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Highly-(001)-Oriented Ferroelectric PZT Thin Films on Glass by CW Green-Laser Crystallization

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1. Introduction

A low-temperature poly silicon (LTPS) thin-film transistor (TFT) on a glass substrate has become an active key device for low cost electronic systems such as flat panel displays. If low-power dissipation non-volatile memory such as FeRAM is fabricated on the same glass substrate of TFTs, various functions would be realized for future applications such as RFIDs. Ferroelectric films such as PZT films are produced through the conventional process such as furnace annealing or rapid thermal annealing. The crystallization temperature of PZT films should be above 600ºC, while glass substrates would be warped at the temperature. Ar+ laser annealing with a wavelength of 488 nm and KrF laser annealing with a wavelength of 248 nm for PZT films on glass substrates have been investigated to effectively reduce the temperature[1-2]. Continuous-wave (CW) green laser annealing with a wavelength of 532 nm was also used to crystallize PZT films on glass gaining crystallinity of the ferroelectric perovskite (001) orientation [3].

In this paper, the conditions of the CW green laser irradiation was optimized with a widened beam profile and a low scanning speed and the significant improvement has been achieved in ferroelectric PZT crystallinity on glass showing good polarization characteristics.

2. Experiments

Firstly, quartz glass substrates were treated in 0.5 % HF solution for surface cleaning. Then the titanium (Ti) layer and the bottom platinum (Pt) electrode were deposited by RF sputtering, at the thicknesses of 50 nm and 200 nm, respectively. After sputtering, the PZT precursor (100/40/60) was spin-coated on the Pt/Ti/quartz substrate at a speed of 2000 rpm for 20 s. For the PZT thickness of 250 nm and 500 nm, this spin-coating procedure was performed once and twice, respectively. It was prebaked at 120°C for 5 min, and baked at 350°C for 30 min. And then, the PZT films were set on an X-Y linear stage, and a focused laser beam scanned the film surface. The CW laser with a wavelength of 532 nm was used for PZT crystallization [3]. The laser beam intensity had a Gaussian distribution, and shaped elliptic which has the size of 1.1 mm ×34 μm(1/e2). The laser scanning speed was fixed at 0.08 cm/s, and the laser output power was varied from 5 W to 8W. The Pt top electrode was formed on the laser annealed PZT film by RF sputtering.

3. Results and Discussions

Figure 1 shows microphotographs of the lateral crystallization morphology (a) and the island crystallization (b) of the PZT films, as well as the expansion photograph (c) of the island crystallization, respectively. The morphology of island crystallization (b) appears uniform in the laser exposed area comparing with the lateral crystallization (b). Figure 2 shows the XRD patterns of PZT films after laser crystallization with various powers. The perovskite and pyrochlore peaks appeared at specific Bragg angles. The peaks of perovskite (001) and (002) were notable, with maximum value about 9885.5 and 5360.7, respectively. Figure 3 shows XRD peak intensities for perovskite (001) and (002) as well as pyrochlore (222) as a function of laser power. With the increment of laser power, both perovskite (001) and (002) peaks began to increase. The maximum value could be obtained at the laser power of 6 W. Then the peak value decreased as the laser power continued increasing. The minimum value appeared at the laser power of 7 W. On the contrary, the pyrochlore (222) peak showed a completely converse trend. The maximum value could be gained at laser power of 7W while the minimum one at 6 W. We could know from the two different trends that perovskite increases when pyrochlore deceases, on the other hand, perovskite decreases when pyrochlore increases. Figure 4 is the permittivity of laser crystallization. The maximum permittivity was 955.8. Merging the data of XRD peak intensities and peak permittivity, the best crystallization conditions of the widened laser beam profiles are given in Fig.5. As the laser power becomes stronger, both XRD peak intensities and peak permittivity started to increase. At the laser power of 6 W the maximum value of both XRD peak intensities and peak permittivity could be gained. Therefore, laser power of 6 W, scan speed of 0.08 cm/s was determined to be the best conditions. Figure 6 shows the ferroelectric hysteresis loops of the island-crystallized PZT films under best experiment conditions. The applied voltage was ranged from 1 V to 10V. The remanent polarization was about 20 μC/cm^2 while the coercive field around 65-75 kV/cm.

