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Shock – Compaction of Bi-Pb-Sr-Ca-Cu-O Particles

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Researches for applications of high-Tc BPSCCO superconductor particles have been made to overcome the weak-link problem around the grain boundary for higher Jc. Shock compaction for BPSCCO superconductor particles have been investigated by shock compaction technique. After the shock compaction characterizations of as-shocked BPSCCO superconductor particles are investigated by X-ray diffraction (XRD)-analysis for the measurements of lattice parameters and SQUID -measurements for the susceptibility. Grain growth with growth steps of as-shocked BPSCCO superconductor particles are observed by AFM(Atomic Force Microscope) and SEM(Scanning Electron microscopy). As a result, the as-shocked specimen showed an oriented crystal structure for as-shocked BPSCCO superconductor particles calculated by XRD just after the shock compaction under 2-5GPa. From SEM-observations, the surface of the specimens for as-shocked BPSCCO superconductor particles has large grains of 3-5 μ m in length partly with large growth-steps caused mainly by heats generated in shock compaction. The Δ M(0.073 emu/g) of shocked specimen after annealing at 850 for 96 hr became higher than that of starting specimen. These increase of Δ M indicate the introduction of a new pinning center through the shock compaction and annealing processes.

Key words: Bi-Sr-Ca-Cu-O superconductor, shock–compaction, magnetic sensor, superconductor particles

1. INTRODUCTION

Bi-Pb-Sr-Ca-Cu-O(BPSCCO) oxide superconductors are very attractive materials as a highly sensitive magnetic sensor in which magnetic sensitivity of the sensor[1] is found to be about 27 % / (10^{-4} T) using BPSCCO particles pasted for constructing the magnetic sensor.[2] Researches for applications of high-Tc BPSCCO superconductor particles have been made to overcome the weak-link problem around the grain boundaries for higher Jc. Shock compaction for BPSCCO superconductor particles[3] have been investigated by shock compaction technique[4]. After the shock compaction under 2-3GPa characterizations of as-shocked BPSCCO superconductor particles are investigated by X-ray diffraction (XRD)-analysis for the measurements of lattice parameters and SQUID -measurements for the susceptibility[5]. the grain growth with growth steps of as-shocked BPSCCO superconductor particles are observed by AFM(Atomic Force Microscope).

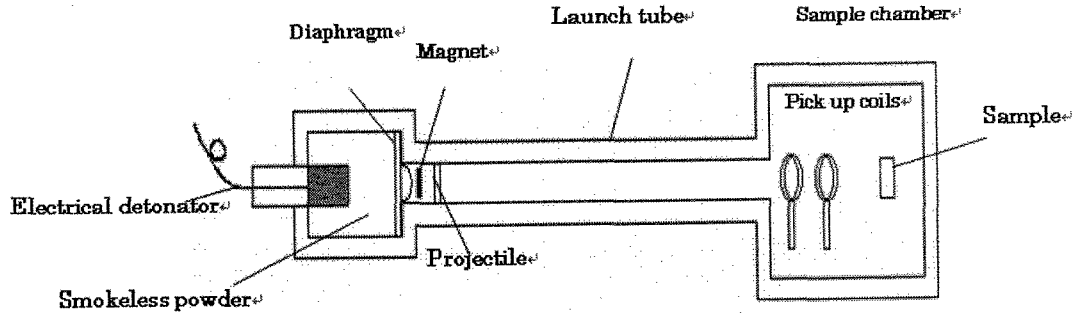

Fig. 1 BPSCCO specimen encased in stainless containers in a shock compaction system

2. EXPERIMENTAL

The BPSCCO particles was finely milled for 90 minutes. The particle size distribution was measured by a laser diffraction size analyzer, which employed laser diffraction and scattering methods. In this measurement, an isopropyl alcohol was used for dispersing the BPSCCO particles. The average particle size of the particles is found to be about 2.7 μ m.

The specimens were pressed into pellets with 10 mm in diameter and around 1mm in thickness. These pellets were tightly encased in stainless containers. Shock compaction experiments[4] were carried out under the shock pressure of around 2-3GPa by using a propellant gun-system as shown in Fig.1..

Δ M (the difference of susceptibility at 5K obtained from the temperature dependency of field cooling and zero field cooling at 20 Oe) which is proportional to Jc , is measured by SQUID magnetometer.

AFM images can be used to obtain quantative informations about the properties of the surface of BPSCCO particles annealed after shock compaction by using Tapping Mode AFM imaging technique of Amplitude Mode image and Section analysis.

3. RESULTS & DISCUSSION

From the XRD-analysis, it is found that Bi-2223 phase is appeared clearly after the shock compaction process under 2-3GPa with Bi2212 phase.

