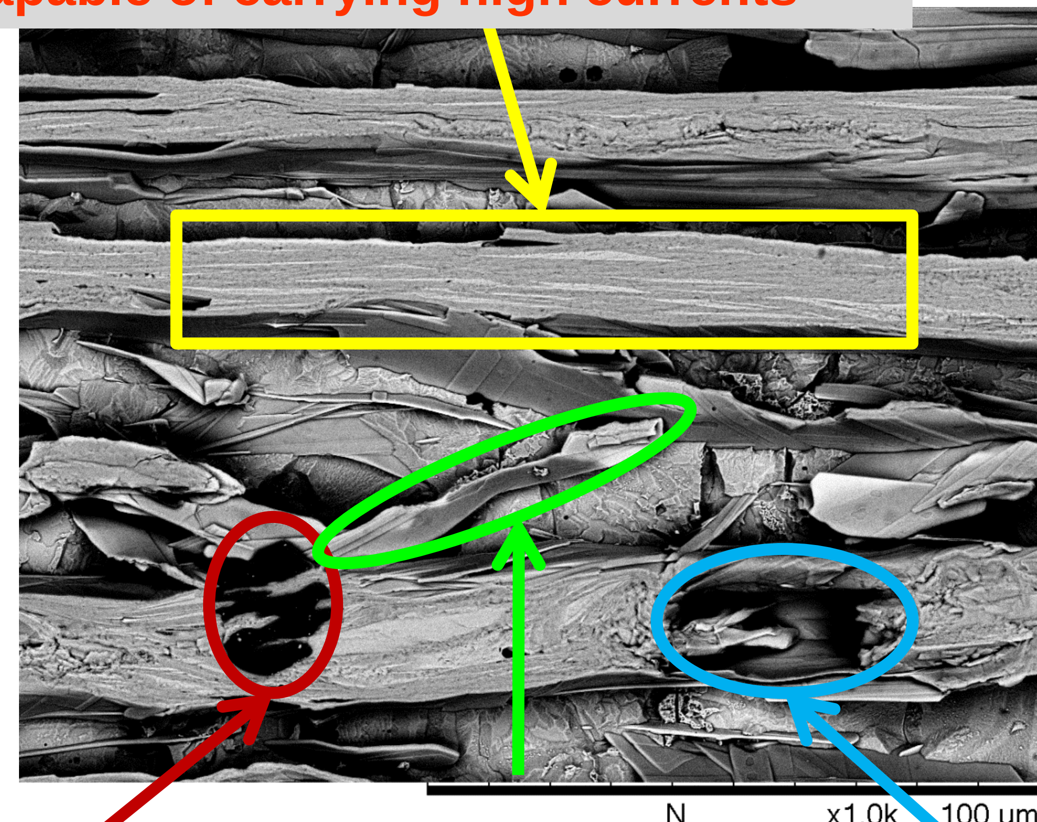
Bi2212/Ag Wire after partial-melt processing





Challenges on Bi2212 precursors

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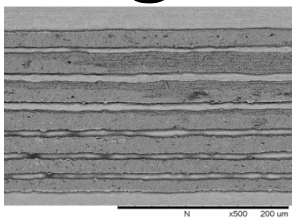
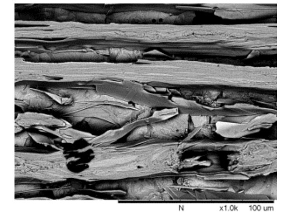




- Stoichiometry
- Chemical homogeneity
- Grain size
- Carbon content
- Agglomeration (type, size)
- Other trace elements content
- Tap density

- Melting behavior
- Secondary phases distribution (size, content, type)
- Porosity
- Wire fabrication
- Grain alignment/ texture
- Large-scale production