4. Conclusion

Low-temperature crystallization of ferroelectric PZT films on glass substrate using a widened CW green laser was achieved. Laser scanning speed was effectively fixed at a low speed of 0.08 cm/s. By varying the laser output power from 5 W to 8 W, significant feature was found on laser output power of 6 W. The notable peaks of perovskite (001) and (002) appeared with maximum value about 9885.5 and 5360.7, respectively. A significant peak permittivity result of 955 was obtained. The remanent polarization was about 20 μC/cm^2 while the coercive field around 65-75 kV/cm.

Acknowledgment

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References

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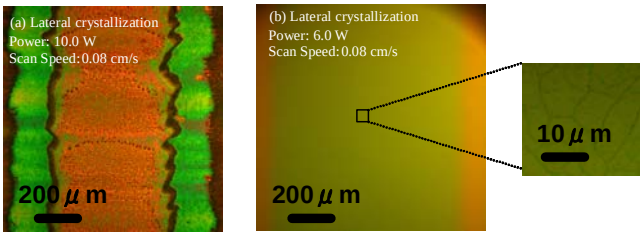

(a) (b) (c)

Fig.1 Microphotographs of PZT thin films after laser crystallization: (a) lateral crystallization, (b) island crystallization and (c) expansion picture for island crystallization.

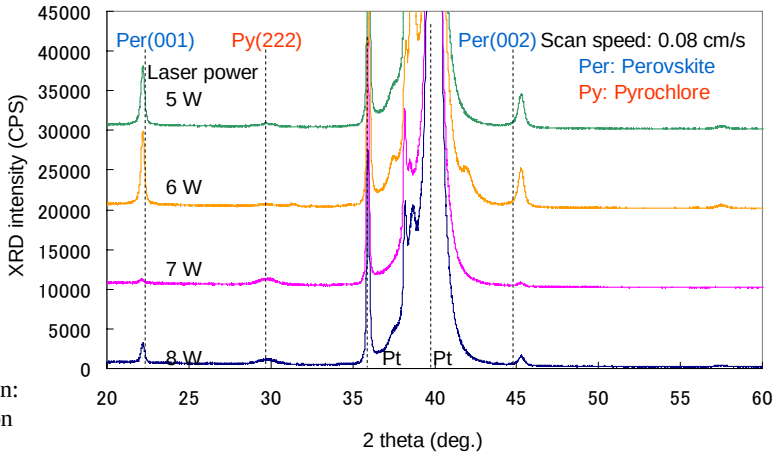

Fig.2 XRD spectra as a function of laser power.

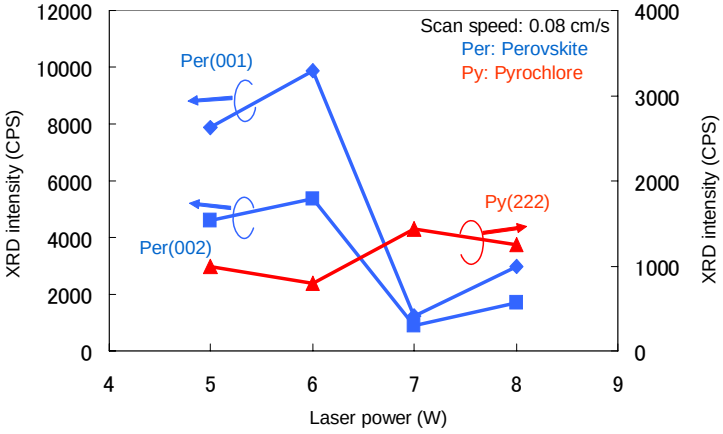

Fig.3 Laser power dependence of XRD intensity peak for Per(001) (002) and Py(222).