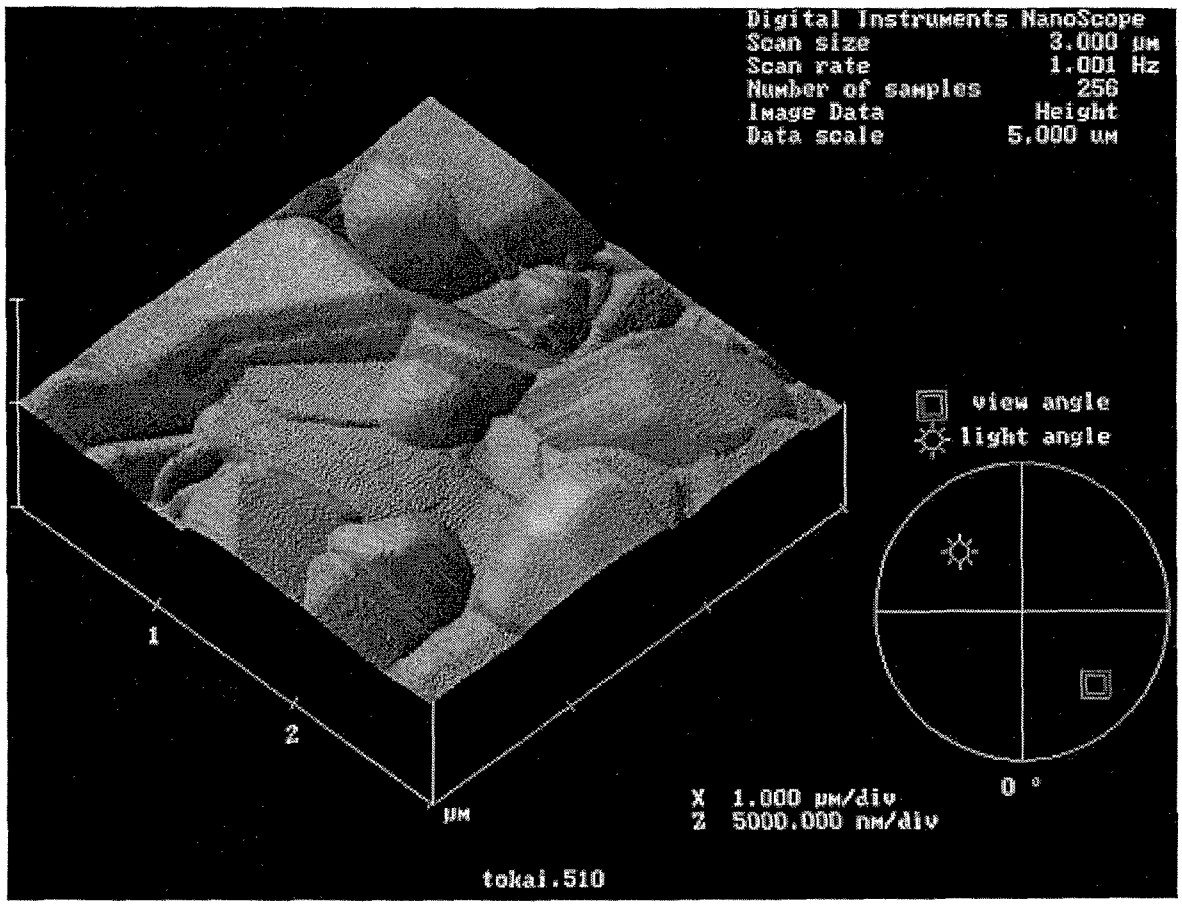

Fig. 2 AFM-image for annealed BPSCCO at 850℃ for 96hr after shock of Amplitude Mode image

From the temperature dependence of the susceptibility in BPSCCO superconductors, the Bi-2223 structures of as-shocked BPSCCO probably have shock-induced defects by the shock compaction. Therefore in the measurements of the susceptibility by SQUID magnetometer, it is found from the susceptibility measurements as a function of temperatures that Δ M clearly increases to 0.073 (emu/g) for as- shocked BPSCCO after annealed at 850 ℃ for 69hr, which seems to indicate the new pinning centers around the grain boundaries caused probably by the new defects of vacancies as shown in Fig.3.

The Amplitude Mode image shows the surface details better than the unfiltered Height Mode images for BPSCCO particles as shown in Fig.2. This shows Tapping AFM images of the surface and edges for annealed BPSCCO particles at 850 ℃ for 69 hr after shock compaction. It is found from the section analysis that the vertical distance around edge area varies from 86 to 478 nm.

