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SnO_2:F FILM PROPERTIES: EFFECT OF ELECTROCHEMICAL AND MECHANICAL POLISHING

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The effect of electropolishing and mechanical polishing on the transmittance and sheet resistance of SnO_2:F films prepared by using two mixed solvent media has been studied. Surface morphology changes recorded by SEM are presented.

Key Words: Tin oxide, optical transmittance, electrochemical polishing, mechanical polishing

INTRODUCTION

Fluorine doped SnO_2 films are good ohmic substrates for photoactive layers of cadmium chalcogenides [1-7] and for backwall illuminated solar cells [8]. Optical transmittance of the SnO_2 substrate determines the amount of light actually reaching the photoactive material in the backwall illuminated devices and a low sheet resistance minimises series resistance losses in the devices. The quality of the sprayed SnO_2 films depends very much on the preparative parameters like the substrate temperature, spray rate, degree of atomization and the rate of cooling [2].

Low resistance SnO_2:F films (3.6 ohms per square) have been obtained by spray pyrolysing $SnCl_2$ in 1:1 dioxan-water as the solvent medium and a minimum sheet resistance of 5.5 ohm per square has been obtained with a 1:1 rectified spirit-water solvent medium [9] These films showed low optical transparency (10-12%) in the visible region. The optical properties of films depend, in general, on the surface roughness and inhomogeneity of the films, in addition to thickness. This note concerns a study on the effect of polishing treatments on low transmittance SnO_2:F films.

EXPERIMENTAL

The electrochemical polishing of the SnO_2:F films was done employing 1:1 and 1:10 HCl [10] at different current densities and for different durations. A platinum foil was used as the anode. The SnO_2:F film prepared by using the two solvent media was studied. All the experiments were conducted at room temperature. The optical transmittance measurements were made using a Beckmann DU Spectrophotometer. Mechancial polishing of the layers was done using Luster Ronuk Compound Tripol 'A' with a polishing wheel.

RESULTS AND DISCUSSION

Electrochemical polishing

During cathodic treatment of the SnO_2 films, the nascent hydrogen produced reduces SnO_2 to metallic tin which eventually dissolves in the electrolyte [10,11]. It has also been observed that there is a reduction in the thickness of the films after the cathodic treatment, which is expected. Tables Ia and Ib give the optical transmittance and sheet resistance values before and after treatment at two different current densities.

Table I(a): Effect of electrochemical polishing
Transmittance (per cent)

Current density mA/cm²		1:1 Rectified spirit-water					1:1 Dioxan-water				
		400 nm	500 nm	600 nm	700 nm	800 nm	400 nm	500 nm	600 nm	700 nm	800 nm
20	Before polishing	9.5	4.0	5.0	11.5	4	4.4	5.2	7.6	13	7.0
	After polishing	22	32	31	39	31	5.5	5.4	6.0	5.7	3.5
40	Before polishing	31	38	46	51	31	2.7	2.9	3.1	3.8	2.6
	After polishing	31	57	72	78	20	3.0	2.5	3.0	3.6	2.2

Table I(b): Effect of electrochemcial polishing: Sheet resistance in ohm per square

Time = 5 mts	1:1 Rectified spirit-water		1:1 Dioxan-water	
Current density mA/cm²	Before polishing	After polishing	Before polishing	After polishing
20	6.7	6.5	10.5	7.5
40	15.4	8.8	13.1	3.8

From the Tables, it can be seen that the sheet resistance of the films prepared using rectified spirit in water does not change appreciably on electropolishing. But when polishing was performed at a current density of 40 mA/cm² for the same duration, the decrease in resistance was of the order of 50%. The increase in transmittance was 19-26% in the range 500-700 nm. In the case of films prepared by using dioxan-water solvent mixture, the variation of current density of polishing has not shown notable change in the transmittance values. The change in sheet resistance was more than 70% when the films were treated at a current density of 40mA/cm². The change was only 30% at a current density of 20 mA/cm². This result can be attributed to the larger reduction in thickness at higher current densities overcompensating the beneficial surface polishing.

Mechanical polishing

The sheet resistance of the films obtained with varying composition of the two mixed solvent media are shown in Fig.1.

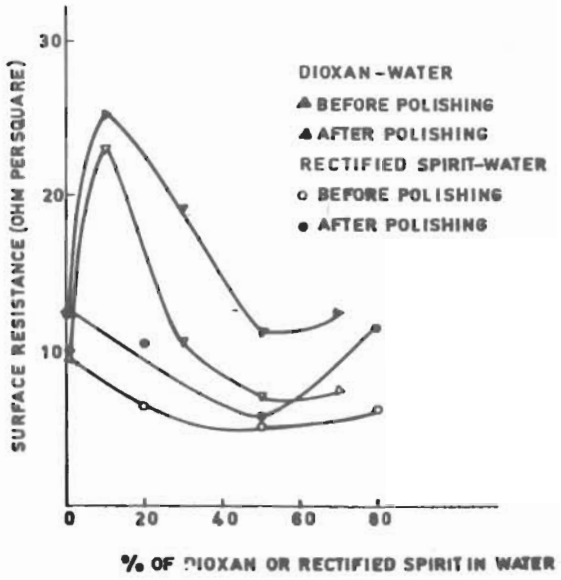


Fig.1: Variation of surface resistance with composition of mixed solvents before and after mechanical polishing

The change in resistance is mainly due to the change in thickness of the film during mechanical polishing. The high temperatures produced at the point of contact may result in the formation of amorphous material [12] thereby increasing their resistance as shown in Table II. Transmittance is not altered very much.

