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**ANALYSIS OF THE CRITICAL TEMPERATURE OF
SUPERCONDUCTOR SAMPLES BASED ON $\text{Bi}_{1,7}\text{Pb}_{0,3}\text{Sr}_2\text{Ca}_{(n-1)}\text{Cu}_{(n)}\text{O}_y$
($n=9-20$) PRECURSORS OBTAINED IN A LARGE SOLAR FURNACE**

E. B. Eshonkulov

¹Materials Science Institute, Academy of Science,
Republic of Uzbekistan, Tashkent, Uzbekistan
e-mail: elyoreshonkulov94@mail.ru

In modern science and technology, the efficient use of renewable energy sources represents one of the priority directions. Among them, solar energy stands out as a clean, inexhaustible, and environmentally safe source. By concentrating high fluxes of solar radiation, Large solar furnace (LSF) make it possible to achieve extremely high temperatures, which provide advantages over conventional heating technologies in terms of both efficiency and environmental sustainability. In the field of materials science, the use of solar energy is emerging as a particularly promising approach for the synthesis of high-temperature superconductors. The synthesis of ceramic samples of the Bi–Pb–Sr–Ca–Cu–O system in LSFs not only ensures energy efficiency but also enables the formation of new features in the phase structure and morphology of the material. Therefore, determining and analyzing the critical temperature of layered superconducting samples of composition $\text{Bi}_{1,7}\text{Pb}_{0,3}\text{Sr}_2\text{Ca}_{(n-1)}\text{Cu}_{(n)}\text{O}_y$ ($n=9-20$), synthesized using concentrated solar energy, is of significant scientific importance [1].

The main objective of this research is to determine and analyze the critical temperature (T_c) of high-temperature superconducting ceramic samples of composition $\text{Bi}_{1,7}\text{Pb}_{0,3}\text{Sr}_2\text{Ca}_{(n-1)}\text{Cu}_{(n)}\text{O}_y$ ($n=9-20$) synthesized in an LSF. For this purpose, the superconducting transition was investigated by measuring the temperature dependence of electrical resistivity and diamagnetic properties. By addressing this task, the electrophysical characteristics of superconducting materials synthesized using solar energy are determined, thereby contributing to the development of scientific foundations for energy-efficient, environmentally friendly, and high-performance technologies.



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To determine the superconducting transition temperature (T_c) of $\text{Bi}_{1,7}\text{Pb}_{0,3}\text{Sr}_2\text{Ca}_{(n-1)}\text{Cu}_{(n)}\text{O}_y$ ($n=9-20$) ceramic samples synthesized in the Large Solar Furnace (LSF), two primary methods were employed: electrical resistivity measurements and magnetic susceptibility analysis [2,3].

For the electrical resistivity measurements, the four-probe technique was applied. This method enabled the determination of resistivity based on the current passing through the sample and the potential difference measured between the two inner contacts. By minimizing the influence of defects and impurities, the resistivity of the samples was investigated in the temperature range of 77–330 K, with gradual cooling achieved using liquid nitrogen. The temperature-dependent variation of resistivity was recorded, allowing the identification of the superconducting transition point.

For the magnetic property analysis, the "two-coil" method was used. In this approach, the inductance of the coil containing the sample varied proportionally with changes in temperature, which resulted in measurable variations in the overall signal. The magnetic field was excited by a function generator within the frequency range of 1370–19,428 Hz, and the signal obtained from the receiver coils was recorded with high precision using a voltmeter connected to a computer. The temperature-dependent signal variation was evaluated in correlation with the superconducting transition of the samples.

Thus, the results obtained from the two experimental techniques were comparatively analyzed, and the critical temperature of the ceramic samples was determined.

The temperature dependence of electrical resistivity and the diamagnetic properties of ceramic samples of the $\text{Bi}_{1,7}\text{Pb}_{0,3}\text{Sr}_2\text{Ca}_{(n-1)}\text{Cu}_{(n)}\text{O}_y$ ($n=9-20$) system with nominal compositions Bi/Pb 2289, Bi/Pb 221112, Bi/Pb 221415, and Bi/Pb 221920 were investigated. From the obtained results, the values of $T_{c,\text{onset}}$, $T_{c,\text{offset}}$, and the transition width (ΔT) were determined (Fig. 1).

