L-60

Growth of BaO Films for Superconducting Materials by Electric Field Assisted Pulsed Laser Deposition

○Satoshi Omuro[1], Shoma Kamada[2], Satoshi Kurumi[3], Ken-ichi Matsuda[3] and Kaoru Suzuki[3,4]

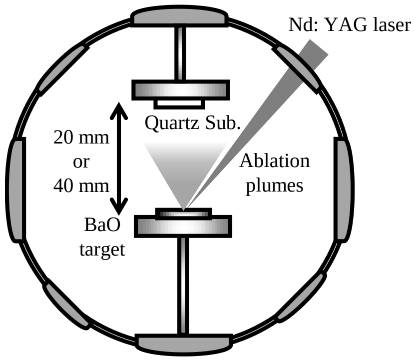
Abstract: In this study, we have tried to low deposition-rate growth and remove the oxygen from BaO targets by pulse electric or direct current electric field assisted off-axis PLD. As a result, high Ba^+ peaks of 553 nm and 706 nm were observed at pulsed electric field impression. The deposition rate was decreased at off-axis process than that of on-axis. Deposition rate of pulsed electric field assisted films increased than that of direct current (DC) electric field assist films. Grain size of off-axis films shows less than 4 μm.

1. Introduction

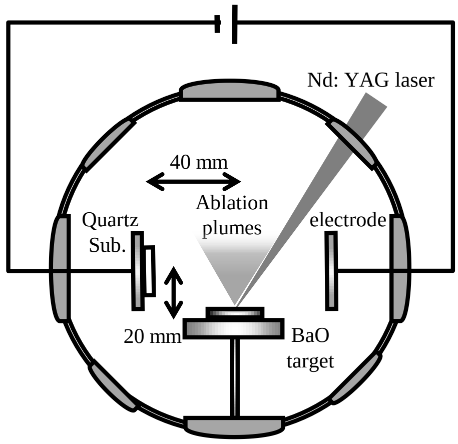
Fe-based superconductors ($BaFe_2As_2$, and SrLaFeAsF et al.) have demonstrated attractive characteristic of low consumption energy, and fast responses, etc. In order to obtain the superconductor, it needs a highly quality source material, and, requires high growth technology. Additionally, it is difficult to handle the starting materials (Sr, La, Ba et al) because they were easy to oxidizing. To improve these problems, we focused on the off-axis process, which is expected to decrease the droplet amount and the deposition rate, therefore, it is suitable to grow these superconductive materials. Moreover, electrical field were expressed in pulsed laser deposition (PLD) system as oxygen removal source. In this study, we have attempted to remove the oxygen atoms from BaO, and develop the low deposition rate growth by off-axis electric field assisted PLD (EFA-PLD).

2. Experimental method

Fig. 1 shows experimental apparatus of on-axis PLD (a) and off-axis PLD (b). BaO sample films were grown on quartz substrate (10 × 10 × 0.5 mm) using a focused Nd: YAG laser (LOTIS TEE LS 2147, wavelength: 355 nm, pulse width: 20 ns, repetition frequency: 10 Hz, laser power: 380 mJ) for 60 min. BaO laser targets was obtained from BaO powder (ALDRICH, purity: 90 %) which was pressed at 80 kN for 30 min. A distance between the target and the substrate was 20 mm (On-axis), and 20 mm × 40 mm (Off-axis). Electrodes were set between the target as showed in Fig. 1 (b), and cathode electrode was attached the back of the substrate. Ablation plumes were observed from the target by laser irradiation. Electric field was impressed to between ablation plums by applying pulse or DC voltage.. These ablation plums were deposited on the substrates. Emission spectra of ablation plumes were measured by spectrometer(Lambda Vision, Spectra Views). Thickness and surface were observed by scanning electron microscope



(a) On-axis



(b) Off-axis

Fig. 1 Electric field assist PLD

Table 1 Growth conditions of BaO films

Sample film	Air pressure [mtorr]	Distance [mm]	Voltage [V]
#1(on-axis)	10	20	0
#2(on-axis)	10	40	0
#3(off-axis)	10	20×40	1000 (DC)
#4(off-axis)	10	20×40	500 (pulse)

1:Student Departure of electrical engineering, CST Nihon-U. 2: Graduate student of Electrical Engineering, CST, Nihon-U. 3: Department of Electrical Engineering, CST, Nihon-U. 4: Advanced Materials Science Center and Center for Creative Materials Research.

(SEM, Hitachi High Technologies, S-3000N). Details of growth condition s were shown in table 1.