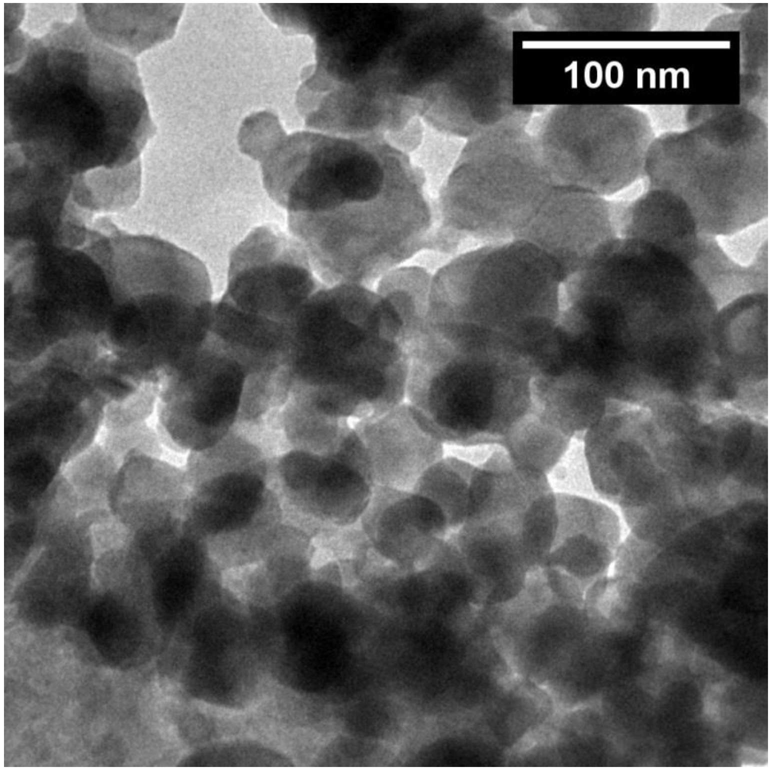
Technical Approach

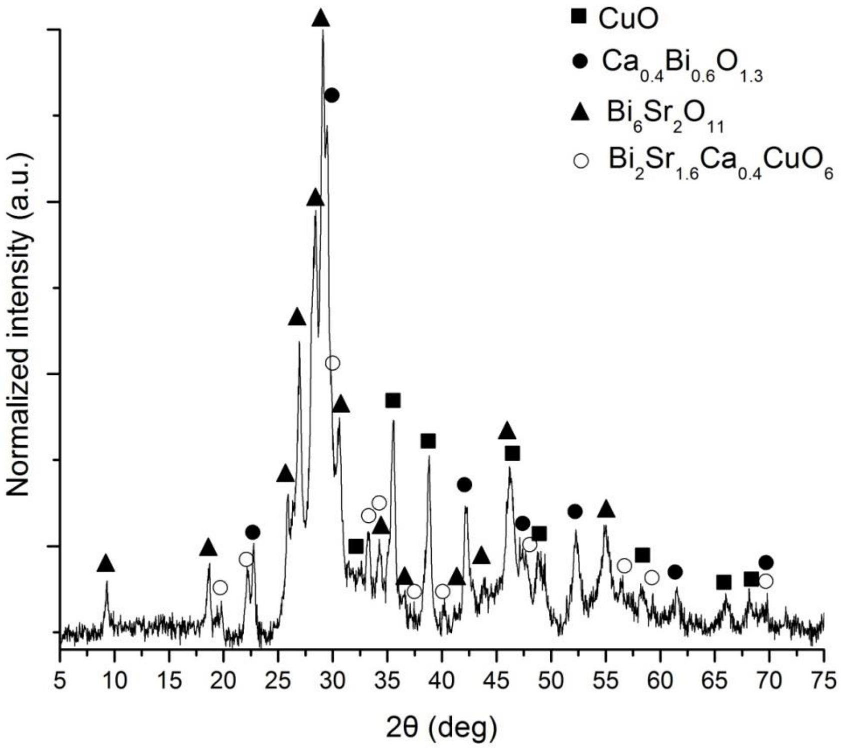
NanoSpray Combustion^{TM} (nGimat,LLc)

