NANOCRYSTALLISATION OF AMORPHOUS ANALOGUES OF BSCCO SUPERCONDUCTORS

Maria Kacprzak[1], Tomasz K. Pietrzak[1]

[1]Warsaw Univeristy of Technology, Faculty of Physics, Poland
maria.kacprzak2.stud@pw.edu.pl

Superconductors are materials whose electrical resistivity becomes zero and which expel a magnetic field below a characteristic critical temperature (T_C). They can be divided into two main types. The first type is characterised by low-T_C (below 10 K) and the presence of the critical magnetic field above which superconductivity is destroyed. The second type includes materials in which, above a certain magnetic field B_1, the magnetic field penetrates the superconductor, leading to the formation of a mixed state. Above the critical field B_2, the superconducting state is destroyed. In addition, they often present high-T_C (above 100 K). It is worth noting that the type-I superconductors are mainly metals, whereas type-II superconductors are typically metal compounds and ceramics. Probably, the YBCO superconductor is known as the most popular type-II superconductor.

However, in the present study, attention is focused on the BSCCO superconductor. BSCCO is a family of high-temperature superconductors with a chemical formula $Bi_2Sr_2Ca_{n-1}Cu_nO_{2n+4+x}$. These compounds are well known for their high critical temperatures. There are three main types of BSCCO: 2201 (*n=1*) with T_C of approximately 10 K (very-low T_C phase), 2212 (*n=2*) with T_C≈85 K (low T_C phase) and 2223 (n=3) with T_C≈105 K (high-T_C phase). There is also a less common 4334 (n=4) phase, which exhibits even higher T_C values, though it has not been extensively studied yet.

Previous studies conducted by our research group have provided experience in developing highly conductive cathode materials for Li/Na-ion batteries via thermal nanocrystallisation of their amorphous analogues [1]. The intriguing properties of these nanomaterials originated from their microstructure, namely the presence of nanoscopic crystallites embedded in a residual glassy matrix.

In this research, the same approach was applied in order to obtain a nanocomposite with grains of the superconducting phase. Firstly, a glassy analogue of BSCCO 4334 was synthesised [2] using a standard melt-quenching approach. Then, the sample was examined using DTA (Differential Thermal Analysis) — to determine the glass transition and crystallisation temperature and XRD (X-Ray Diffractometry) — to verify amorphousness. Secondly, the samples were heated to induce thermal nanocrystallisation of superconducting phases. Eventually, the electrical conductivity will be examined, searching for the transition between the normal and superconducting state.

[1] T. K. Pietrzak, M. Wasiucionek, and J. E. Garbarczyk, “Towards higher electric conductivity and wider phase stability range via nanostructured glass-ceramics processing,” Nanomaterials, vol. 11, no. 5, p. 1321, May 2021, doi: 10.3390/nano11051321.
[2] M. Gazda, B. Kusz, L. Murawski, S. Stizza, and R. Natali, “(Bi,Pb)-Sr-Ca-Cu-O glass-ceramics – superconductor and granular metal,” Optica Applicata, vol. 38, no. 1, pp. 153–161, Jan. 2008.