Heat-Resistant Transparent Conducting Films with ZnO-Based Multilayered Structures Fabricated by Pulsed Laser Deposition

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1. Introduction

It is the purpose of this report to fabricate transparent conducting multilayered films with anti-heat properties using ZnO as the chief ingredient. The multilayered films are composed of ATO (15 wt% Sb_2O_3 doped tin oxide)/AZO (1.5 wt%Al_2O_3 doped zinc oxide) structure or ATO/TZO (1 wt% Ti_2O_3 doped zinc oxide) structure. After the fabrication process, a test of anti-heat properties was carried out at 500℃ for 24 hours. Electrical and optical properties were compared before or after the test of anti-heat properties. In this report, favorable experimental results are described.

2. Experimental

The AZO films (～400 nm) or the TZO films (～400 nm) films have been deposited at 250℃ on glass substrates by irradiating the pulsed laser beam of an ArF laser (λ=193 nm) with energies 80 mJ on the AZO or TZO targets, respectively. After this process, in order to the multilayered ATO/AZO or ATO/TZO structures, the ATO films (～100 nm) have been deposited at 250℃ on the AZO layer or the TZO layer. Oxygen partial pressures employed were 0 Pa for AZO films, 0.025 Pa for TZO films and 0.8 Pa for ATO films.

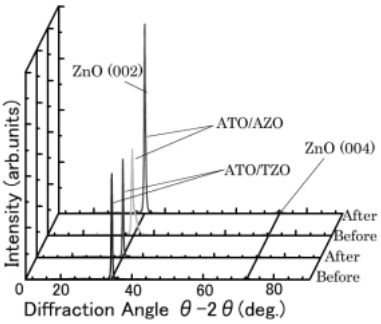

Fig.1. XRD patterns.

3. Results

Electrical properties of the multilayered films with ATO/AZO or ATO/TZO structures before or after the test of anti-heat properties are shown in Table 1. After the test of anti-heat properties, the sheet resistance of the ATO/AZO structure increased by 98.1% while that of the single layer of ATO or AZO films changed to an insulated state. From this result, it was confirmed that for the multilayered structures, the ATO film layer served as a protection layer to prevent from changing to an insulated state.

Next, the sheet resistance of the ATO/TZO structure increased only by 1 % after the test and therefore, it was recognized that the anti-heat property of ATO/TZO structure was superior to that of the ATO/AZO structure.

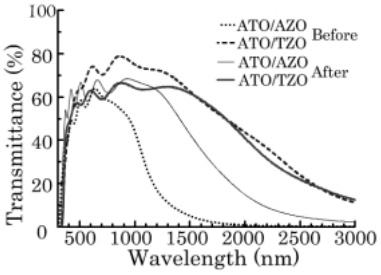

Fig.2. Optical properties for Transparent conducting ATO/AZO, ATO/TZO films.

Fig.1 shows XRD spectra for the ATO/AZO structure and ATO/TZO structure. From the result, it was confirmed that after the anti-heat test, the c-axis oriented peaks ZnO (002), ZnO (004) were identified, and there was no deterioration of the crystallinity of film structures. Moreover, for the ATO/AZO structure, the film crystallinity largely improved .

Fig.2 shows the optical transmittance spectra before or after the test. From the result, it was found that for the ATO/TZO structure, there was not an obvious change in the transmittance spectra in the wavelength range over 1500 nm available for the infrared spectra of solar cells, while an optical transmittance of the ATO/AZO structure increased by 36% in the wavelength of 1500 nm after the anti-heat test.

Table 1. Electrical properties for Transparent conducting ATO/AZO,ATO/TZO films

ATO/AZO	Sheet Resistivity (Ω/sq)	Resistivity (Ω・cm)	Hall Mobility (cm^2/V・s)	Carrier Concentration (cm^{-3})	Improvement Ratio (%)
Before	5.2	2.57×10^{-4}	29.4	8.23×10^{20}	Sheet Resistivity -98.1
After (500℃, 24h)	10.3	5.16×10^{-4}	33.3	3.63×10^{20}	
ATO/TZO	Sheet Resistivity (Ω/sq)	Resistivity (Ω・cm)	Hall Mobility (cm^2/V・s)	Carrier Concentration (cm^{-3})	Improvement Ratio(%)
Before	10.8	4.95×10^{-4}	42.0	3.01×10^{20}	Sheet Resistivity -0.9
After (500℃, 24h)	10.9	5.03×10^{-4}	54.0	2.30×10^{20}	

4. Summary

In order to improve the anti-heat properties possessed in AZO or TZO single layer film, the ATO film was employed as a protection layer and the multilayered structures of ATO/AZO or ATO/TZO were composed. As a result, it was confirmed that there was not an obvious change in the electrical and optical properties of the ATO/AZO structure after the anti-heat test while, for the ATO/TZO structure, optical transmittance increased largely in the infrared wavelength region available for solar cells.

References

1) T. Yasui, K. Ikuta, G. Zhang, T. Aoki, T. Matsushita, A. Suzuki , and M. Okuda : JSAP, **56** (2009) 1p-ZK-8.