+

Solid-state calcination

Starting materials: Nanosize oxides via NanoSpray Combustion™

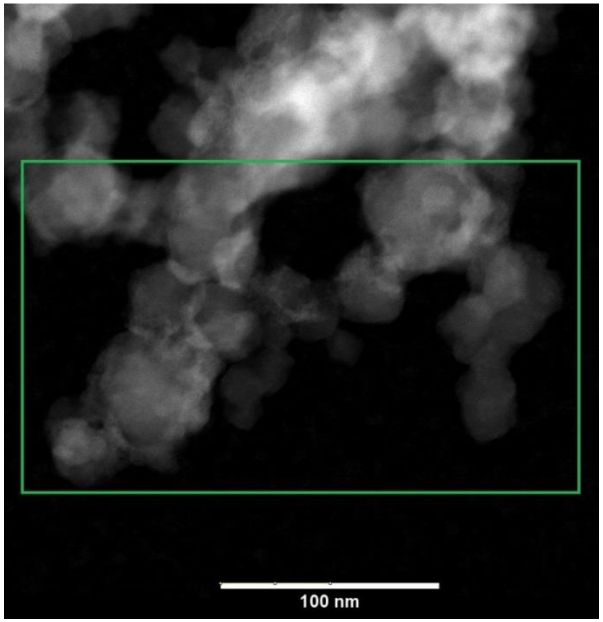


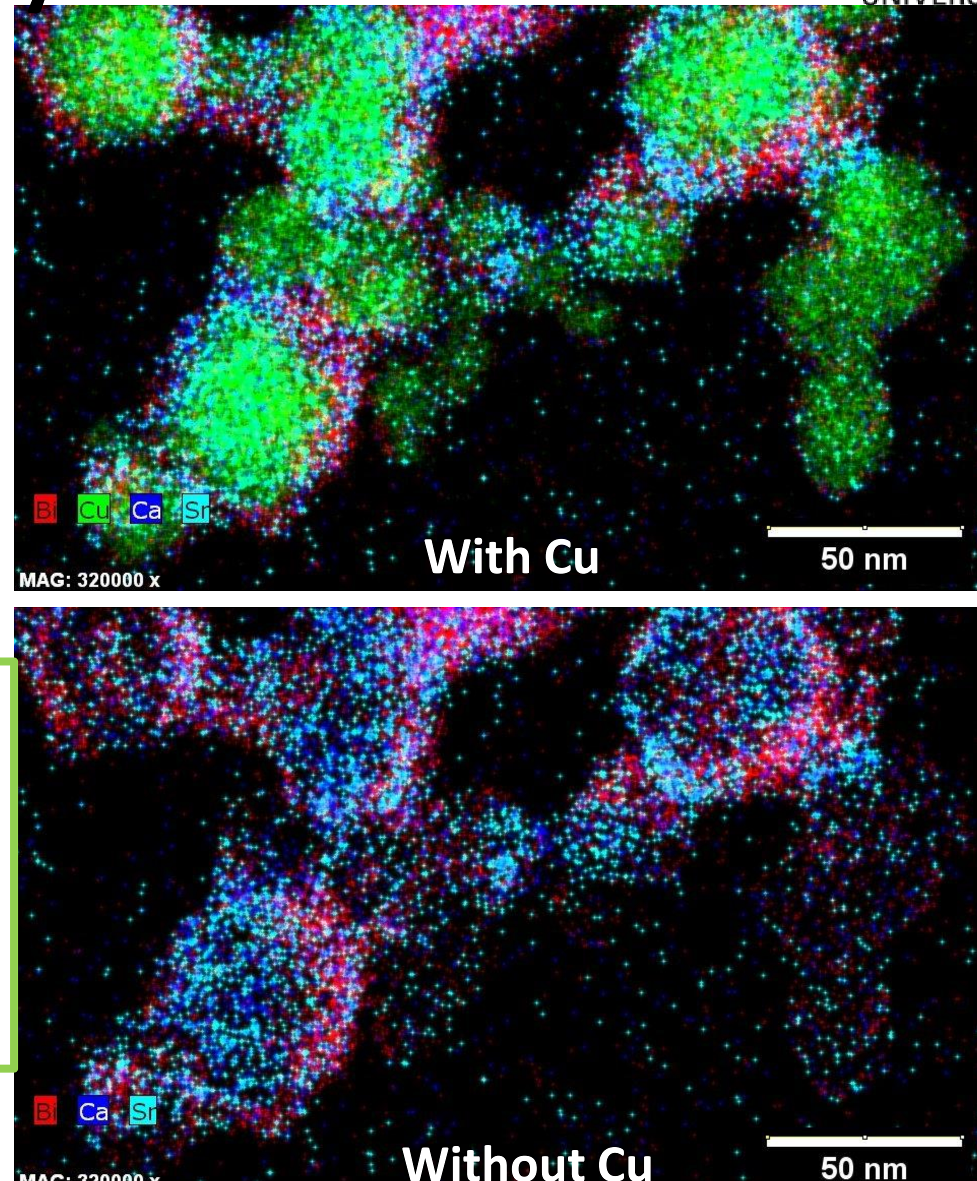


Average surface areas range from 9-14 m^2/g; Particle size: 67-104 nm

Multiple oxides

HAADF-STEM/EDS to reveal nm-scale chemical homogeneity





Mass transport diffusion length on 10s of nm scale →ensure homogeneous and synergetic reaction to form Bi2212;

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Powder calcination: phase transformation from nano-oxides to Bi2212