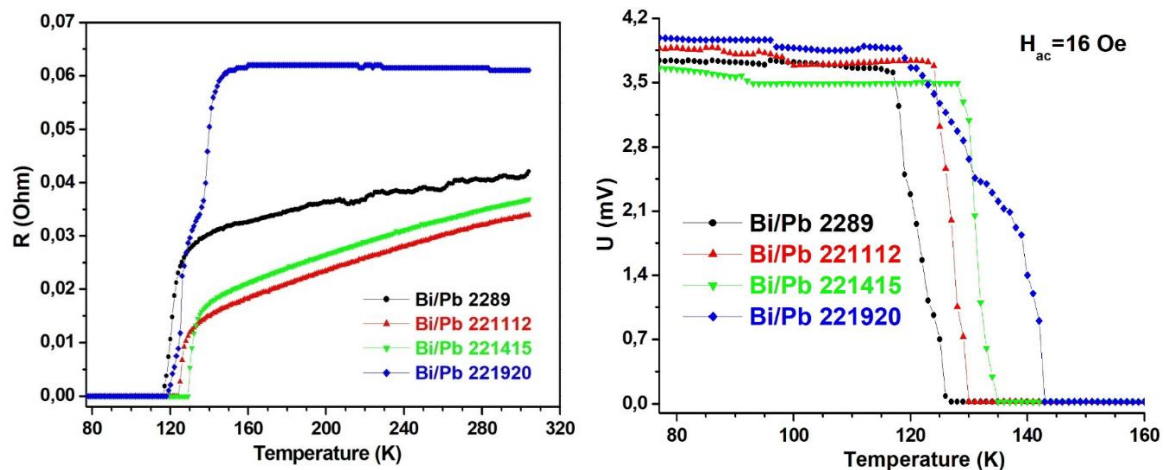


Figure 1. Analysis of critical temperatures of HTSC samples based on precursors obtained in a large solar furnace

According to the results, the $T_{c,onset}$ value was found to increase with the number of Ca and Cu layers in the structure. For the Bi/Pb 221920 sample, $T_{c,onset} \approx 143$ K, which represents the highest value among the studied compositions. However, in this sample, the transition width ΔT was very large (25 K), which can be explained by its multiphase nature and the lack of optimized temperature or time conditions during the synthesis process. In contrast, for the Bi/Pb 221112 and Bi/Pb 221415 samples, $\Delta T \approx 6$ K, indicating a sharp and smooth transition. This narrow transition is evidence of their high structural quality and degree of texturing.

The analysis of magnetic properties was fully consistent with the resistivity results. The onset of diamagnetism and the superconducting transition temperature were observed at approximately 126 K for Bi/Pb 2289, ~ 129 K for Bi/Pb 221112, ~ 135 K for Bi/Pb 221415, and ~ 142 K for Bi/Pb 221920. The Bi/Pb 221415 sample reached a state of complete diamagnetism at ~ 130 K, distinguishing itself as a high-quality composition.

These results are closely related to a key feature of the synthesis process — the use of a solar furnace. Solar energy enabled the efficient and environmentally friendly attainment of high temperatures. This not only provided energy savings and ecological advantages compared to conventional furnaces but also ensured precise control of the required thermal regime during synthesis, positively influencing the texturing of the materials. Thus, the obtained results demonstrate that synthesis



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carried out in a solar furnace ensures that nanostructured $\text{Bi}_{1,7}\text{Pb}_{0,3}\text{Sr}_2\text{Ca}_{(n-1)}\text{Cu}_{(n)}\text{O}_y$ superconducting materials possess both high critical temperatures and high-quality phase composition. Based on the analysis, the Bi/Pb 221112 and Bi/Pb 221415 compositions were identified as the most optimal in terms of superconducting properties. Meanwhile, the Bi/Pb 221920 composition, with its high $T_{c,\text{onset}}$ value, can be considered a promising candidate; however, further optimization of technological parameters during synthesis is required. Overall, the synthesis of high-temperature superconductors using solar energy provides great potential for applications in energy and quantum technologies.

References

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