3. Results

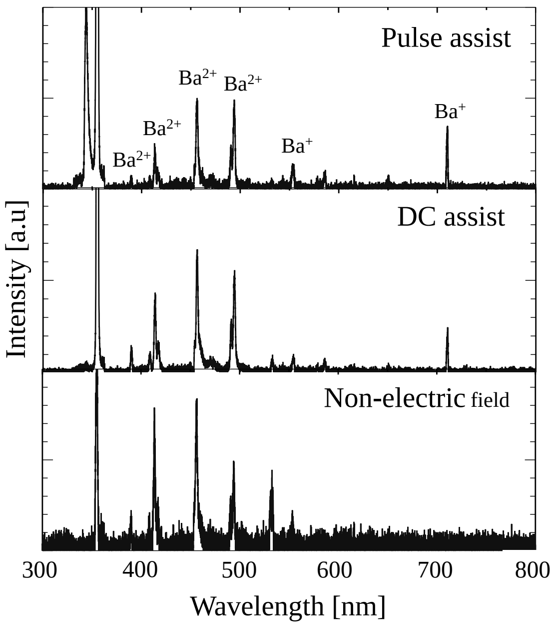


Fig. 2 Emission spectra of ablation plumes

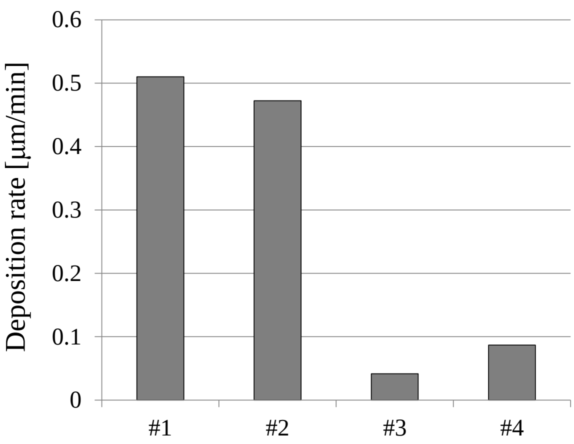


Fig. 3 Deposition rate of BaO

Fig. 2 shows emission spectra of ablation plume from BaO target. Emission peaks were observed the range from 355 to 750 nm. The highest peak of 355 nm was wavelength of Nd; YAG laser. Peaks of 389 nm, 413 nm, 455nm and 493 nm were emission due to Ba^{2+}, while peaks of 553 nm and 706 nm were emission due to Ba^{+}. Ba^{2+} peaks of 389 nm, 413 nm, 455 nm and 493 nm became weak by applying electric field. While Ba^{+} peaks of 553nm and 706 nm became strong by applying electric field.

Fig. 3 shows deposition rate of grown BaO films. Deposition rate of #1 and #2 at on-axis samples were 0.51 µm/min and 4.7 µm/min, respectively, while deposition rate of #3-#4 at off-axis samples were 0.04 µm/min and 0.09 µm/min. Moreover, deposition rate of #4 was higher than that of #3. This indicated that pulse assist could attract ablation plums to the substrate on cathode than that of DC assist.

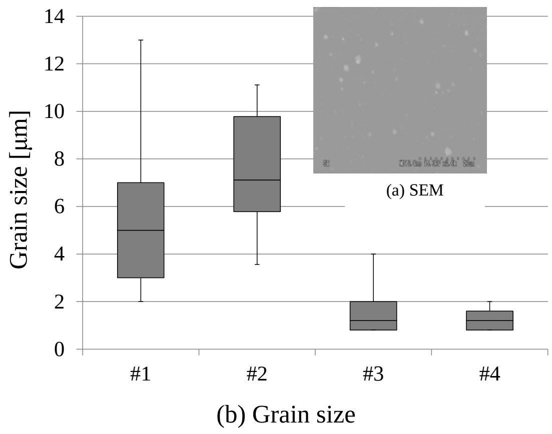


Fig. 4 Grain size of droplet

Fig. 4 shows the grain size of deposited BaO films. Centr value of #1 and #2 at on-axis samples were 5.0 µm and 7.1 µm, respectively, while center value of #3 and #4 at off-axis samples were 1.2 µm both. However, size distribution of #3 and #4 at off-axis samples were 2.8 µm and 0.8 µm. This suggests that off-axis process could decrease the grain size, which was suit for the film deposition. Moreover, impressing the pulse electric field shows uniformly grain size; it could grow the high quality films.

4. Conclusion

We have attempted to deposit the BaO films by EFA-PLD to remove the oxygen, decrease the deposition rate and control the grain size. Emission spectra showed, Ba^{+} peaks of 553 nm and 706 nm at pulse assist were stronger than other condition. Deposition rate of pulse assist was 0.09 µm. This was higher than that of DC assist. Ablation plums at pulse assist were attracted stronger than that of DC assist. Size distribution at pulse assist showed to 0.8 µm. These results indicated that pulse assist could attract more strongly grains than DC assist.

Reference

[1]H.Miyazawa, et al: “Synthesis of BaO thin films by off-axis Pulsed Laser Deposition and validation assisted electric field”, Faculty of Science and Technology Annual Conference, Vol. 56, pp973-974, (2012)

[2]S.Lee, et al: ”Template engineering of Co-doped BaFe2As2 single-crystal thin films”, Nature Materials , Vol. 9, No. 5, pp397-402, (2010).

[3]A.N.ZaideV, et al: “TABLES OF SPECTRAL LINES”, IFI/OLENUM, NEWYORK-LONDON, pp376-377, (1970)