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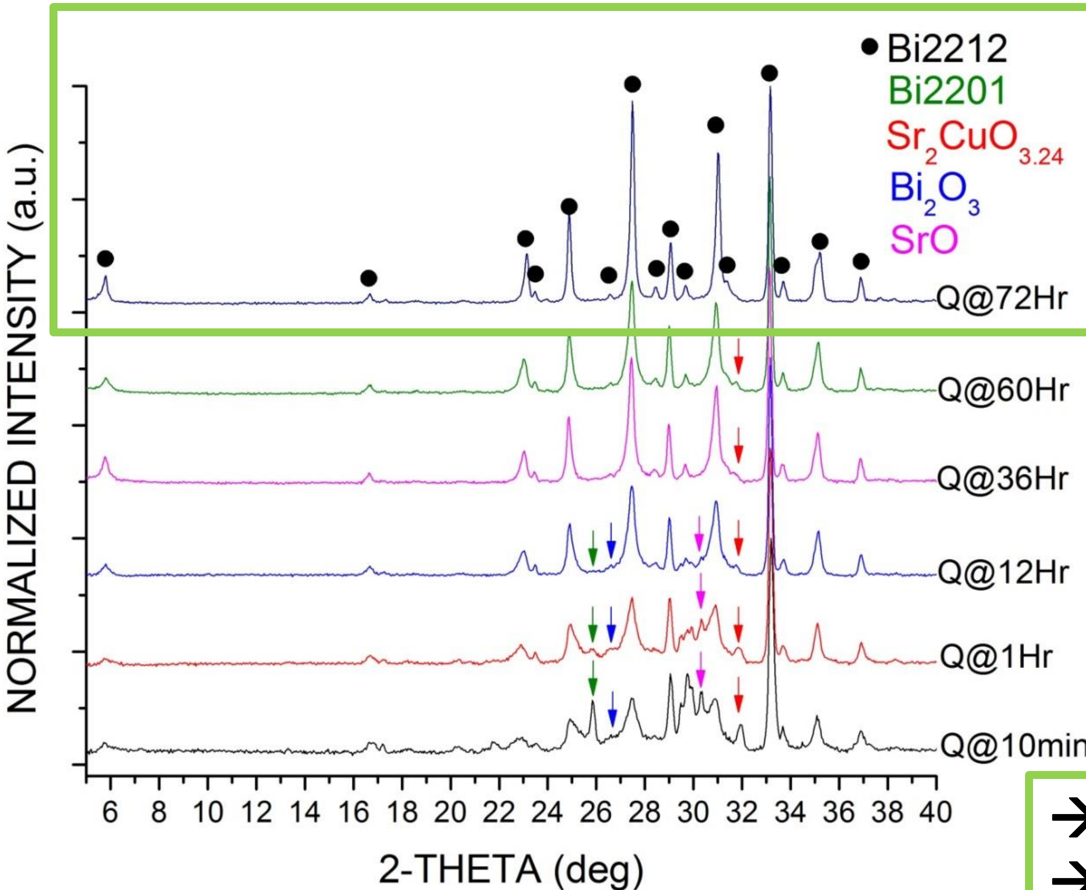
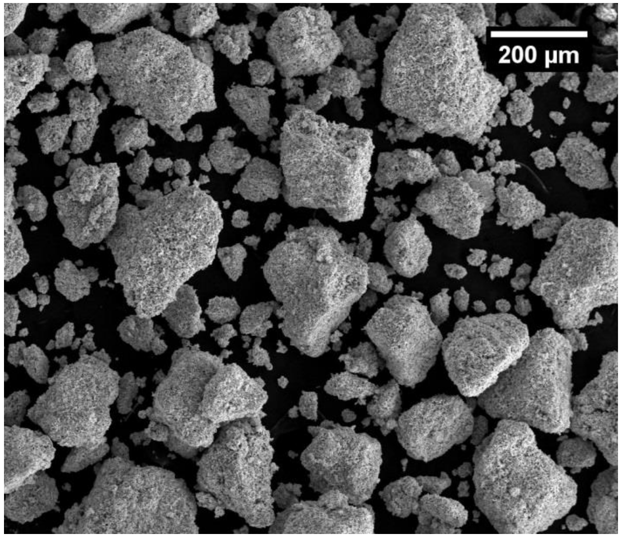
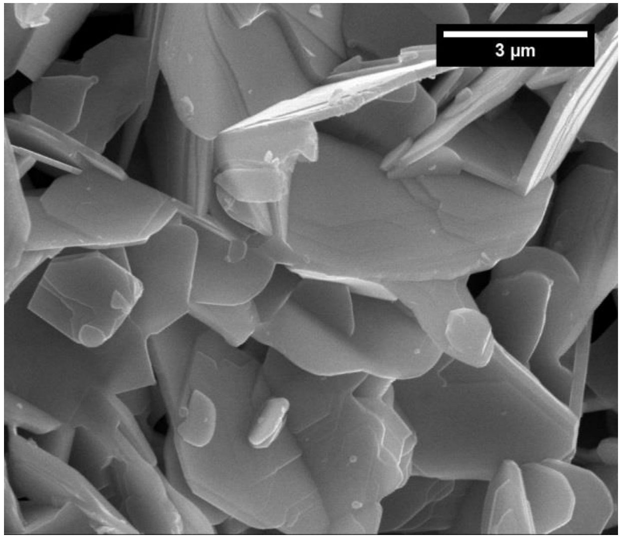