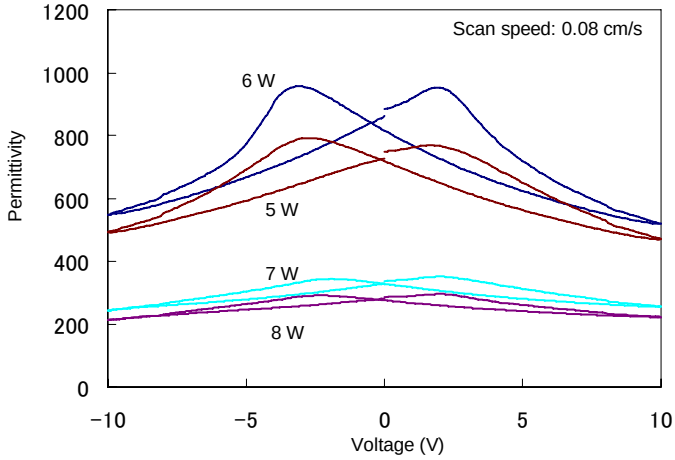

Fig.4 Permittivity of laser crystallization as a function of laser power.

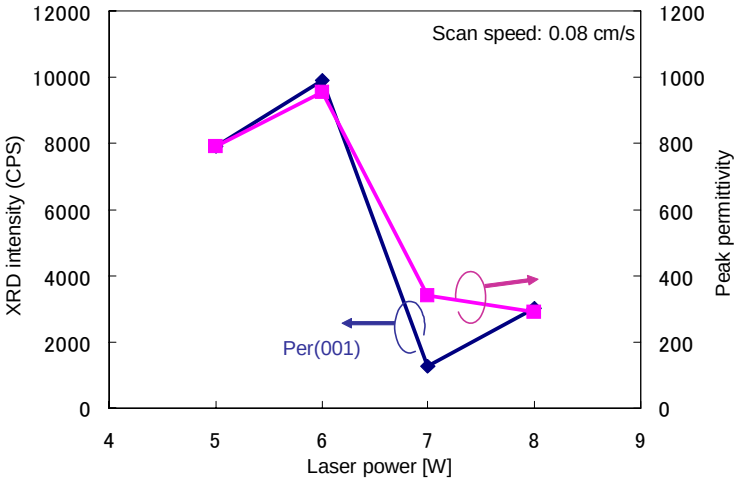

Fig.5 Laser power dependence of XRD intensity peak and permittivity.

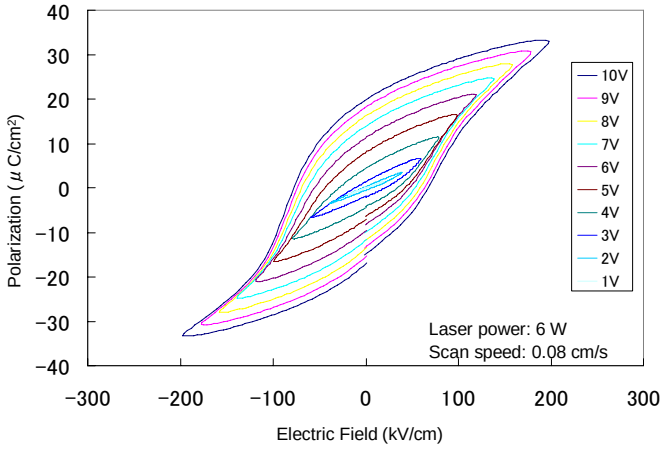

Fig.6 Ferroelectric hysteresis loops of island crystallized PZT thin films at laser power of 6W, scan speed 0.08 cm/s applied sweep voltage from 1 V to 10 V.