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*Physics*

# Synthesis of $La_{2-x}Ba_xCuO_4$ High-Temperature Superconductor by Means of Photostimulated Solid State Reaction

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**ABSTRACT. The first successful synthesis of $La_{2-x}Ba_xCuO_4$ high-temperature superconductor by means of photostimulated solid state reaction is reported. It is shown that this reaction is two orders of magnitude faster than conventional high-temperature solid state reaction in furnace and is stimulated by optical exposure.** *© 2011 Bull. Georg. Natl. Acad. Sci.*

***Key words:*** *high-temperature superconductors, solid state reaction, photostimulated processes.*

Photostimulated physical processes are widely used today in solid state electronic technologies, such as formation of ohmic contacts, p-n-junctions, defect annealing, recrystallisation of amorphous layers etc [1]. Being activation-diffusive in origin, these processes occur in solid phase and their efficiency depends on the duration, energy and spectral distribution of photonic exposure [2,3]. The experiments indicate that photostimulated diffusion rate can exceed ordinary thermodiffusion rate by several orders of magnitude [4, 5].

Here we report the first successful synthesis of $La_{2-x}Ba_xCuO_4$ high-temperature superconductor (HTSC) by means of a pure photostimulated solid state reaction. The rate of reaction appears to be approximately two orders of magnitude higher compared to ordinary high temperature solid state reaction performed in furnace.

The raw reagent powders of $La_2O_3$, $BaCO_3$ and CuO weighed in stoichiometric proportions for x=0.125 were thoroughly stirred in agate mortar and pressed under 5 ton hydraulic press into 12 mm diameter and 1.8 mm thick pellets. Several identical pellets were produced for experiments.

Photonic irradiation of samples was carried out by means of original equipment with halogen filament bulbs under controlled temperature , which was measured with quick-response thermocouple. The maximum duration of photonic pulse was 20 sec, the maximum temperature of sample being reached in 7 sec.

Sample #1 was irradiated with 3 pulses on each side separately at $T_{max}$=1000°C; sample #2 was irradiated with 3 pulses simultaneously on both sides at $T_{max}$=1000°C and sample #3 was irradiated with 3 pulses on each side separately at $T_{max}$=1100 °C. Consequently black ceramic pellets with resistance 1-20 ohm (as measured with ordinary multimeter) were obtained.

In order to analyze the superconducting characteristic of the obtained samples the measurements of temperature dependence of magnetization were performed . The vibrational magnetometer produced by CRYOGENIC Ltd. and operating in temperature range 2 - 300 K and magnetic field up to 5 T was used.

The samples were cooled in zero magnetic field down to 2 K, then magnetic field B=20 G was applied and magnetization was measured on sample heating (ZFC proc-

ess). The same measurements were performed by cooling the samples from above $T_c$ with the same applied magnetic field (FC). If the sample is superconductor, a negative magnetic moment (of diamagnetic origin) is induced due to screening effect, which disappears at superconducting transition temperature $T_c$.

All three samples after irradiation were found to be superconducting with the same onset critical temperature $T_c$~28 K. The ZFC and FC curves for sample #1 are presented in the Figure (for other samples the curves are very similar). In the inset of the Figure analogous curves are presented for comparison for the same compound prepared by the ordinary high-temperature solid state reaction in furnace at 1130 °C for 50 hours.

In order to determine the role of thermal factor in our synthesis process we performed a control test: identical pellet was inserted in furnace zone preliminarily heated to 1000°C of and quickly removed after 1 minute. This sample showed no superconductivity.

The results obtained provide evidence of the photostimulated nature of performed solid state reaction, and demonstrates the possibility of production of HTSC using only optical exposure. The rate of superconducting phase formation is two order higher relative to ordinary process. This is of considerable practical use not only for HTSC synthesis but for other advanced materials which require a solid state reaction process.

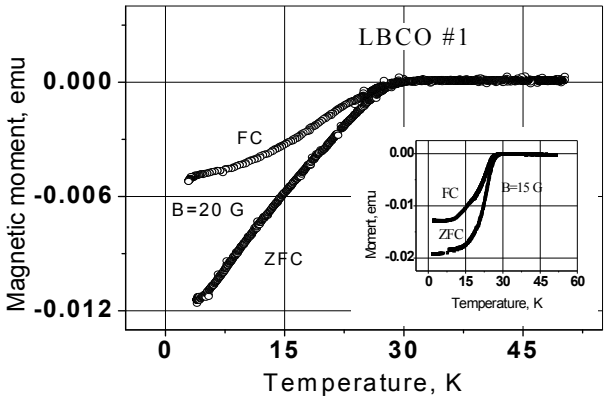


Fig. Temperature dependence of magnetization in $La_{2-x}Ba_xCuO_4$ HTSC (x=0.125, sample #1) obtained by photostimulated solid state reaction. Inset shows, for comparison, the results obtained for the same compound prepared by the ordinary high-temperature solid state reaction in furnace at 1130 °C for 50 hours.

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*ფიზიკა*

# მაღალტემპერატურული ზეგამტარის $La_{2-x}Ba_xCuO_4$-ის სინთეზი ფოტოსტიმულირებული მყარსხეულოვანი რეაქციის მეთოდით

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**პირველადაა განხორციელებული მაღალტემპერატურული ზეგამტარის $La_{2-x}Ba_xCuO_4$-ის სინთეზი ფოტოსტიმულირებული მყარსხეულოვანი რეაქციის მეთოდით. ნაჩვენებია, რომ ამ რეაქციის სიჩქარე ორი რიგით აღემატება ტრადიციულ თერმულს და მისი რეალიზაციის ეფექტურობა განისაზღვრება არა ტემპერატურული, არამედ ოპტიკური ფაქტორებით.**

## REFERENCES

1. *I.B. Khaibullin, L.S. Smirnov* (1985), Fizika i tekhnika poluprovodnikov, **19**, 4: 569-596 (in Russian).
2. *Z.V. Dzhibuti, N.D. Dolidze, G.Sh. Narsiya, G. L. Eristavi* (1997), Tech. Phys. Let., **23**, 10: 746-747.
3. *Z.V. Jibuti, N.D. Dolidze, G.L. Eristavi* (2008), Tech. Phys, **53**, 6: 808-810.
4. *L.N. Ziuz, A.E. Kiv, O.R. Niazova, F.T. Umarova* (1970), Tech. Phys. Let., **12**: 213-216 (in Russian).
5. *I.G. Gverdtsiteli, A.B. Gerasimov, Z.G. Gogua, et al*. (1987), Bull. Georg. Acad. Sci., **128**, 2: 293-29 (in Russian).

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