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Anomalies of the Diffusion Mass-Transfer during 2D-Decomposition of Superconducting $YBa_2Cu_3O_{6+X}/Y_2BaCuO_5$ Composites

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1. Introduction

In a series of TEM studies, for instance, [1, 2], the growth and dissolution of large stacking faults-like precipitates (SFLP) in the melt textured $YBa_2Cu_3O_{6+X}/Y_2BaCuO_5$ ceramics has been observed. As is shown [3], the SFLP's can be considered as the two-dimensional phases ($Y_2Ba_4Cu_7O_{14+Z}$ or $YBa_2Cu_4O_8$) of nanometer thickness, being the 2D-decomposition reaction products of the $YBa_2Cu_3O_{6+X}$ orthorhombic metastable structure.

2. Discussion - analytical results

In the present contribution, the thermodynamic and kinetic (diffusion) aspects of these processes are considered on the basis of the analysis [3] of data [1,2].

The thermodynamic analysis of the related data has shown that: (i) the superconducting (orthorhombic) phase Y123 is a thermodynamically unstable (or a highly metastable) structure at $P_{O2} = 2\cdot10^9$-$1\cdot10^3$ Pa and T = 1223-573 K; (ii) the decomposition of orthorhombic Y123 under the oxygenation treatment is of a topo-chemical character (that is, the chemical reactions are localized in the near-lattice defects' nanoregions); (iii) it can result in a quenched phase fluctuation-like effect, especially for melt-textured composites, thin films, coatings, nanomaterials and heterostructures; (iv) the decomposition of orthorhombic Y123 under the standard oxygenation treatment of Y123/Y211 melt-textured composites, with formation and growth of the stacking fault-like precipitates of Y124 (Y247) phase and precipitates of Ba-Cu oxides, is described by using the (P_{O2}-T)-diagram of the related chemical reactions and the (P_{O2}-T-X)-diagram for $YBa_2Cu_3O_{6+X}$; (v) the decomposition process can be controlled by oxygen and/or copper diffusion transport to the lattice defects' active regions - 'internal reactors'; the anomalies of the diffusion transport can be related to the near-defects' segregation.

The nature of the tetrahedral-orthorhombic phase transition and the related elements of the Y123-oxygen quasi-binary phase diagram are considered within approaches of physical chemistry of materials. Thermodynamic activity and chemical and tracer diffusivities of oxygen are also considered.

3. Conclusion

The growth of the SFLP under the conditions of the standard oxygenation treatment of the ceramics can be described by two successive reactions. The first fast one provides the CuO precipitate formation, and it is localized in the lattice defects' regions (cracks, interfaces and grain boundaries near the Y_2BaCuO_5 inclusions). The second “sluggish” step (with participation of the CuO phase) provides the SFLP formation in the near lattice defects’ regions.

The processes can be controlled, depending on the conditions, by anomalous oxygen or the other elements’ (Cu, Ba) diffusion transport to the lattice defects’ active regions – the ‘reactors’. The anomalies of the diffusion transport are mainly related to the influence of the impurity segregation at lattice defects of the dislocation type.

On the basis of a thermodynamic analysis of the related experimental data, a possibility to identify phase fluctuation-like effects in the high-temperature superconducting (HTSC) cuprates is shown, especially with respect to the physical properties of melt-textured composites, thin films, coatings, nanomaterials and heterostructures.

References

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