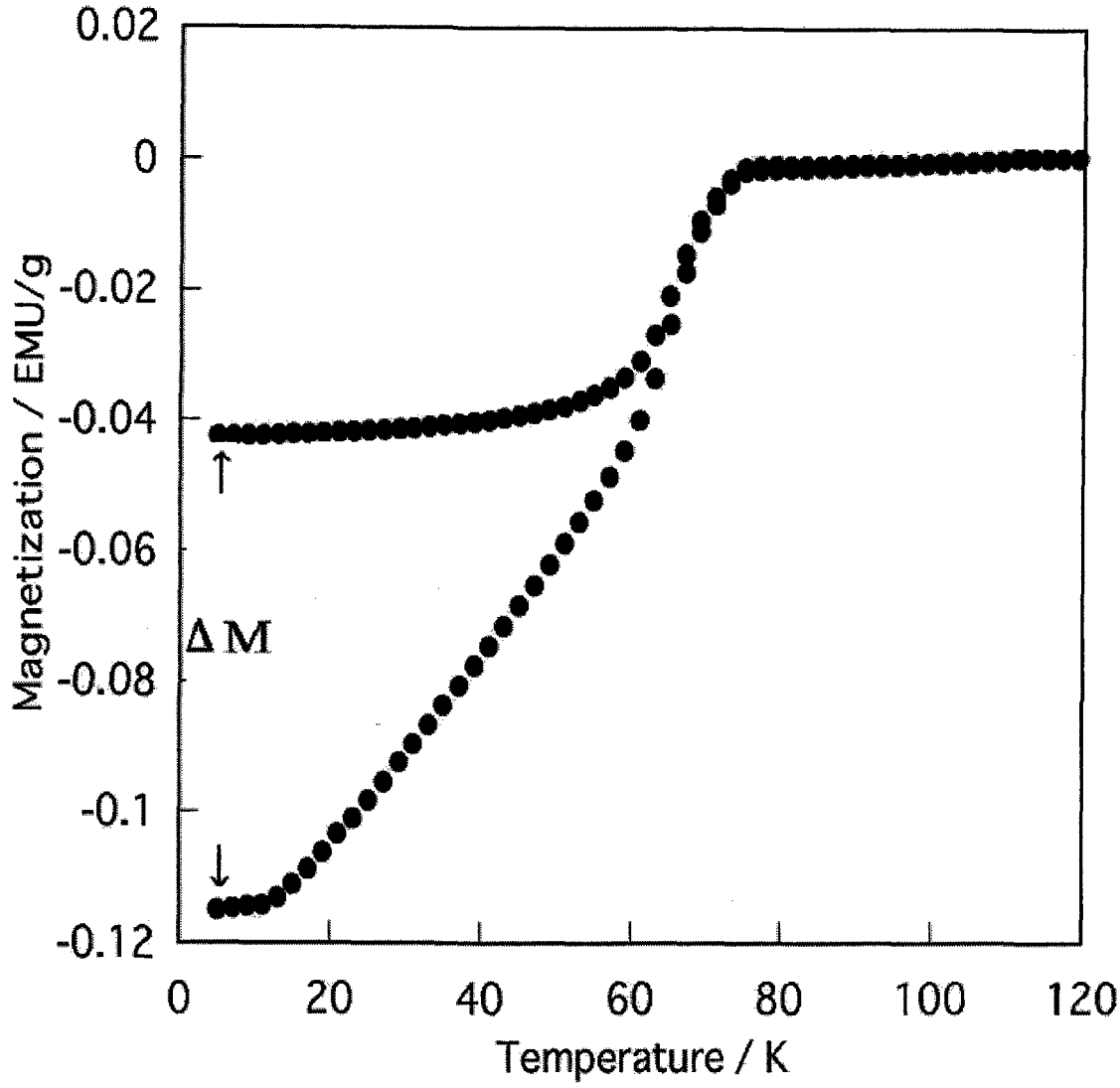

Fig.3 The measurements of Δ`M at 5K obtained from the temperature dependency of field cooling and zero-field cooling at 20Oe by SQUID magnetometer.

4. CONCLUSION

The shocked specimen was compacted in platelet disk with a high crystal density over 97% . The as-shocked specimen showed an oriented crystal structure with large grains of 3-5 μ m in length partly for shocked specimen by 2-3GPa. The Δ M(0.073 emu/g) of shocked specimen after annealing at 850 for 96 hr became higher than that of starting specimen. These increase of Δ M indicate the introduction of a new pinning center through the shock compaction and annealing processes. The Amplitude Mode images of AFM show large edge effects which reflect the amplitude changes. Also from the section analysis of AFM, the vertical distance of about 86- 478 nm is obtained around the edge area in grains for annealed BPSCCO after shock compaction.

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