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Superconducting joining of melt-textured YBCO

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Abstract

Superconductive junctions between superconductive melt-textured $YBa_2Cu_3O_{7-\delta}$ blocks (MT-YBCO), that are practically invisible in a polarized light, have been made using a $TmBa_2Cu_3O_{7-\delta}$ powder, which is close to materials being joint in superconductive and mechanical properties (microhardness and bending strength). By SEM study we have found that in the best seams Tm has been present in a thin (about 40–50 μm) layer along the seam.

Keywords: Melt-textured $YBa_2Cu_3O_{7-\delta}$; $TmBa_2Cu_3O_{7-\delta}$; Superconductive joining by soldering

The quality of type II superconductors and, hence, of melt-textured $YBa_2Cu_3O_{7-\delta}$ (MT-YBCO) is defined by the maximum of magnetic energy, which can be trapped in the material. The magnetic energy depends on the critical current density and diameter of superconducting current loop that in turn is limited by the magnetic domain size. At present the size limit for a high quality material is about 50–60 mm. The attempts to synthesize larger samples led to the degradation of material quality. Our study is aimed at developing a method of formation of superconductive joining between MT-YBCO blocks using a $TmBa_2Cu_3O_{7-\delta}$ (Tm123)-based solder with similar to joined material superconductive and mechanical properties. First positive results of using Tm123 as a solder have been reported by Zheng et al. [1,2] and Prikhna et al. [3]. Being an isostructural analog of the matrix Y123-phase (of MT-YBCO) and having close to Y123 temperature of superconducting transition and lower (by ≈30 K) temperature of incongruent melting than MT-YBCO has, the Tm123 is an appropriate solder that can well accommodate to the structure of the joint material and thus, the joint with similar to MT-YBCO superconductive and mechanical properties can be formed.

The encouraging results have been obtained when Ag-doped MT-YBCO, melting temperature of which is also lower than that of MT-YBCO,

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was used as a solder [4], but up to now as in the case with multi-seed growth [5], no unambiguous proof of the advantages of this method of joining over the single-seed melt-texturing growth has been given.

Hear we continue to examine the peculiarities of superconductive seam formation between MT-YBCO blocks using a Tm123 powder. Previously [3] we have found that it is better to conduct the soldering of superconductive MT-YBCO parts in oxygen atmosphere and that the addition of the Y211 phase to Tm123 powdered solder gives no advantages.

As starting samples, we used pieces of MT-YBCO cut from the same cylindrical block of a seed-grown material. The cuts were made perpendicular to the basis of the cylinder (or approximately perpendicular to the *ab*-plane of the Y123-phase domains of MT-YBCO). The solder (Tm123 powder) was put onto the surfaces of the

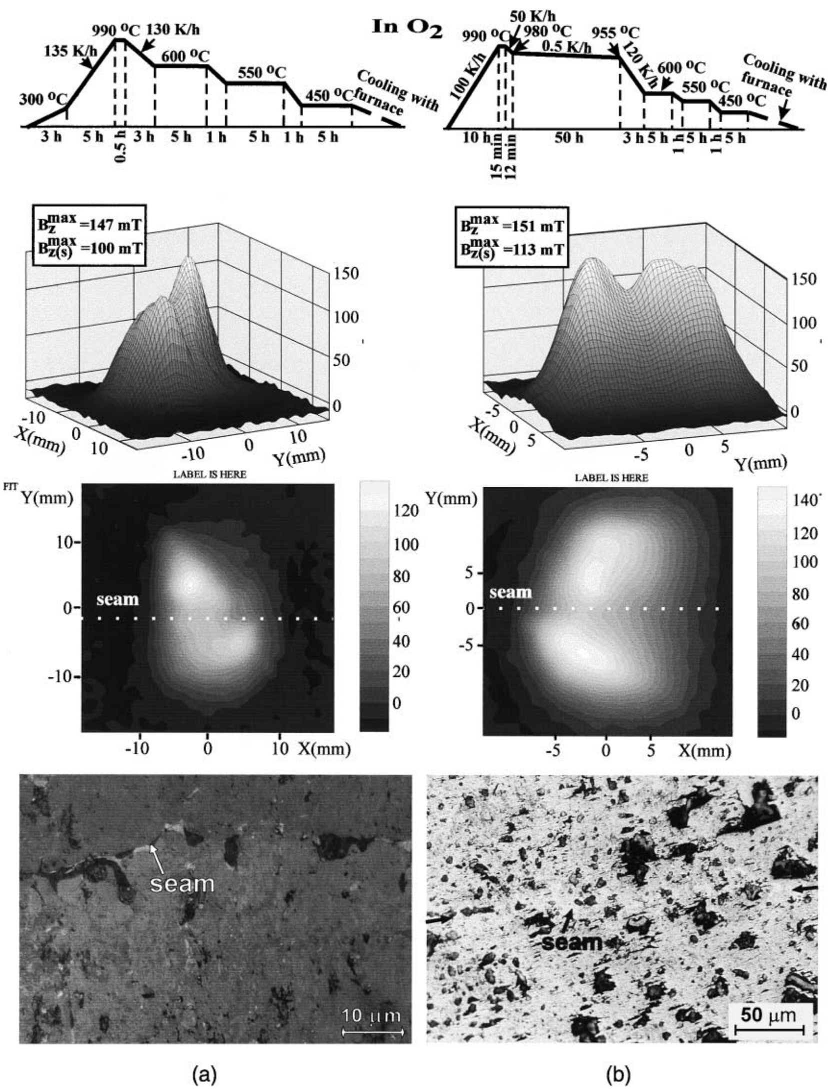

Fig. 1. Regimes of soldering (a,b), the field mapping of the soldered materials obtained in accordance with this two regimes and view of the formed seams in a polarized light.

cut by sieving or sedimentation from a suspension in acetone. Than one piece was placed onto the other and throughout the soldering process joined surfaces were horizontal.

Fig. 1 demonstrates two regimes of soldering, the field mapping of the soldered materials obtained in accordance with this two regimes (the distance between the Hall probe and the surface of the material was 0.8 mm) and view of the formed seams in a polarized light. In both the cases we obtained the seams with superconductive properties compatible with those of the joined material, but the soldering by the first regime (a) was shorter by 52 h than that by the second one (b). The investigations of microhardness showed that under a load of 1.96 N, the microhardness of the seams was practically the same 4.11 ± 0.30 and 3.95 ± 0.3 GPa for the (a) and (b) regimes (see Fig. 1), respectively. The microhardness of MT-YBCO was 4.89 ± 1.81 GPa under the same load. The bending strength measured at the places of joining was 26–32 GPa and compatible with the bending strength of the bulk material. The SEM study has shown that in the best seams, Tm is present in a very narrow layer along the seam, about 40–50 μm.

Acknowledgements

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