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Synthesis of (SrLaF)FeAs superconducting films by pulsed laser deposition ~ Relationship between photo excited lights and crystalline of the films ~

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We have tried to prepare superconducting (SrLaF)FeAs thin films by the photo excited pulsed laser deposition (PE-PLD). The excitation of As Sr and La atoms are observed in the luminescence spectra of the ablation plum during the deposition. The peak intensities due to above excitations become large when the ultra violet rays are irradiated to the plums. The X-ray diffraction measurements show that some oriented peaks of (SrLaF)FeAs are observed in the films produced by the PLD with ultra violet rays. These results indicate that the excitation by the ultra violet rays has an effective role in the growth of the superconducting thin films.

1. Introduction

The synthesis of the high T_c superconducting thin films is very important for the fabrication of superconducting devices such as Josephson devices et al.[1-2]. Among Fe-based superconductors, a Co-doped $SrFe_2As_2$ epitaxial film is firstly reported to become a superconductor with the transition temperature T_c of 20 K [3]. In order to obtain superconducting thin films, there are some serious problems such as expensive substrates and high quality target materials for pulsed laser deposition (PLD) [4]. However, the photo excited PLD (PE-PLD) is considered to have advantages for the synthesis of high quality epitaxial thin films because of the high reactivity of ad atoms on the films [5]. (SrF)FeAs is isostructural to an Fe-based superconductor (LaO)FeP and $(Sr_{1-x}La_xF)FeAs$ with x=0.4 becomes superconducting below T_c of 26.3 K [6]. In this study, we have tried to prepare superconducting (SrLaF)FeAs thin films by PE-PLD, and investigated the relationship between the wavelength of the photo excitation sources and the crystallization of films

2. Experimental

Figure 1 shows the schematic diagram of PE-PLD system. (SrLaF)FeAs thin films are deposited on MgO(001) substrates by PE-PLD. A focused Nd:YAG pulsed laser (LOTIS LS2147: wavelength = 532 nm, pulse width = 16 ns, pulse repetition rate = 10 Hz) is used as a laser ablation source. The laser pulse is irradiated to the bar shaped poly crystal (SrLaF)FeAs target material. The ablation plums are observed in the region between the target and the substrate. The lights produced by the following photo excitation sources are irradiated to the ablation plums. Four photo excitation sources are used; infrared lamp (THERMO RIKO IR2B from 0.5 to 2.5 μm), Xe lamp (KLV CL300BUV: from 0.2 to 1.1 μm), ultra violet (UV)-cut Xe lamp (from 0.4 to 1.1μm), and UV-light emitting diode (UV-LED) (JW-system UV LED peak: 400 nm, width: ± 20 nm).

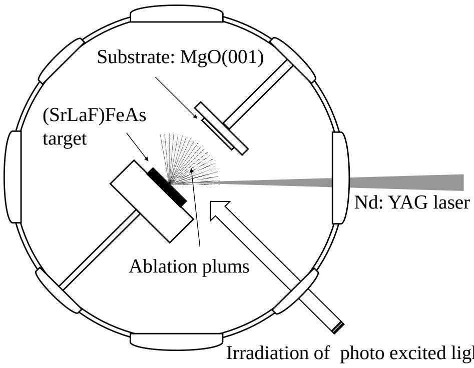

Fig.1 Experimental apparatus for photo excited pulsed laser deposition.

The luminescence of the ablation plums are measured by using a StellarNet EPP2000 spectrometer. As the optical fiber for the spectroscopic measurement is not used at high temperature, the luminescence spectrum of the plum excited by infrared ray cannot be measured. Samples (#1 ~ #5) are prepared under the following conditions. The #1 samples are prepared by the normal PLD without photo excitation, The #2 ~ #5 samples are prepared with infrared lamp, Xe lamp, UV-LED and UV-cut Xe lamp photo excitations respectively. As the as-deposited films are amorphous, they are sealed in an evacuated silica tube and annealed at 1000 °C for 20 hours. The crystallization of the films is measured by the X-ray diffraction (XRD) (RIGAKU RINT2000). The temperature dependence of the electrical resistivity is measured by the Quantum Design PPMS system.