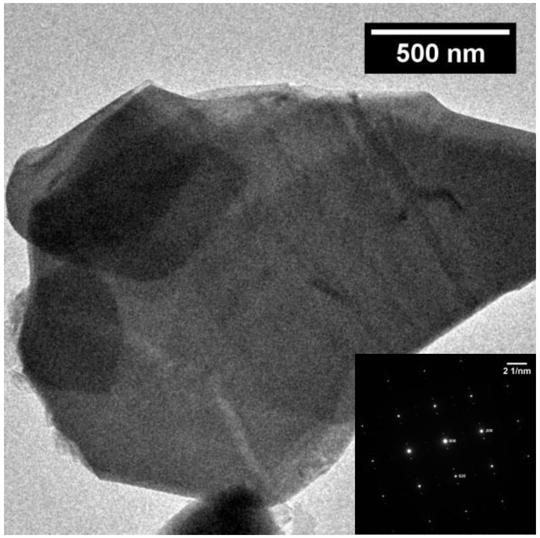
Only Bi2212 peaks are detected: >95wt% pure

→Fast phase transformation;
→no need for repeated pulverization and calcination;

Bi2212 precursor powder after full 72-hrs calcination







Soft agglomerations of Bi2212 single grains
Grain size: 3-8 micron;

Carbon dioxide release during full 72-hrs calcination

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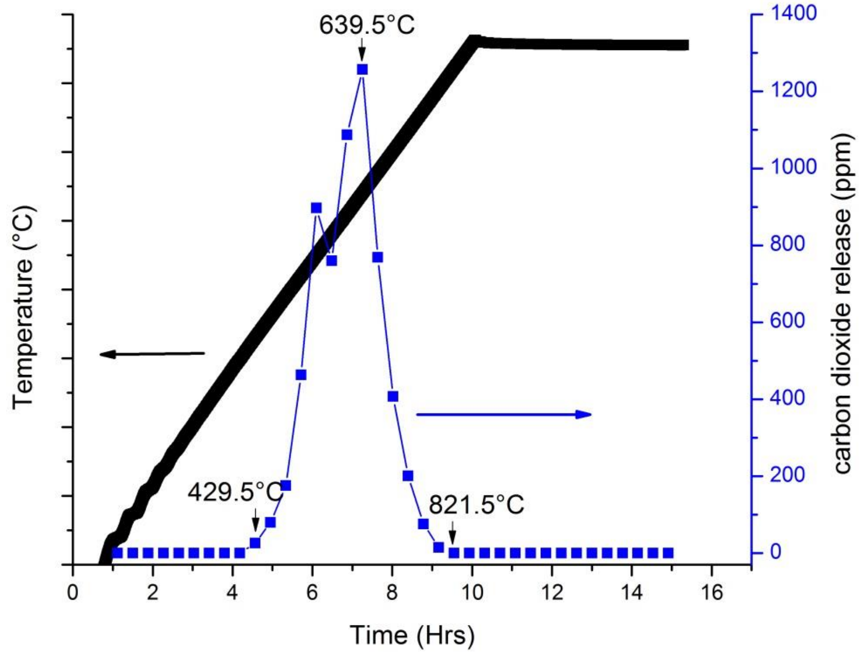

High surface area of starting nanosize oxides
→CO_2 release starts at very low temperature, 300°C lower than conventional method;
→CO_2 release completes before reaching calcination temperature;
→<100 ppm carbon content in the final Bi2212 precursor;

Relationships between Bi2212 precursor properties and wire transport properties

Three precursor batches and wires Bi2212/Ag/Ag-0.1wt%Al

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Stoichiometry | **Wire configuration**

