Understanding the Correlation Between the Melting Behavior of Bi-2212 Powder and the Wire Performance

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Introduction & Background

A superconductor is a material that conducts electricity with no resistance, which saves energy. High-temperature superconductors (HTS) are cheaper and easier to work with because they can function at warmer temperatures. $Bi_2Sr_2CaCu_2O_{8+x}$ or Bi-2212 is a uniquely promising HTS.

More research is needed to correlate the properties of the Bi-2212 powder and wire performance. This research analyzes different Bi-2212 powder using differential thermal analysis (DTA) and thermogravimetric analysis (TGA). These techniques can reveal how different powder manufacturing methods change the properties of the powder and how those properties influence the wire's performance.

Methodology

- The DTA plot in Fig. 1 curves downward as the powder sample is heated. The temperature of the lowest peak (T_m max) shows the maximum heat flow as the powder melts. The beginning and end of the downward curve (T_m start and T_m end in the plot) mark the temperatures at which the powder starts melting and stops melting.
- The TGA data (not included in the poster) shows a sample's weight change with temperature, indicating if there are CO_2 and H_2O impurities in a sample.

Methods

Procedure

- 10-15 mg of Bi-2212 powder were placed in an alumina crucible in the TGA/DTA thermal analyzer: TA Instruments SDT-Q600.
- The sample is heated at 5°C/min to 925°C, held for 5 min, then cooled at 5°C/min to 20°C. O_2 was flowed through the system at 10 mL/min.
- The machine records the temperature difference between the sample pan and the reference pan 0.5 sec.

Data Analysis

- The temperature difference (°C) between the pans is plotted on the Y-axis of a graph, and the furnace temperature (°C) is plotted on the X-axis.

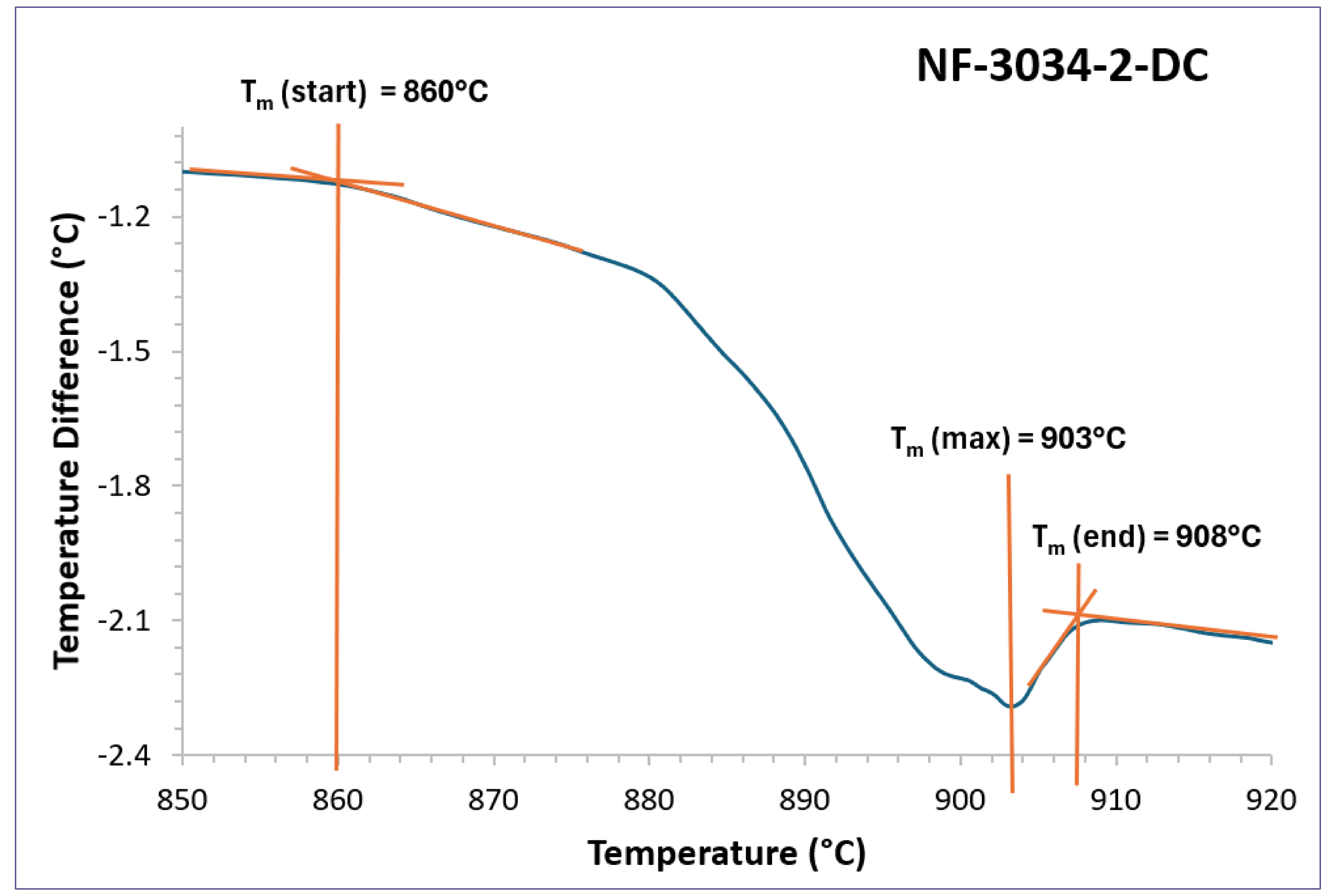

Figure 1. NF-3034-2-DC

A plot of the temperature difference between the pans (sample – reference) as a function of the furnace temperature. At T_m (max) the sample has fully melted and the temperature difference begins to decrease after the melting has occurred.