Table II(a) : Effect of mechanical polishing:
Sheet resistance in ohm per square

	1:1 Rectified spirit-water				1:1 Dioxan-water		
Before polishing	23.6	10.7	7.1	7.6	6.8	5.3	6.2
After polishing	25.3	19.1	11.6	12.7	10.5	5.8	11.9

Table II(b): Effect of mechanical polishing: Transmittance (in%)

	500nm		600nm		700nm		800 nm	
	Dioxan water	RS-W	Dioxan water	RS -W	Dioxan water	RS-W	Dioxan water	RS-W
Before polishing	4.3	11.5	4.4	12.5	5.3	14.0	4.8	12.0
After polishing	4.8	5.9	6.2	5.4	6.0	12.0	6.5	8.0

RS- Rectified spirit
W- Water

The surface morphology of the films before and after electrochemical polishing are shown in Figs. 2 and 3. The effect of the altered morphology is being examined to explain the changes in the electrical resistance and transmittivities of the samples.

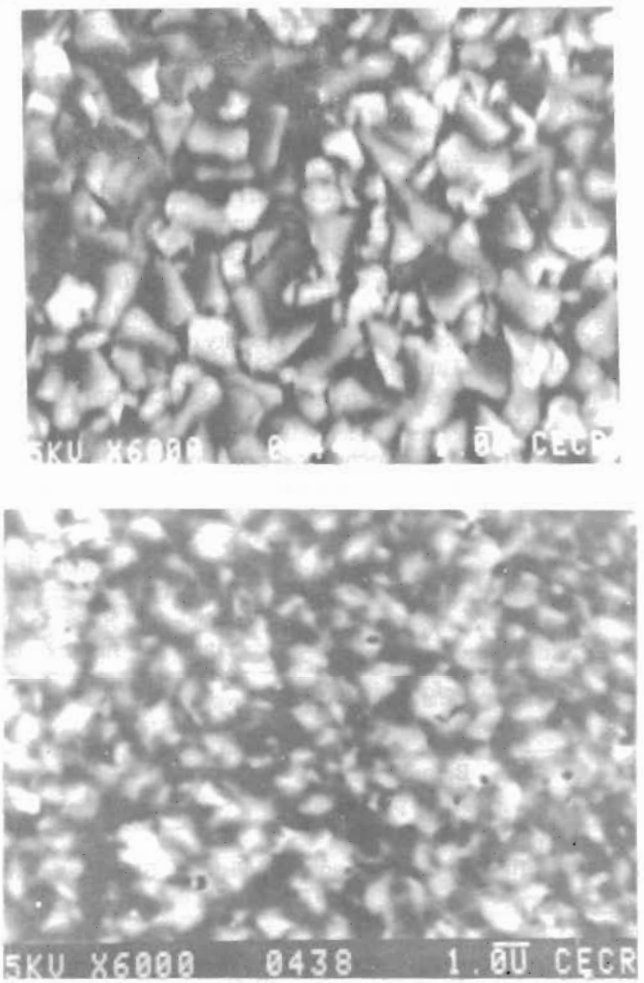
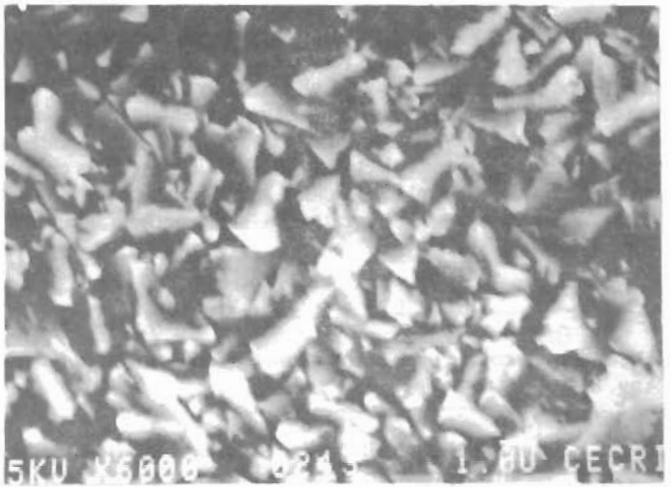


Fig.2: Surface morphology of the SnO_2 film prepared using rectified spirit-water medium (a) before and (b) after electrochemical polishing



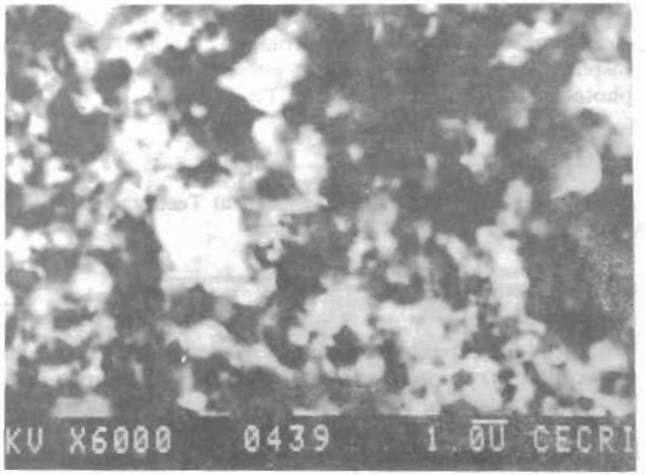


Fig.3 Surface morphology of the SnO_2 film prepared using dioxan-water mixture as solvent (a) before and (b) after electrochemical polishing

CONCLUSIONS

The low resistance SnO_2:F films prepared using $SnCl_2$ in 1:1 rectified spirit-water, when subjected to electrochemical polishing showed a reduction of ~57% in sheet resistance and an increase in transmission in the useful range of 500-700 nm. When 1:1 dioxan-water mixture was used as the solvent medium, no enhancement of transmittance was noticed on cathodic treatment. However, a decrease in sheet resistance was observed. Mechanical polishing was found to increase the surface resistance with negligible change in transmittance.

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