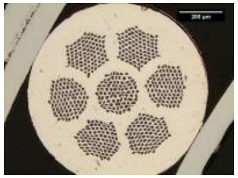
$Bi_{2.26}Sr_{1.90}Ca_{0.90}Cu_{1.98}$

LXA127A, 0.81 mm, FF=15%, 37 x 7

$Bi_{2.15}Sr_{1.89}Ca_{0.93}Cu_{1.95}$

LXA127B, 0.81 mm, FF=15%, 37 x 7

$Bi_{2.26}Sr_{1.89}Ca_{0.86}Cu_{1.99}$



LXA147, 0.81 mm, FF=12%, 91 x 7

*Stoichiometry measured by XRF, with a tolerance of 0.1 mol%

Transport J_c (4.2 K, 5 T) vs PMP peak temperature (1 bar processing)

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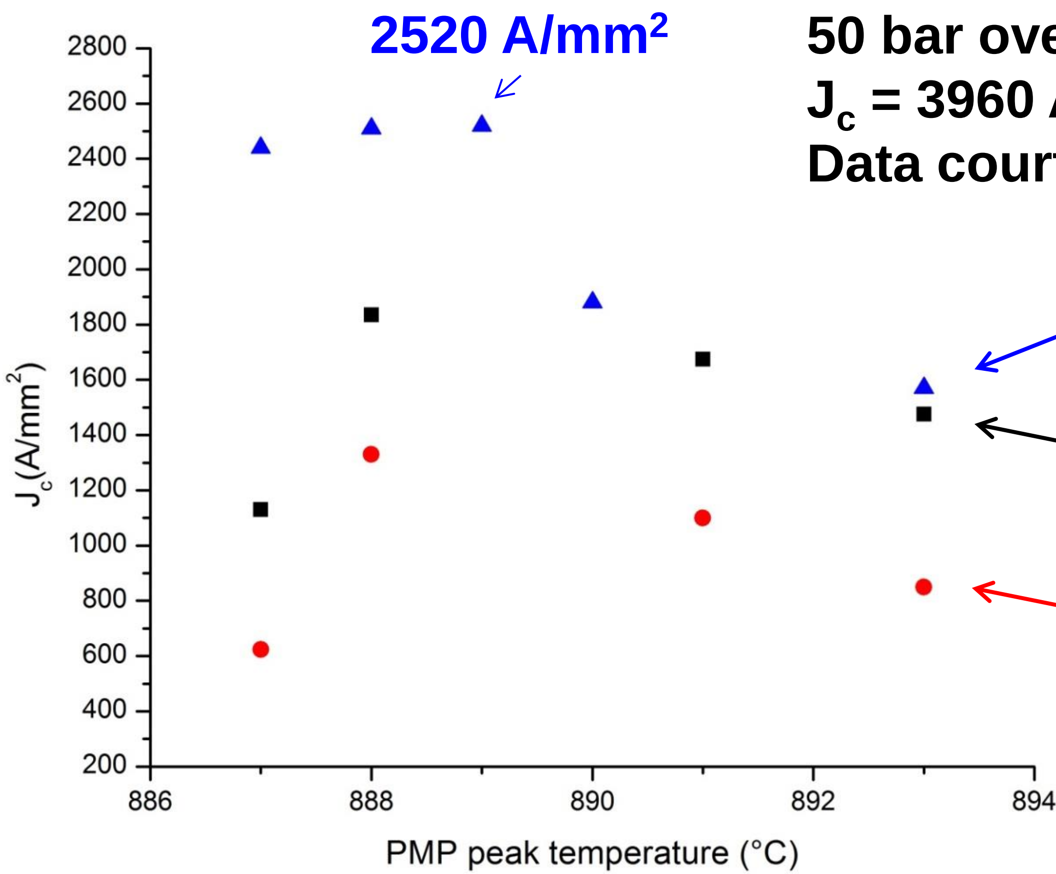
50 bar overpressure on LXA147:
J_c = 3960 A/mm^2 (4.2 K, 5 T)
Data courtesy of J. Jiang, FSU---NHMFL



LXA147

LXA127A

LXA127B

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Phase and carbon content of three precursor batches