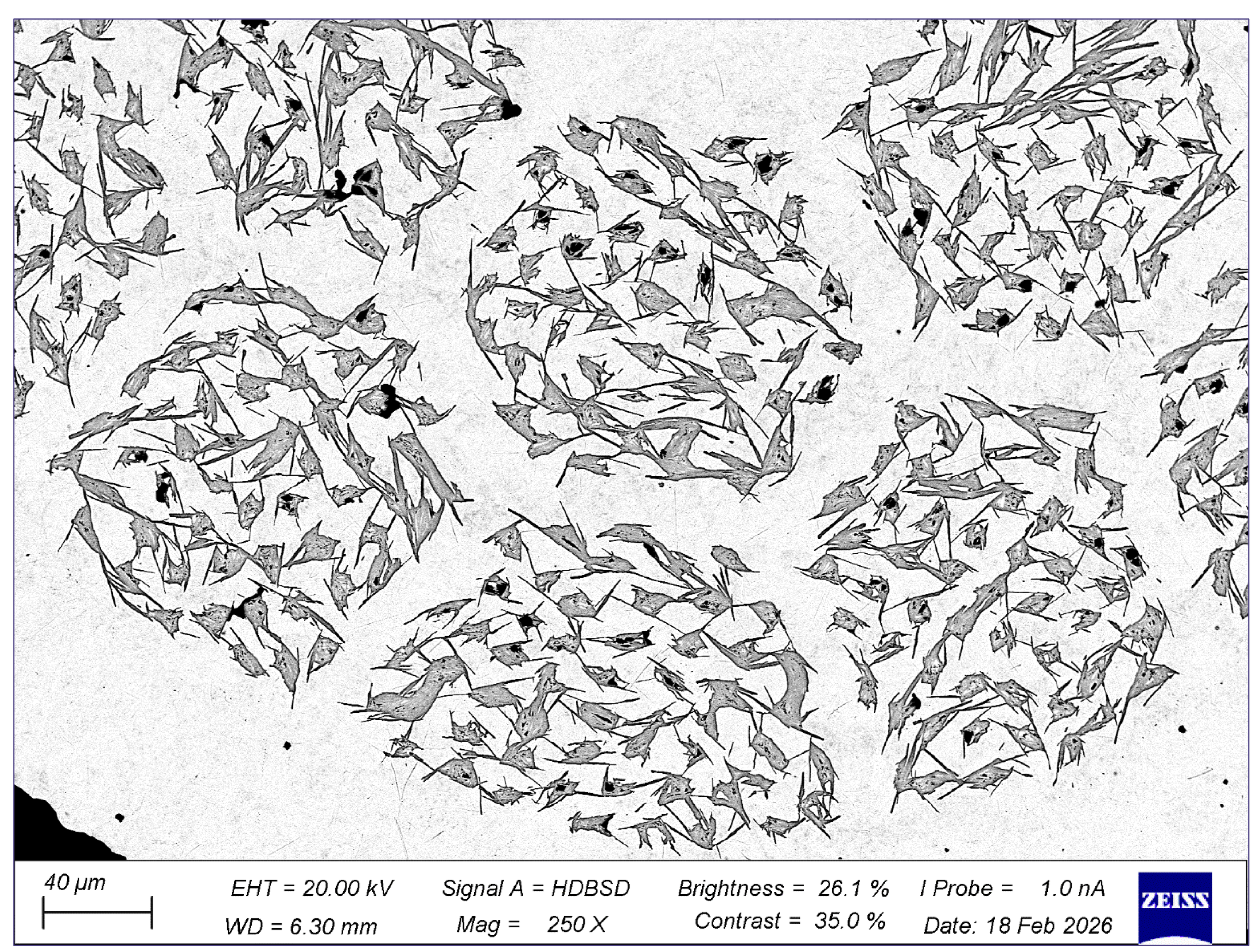

Figure 2. Cross Section of NF-3034-2-DC Wire

A cross section of a wire made from powder NF-3034-2-DC taken on a scanning electron microscope. The gray parts are the Bi-2212 filaments, and the lighter regions are Ag and Ag(0.2 wt% Mg).

Results & Conclusions

Table 1. Melting Behavior of Bi-2212 Powders and Critical Current

This table shows the results of analysis of multiple powders along with the critical current of two wires that were made into wires.

Sample ID	T_m (start)	T_m (max)	T_m (end)	ΔMass	I_c (4.2K,5T)
KZA-040	878°C	897°C	901°C	0.81%	--
NF-3020-HT2	850°C	904°C	907°C	0.91%	--
NF-3020-HT3	848°C	905°C	909°C	0.49%	279 A
NF-3034-2-HT2	850°C	901°C	905°C	0.43%	--
NF-3034-2-DC	860°C	903°C	908°C	0.67%	619 A

Results

- There is more variation in T_m (start) than in T_m (max).
- The mass loss was different for each wire.

Conclusions

- The similarity in T_m (max) shows the powders are relatively consistent. Those with a lower percentage of mass lost when heated are likely to be more pure. These results suggest the manufacturing methods or how the powders have been handled are different.
- These results are preliminary and the research is ongoing. More powders need to be analyzed; and trials need to be repeated to ensure reproducibility.
- DTA and TGA are limited by sensitivity to the environment and need precise control of the purge gas flow.
- An advantage of using DTA and TGA is that they are very sensitive to subtle changes, such as miniscule mass loss.

Acknowledgements

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