3. Results & Discussion

Figure 2 shows the luminescence spectra of ablation

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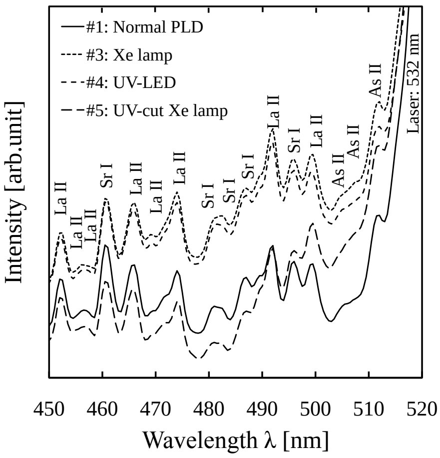

Fig.2 Luminescence spectra of ablation plums

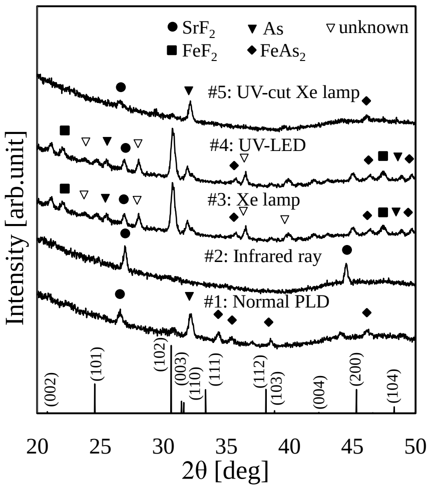

Fig.3 XRD patterns of #1 ~ #5 samples prepared by PLD

plums in the range from 450 to 520 nm. These spectra are divided to two regions. One is from 500 to 515 nm. Peaks in this region are mainly due to the emission from As atoms. The other is from 450 to 500 nm. The peaks in this region are mainly due to the emissions from La and Sr atoms. Peaks due to the As, La and Sr are observed for all samples. However, all peak intensities of the #3 and #4 samples are larger than those of #1 and #5. This indicates that the ultra violet rays keep the excitation of As, La and Sr atoms in the plums.

Figure 3 shows XRD profiles of #1 ~ #5 samples with the simulation profile of (SrLaF)FeAs. The peaks due to the (SrLaF)FeAs are not observed in the #1, #2 and #5 samples. While the impurity peaks due to SrF_2 and $FeAs_2$ are observed in the #1 and #5 samples, only those due to SrF_2 in the samples #2. As the irradiation of infrared rays is a thermal process, As atoms are considered to be lost easily during the film growth because of the high vapor pressure [4]. However, the peaks due to (SrLaF)FeAs are observed in #3 and #4 samples, although the small peaks due to the impurity phases are observed. This indicates that the excitation by ultra violet rays is considered to be important for the improvement of crystalline state.

The absolute values of the electrical resistivity for all samples are about 1 Ω m. These values are about three or four orders of magnitude larger than those of high T_c superconductors. The temperature dependence of all samples is semiconducting and does not show a superconducting above 2 K.

4. Conclusions

The luminescence spectra of ablation plums show emissions from As, La and Sr atoms. The peak intensities excited by ultra violet rays are stronger than those by ultra violet cut rays. While X-ray diffraction patterns of (SrLaF)FeAs thin films prepared without ultra violet rays show only impurity phases, those with ultra violet rays show some oriented peaks of (SrLaF)FeAs. These results indicate that the photo excitation by ultra violet rays increases excited atoms and high quality films are obtained. However, the present (SrLaF)FeAs thin films are semiconducting and do not show a superconductivity above 2 K. The effort to obtain superconducting thin films are now under progress.

5. References

[1] Y. Kamihara, T. Watanabe, M. Hirano, and H. Hosono: J. Am. Chem. Soc. **130**, 3296 (2008).

[2] S. Lee, J. Jiang, Y. Zhang, C. W. Bark, J. D. Weiss, C. Tarantini, C. T. Nelson, H. W. Jang, C. M. Folkman, S. H. Baek, A. Polyanskii, D. Abraimov, A. Yamamoto, J. W. Park, X. Q. Pan, E. E. Hellstrom, D. C. Larbalestier, and C. B. Eom: Nature Materials **9**, 397 (2010).

[3] H. Hiramatsu, T. Katase, T. Kamiya, M. Hirano, and H. Hosono: Appl. Phys. Express **1**, 101702 (2008).

[4] H. Hiramatsu, T. Katase, T. Kamiya, M. Hirano, and H. Hosono: Appl. Phys. Lett. **93**, 162504 (2008).

[5] K. Takayama, S. Soma, T. Inoue, H. Kakinuma, and K. Suzuki: Appl. Phys. A in print.

[6] R. Suganuma, X. Jin, T. Watanabe, K. Takase, and Y. Takano: J. Phys.: Conf. Ser. **200** 012193 (2010).