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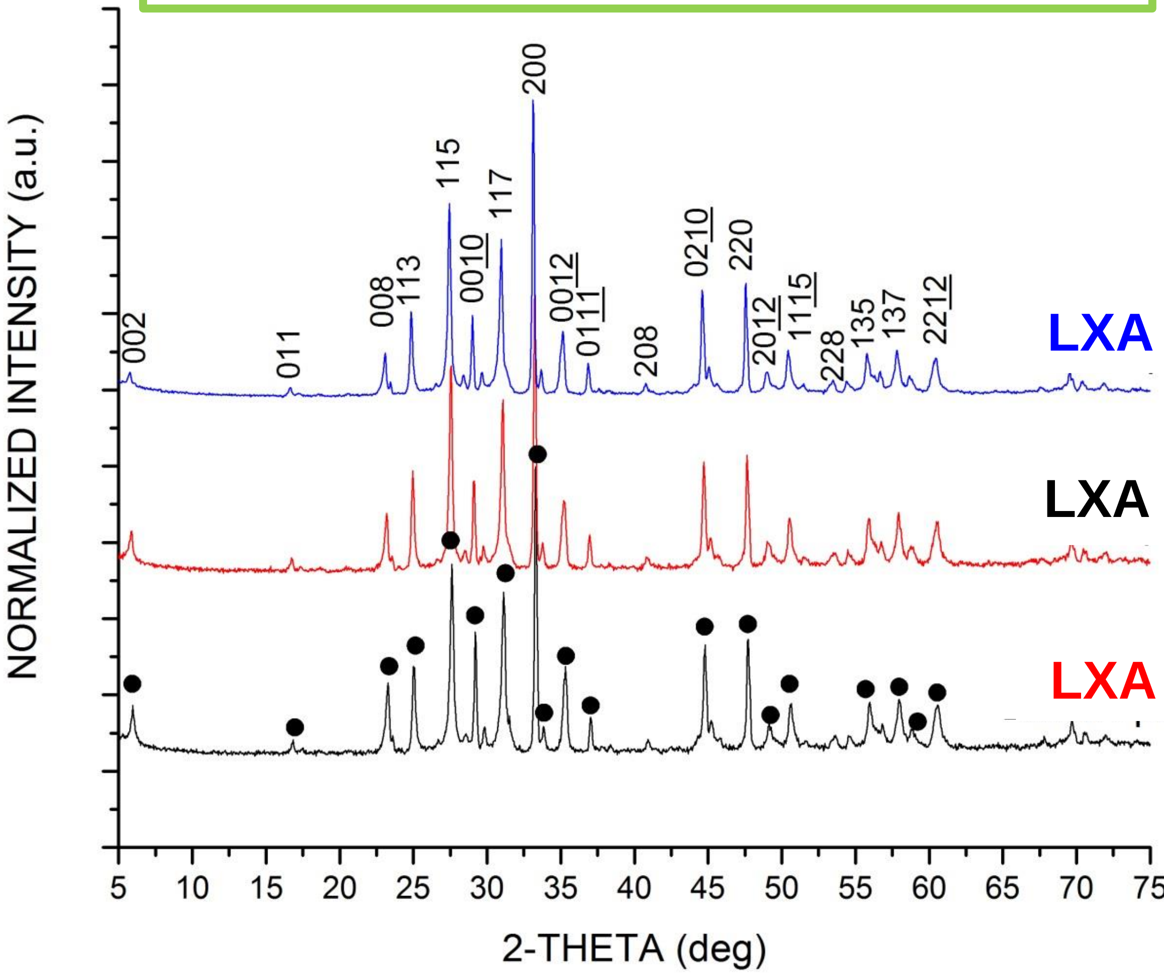
Only Bi2212 peaks are detected



