LOW RESISTIVITY AND FLAT SURFACE OF FTO THIN FILM BY SPRAY PYROLYSIS

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Introduction
SnO2 behaves like an n-type semiconductor with a wide energy gap (~ 3.8 eV) and has a tetragonal structure, which is similar to the rutile structure. Of the various potential dopants for SnO2, fluorine is preferred because F-doped SnO2 (FTO) films show high transparency and good conductivity. The spray pyrolysis method is the most convenient method because of its simple and inexpensive experimental arrangement and the ease with which doping materials can be added. However, there are few reports on the growth and detailed analysis of FTO films deposited by spray pyrolysis.

Experimental procedure
FTO films were grown on a glass substrate by spray pyrolysis with spray solution fluorine concentrations between 0 and 33 mol%. The solution flux was kept at 1 ~ 5 ml/min, and 25 × 25mm FTO films were grown on a glass substrate by spray pyrolysis with spray solution fluorine concentrations.

Results and Discussion
The XRD spectra of the SnO2 films with different F-doping concentrations at a substrate temperature of 500 °C were carried out. Peak positions of the XRD spectrum of SnO2 correspond well to those of the ICDD. The results show that the films have a polycrystalline structure, which is the common tetragonal form of SnO2. A strong (110) orientation is observed in the SnO2 film. The tetragonal structure remains with increasing F-doping. However, the intensity of (200) peak increases with increasing fluorine concentration. These results correspond well to those in other papers [2, 3]. In the present case [4], the (200) plane has minimum surface energy of interaction due to the high substrate temperature of 500 °C. It has been reported that the preferred orientation of SnO2 film on glass substrate is affected by source compounds, growth parameters such as solution concentration, solution feed rate, spraying gas pressure, substrate temperature and solvents.

The average transmittance in the visible region is nearly constant with increasing F concentration. However, the transmittance in the IR region decreases with increasing F concentration. This is due to a shift in the plasma wavelength to shorter wavelengths. Electrical measurements were carried out using Hall technique in van der Pauw configuration at RT. The film thicknesses are between 420 and 490 nm. A resistivity of 1 × 10-2 Ωcm and a carrier concentration of 1 × 1020 cm-3 were obtained in the non-doped SnO2 film. F-doping causes the resistivity to decrease and the carrier concentration to increase. The mobility of approximately 10 cm2 (Vs)-1 in the non-doped SnO2 film increased with increasing F doping. The measurements indicate n-type conduction in all the films tested. The fluorine is incorporated in SnO2 by each F- anion substituting for an O2- anion, introducing more free electrons and thus decreasing resistivity [5]. Thus, the fluorine atoms act as donor-type impurities. The lowest resistivity of 4.0 × 10-4 Ωcm can be obtained at a fluorine concentration of 17 mol%. Its carrier concentration and mobility are 4.7 ×1020 cm-3 and 34 cm2 (Vs)1, respectively.