TRANSPARENT ELECTRODES BASED ON SPRAY DEPOSITED SnO_2

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Introduction

Spray deposition of transparent thin layer electrodes based on spraying of tin chloride solution onto hot substrate is an old and cheap method. In our previous work, we have studied the properties of layers deposited with addition of Sb and)or fluorine as dopants in layers prepared by spraying of either $SnCl_4$ or $SnCl_2$. We have observed that layers from the former are of P-type conductivity while the latter exhibited N-type conductivity. In accordance to it, the electrochemical behaviour of semiconductor electrodes of corresponding type.
The aim of this paper is the preparation and spectroscopic study of thin layers prepared from $SnCl_4$ doped with fluorine, copper, silver and antimony compounds.

Experimental

The spray deposition and methods of investigation were described elsewhere. The solution used for the deposition contained 3 ml of $SnCl_4$ in 15 ml of methanol.
Electrochemical properties of thin layers were measured in a solution containing equimolar amounts of ferrocene and ferricinium in $LiClO_4$ – PC aprotic electrolyte using Cd pseudoreference electrode.

Results and Discussion

The electrical properties of several layers are given in Table 1. The influence of dopant concentration (expressed in at. % to Sn) on the resistivity (□) is shown in Table 2. As we see, the best conductivity was found in the case of layers prepared from $SnCl_4$ doped by fluorine.

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Table 1 *Electric properties of various spray deposited layers of SnO_2.*

Precursor	Dopant	Resistivity ($\Omega/\square$)	Hall constant ($m^3A^{-1}s^{-1}$)	Concentration (m^{-3})	Type of conductivity
$SnCl_4$	-	20.92	2.14×10^{-8}	2.97×10^{26}	P
	F^-	0.203	5.91×10^{-9}	1.06×10^{27}	P
	Sb^{3+}	54.61	3.37×10^{-8}	1.85×10^{26}	P
	$F^- + Sb^{3+}$	10.79	8.65×10^{-9}	7.22×10^{26}	N
$SnCl_2$	-	2090	2.26×10^{-7}	2.76×10^{25}	N
	F^-	251.8	3.08×10^{-8}	2.03×10^{26}	N
	Sb^{3+}	423.5	1.63×10^{-7}	3.84×10^{25}	N
	$F^- + Sb^{3+}$	39.91	2.30×10^{-8}	2.72×10^{26}	P
Sputtered ITO	(In)	146	4.50×10^{-8}	1.39×10^{26}	P

The absorption spectrums in visible range are shown in Fig. 1 for several selected samples. Apparently, the undoped material is the most transparent one. The adsorption edge is shifted slightly by any doping and the absorption increases in the centre of the wavelength range without any marked maximums.

Table 2 *The influence of dopant concentration (expressed in at. % to Sn) on the resistivity.*

%	Fluorine	%	Antimony
0	117.6875	0	117.6875
4	51.75	0.1	27.26625
7	31.8	0.25	28.86375
10	54.8875	0.4	24.81375
13	61.6625	0.7	39.79875
		1	56.325
%	Copper	%	Silver
0	117.6875	0	117.6875
0.05	114.025	0.05	80.4625
0.1	185.1125	0.1	83.5
0.4	747.75	0.25	95.5
0.7	1915.375	0.4	130.3
1	10435	1	132.08

The electrochemical behaviour of the layers possessing opposite conductivities is shown in Fig. 2. Typical P – doped and N-doped materials exhibit voltammetric curves of a marked non-symmetry corresponding to the type of conductivity. A voltammogram of a platinum electrode is shown there for comparison.

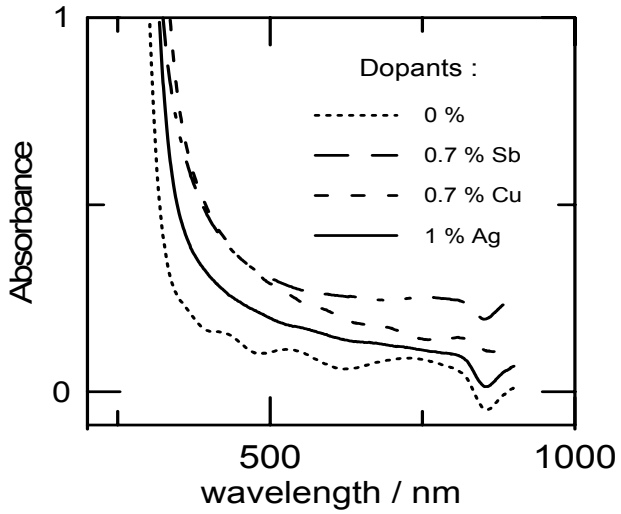

Fig. 1 *Absorption spectra of several layers of doped SnO_2*

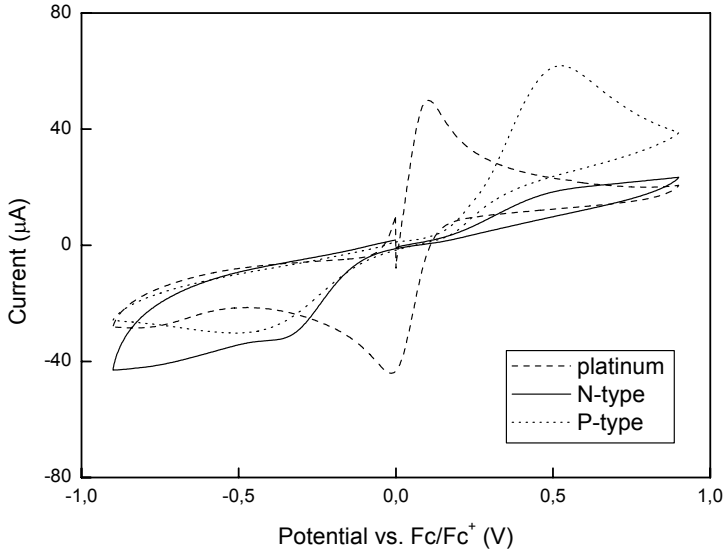

Fig. 2 *Cyclic voltammetry of ferrocene on different layers.*

Conclusions

The spray deposition is a useful method which offers the preparation of conducting layers based on SnO_2. Their physical and electrochemical properties can be modified by addition of suitable, thermally unstable metallic compounds and salts. Copper and/or silver doping increase the resistivity of the layers while antimony and fluorine doping increases cthe conductivity.

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