Carbon content

LXA 147	50 ppm
LXA 127A	60 ppm
LXA 127B	90 ppm

Minor impurity phases in precursor -Image analysis on pellets by SEM/EDS

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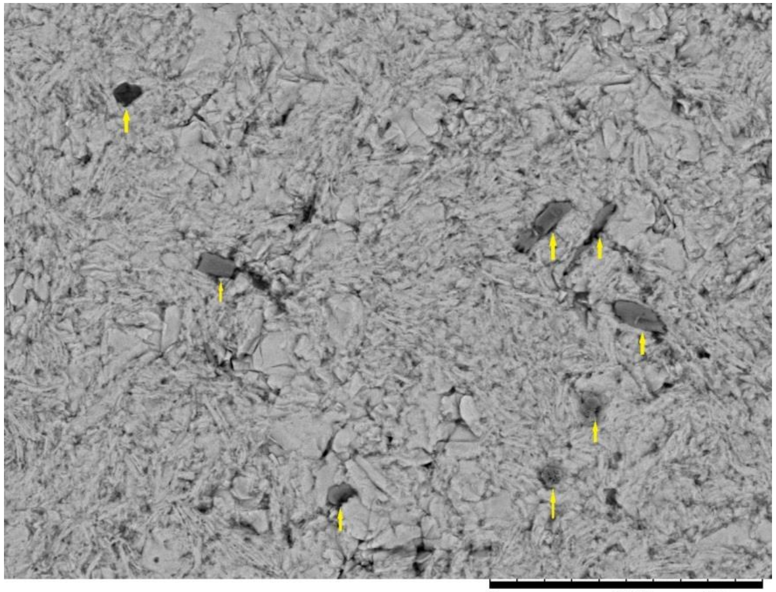
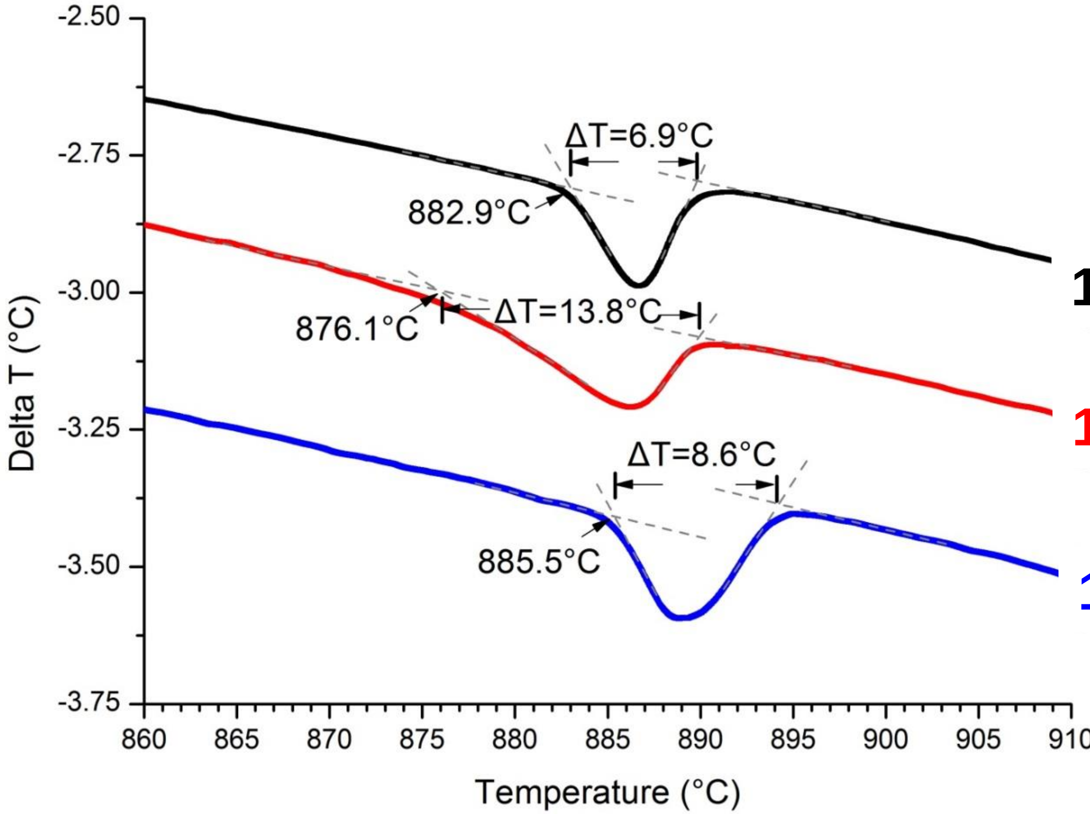


Only minor impurity: $(Ca,Sr)_2CuO_x$(AEC)

AEC Vol% significantly lower than previous studies;
AEC size < filament size;

Characteristic	LXA127A	LXA127B	LXA147
AEC vol%	0.29	0.03	0.86
AEC particle size (µm)	2-11	3-5	4-9

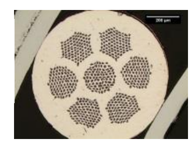
Melting behaviors of three green wires -Thermal analysis



Precursor powder Stoichiometry Std%: Composition variation

127A  **0.42 mol%**

127B  **2.94 mol%**

147  **1.51 mol%**

Shallow and wide melting peak→ high composition variation→ more phase segregations→bad wire performance

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Summary

- A novel method combining NanoSpray Combustion^{TM} and solid-state calcination is used to synthesize Bi2212 oxide precursor.
- >99.1 vol% of Bi2212 single crystals with <0.5 mol% composition variation are synthesized.
- Small particle size, high surface area and short diffusion length of the starting materials →rapid and homogeneous phase transformation to Bi2212 + an early and rapid carbon release.
- Carbon content < 60 ppm is required.
- Precursor with $Bi_{2.26}Sr_{1.89}Ca_{0.86}Cu_{1.99}$ (LXA147) and 1.51 mol% composition variation →State-of-art wire transport current density: 2520 A/mm^2 (4.2 K, 5 T, 1 bar) and 3960 A/mm^2 (4.2 K, 5 T, 50 bar)

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THANK YOU!