Sputtering of Thin Films on Flexible Substrates

Pavlik Rahnev[1], Silvija Letskovska[2], Dimitar Parachkevov[1] and Kamen Seymenliyski[2]

Abstract – **The aim of this work is to investigate the properties of thin film deposited on flexible substrates. The main instrument for experiment is high rate magnetron sputtering. For this purpose high vacuum modified installation B55 (Hoch Vacuum Dresden) is used. As substrates different kind of no organic (metal foil) and organic materials are used. The main parameters of films (resistive, semiconductor, dielectric) are described as deposited and after thermal treatment. The comparison between electrical parameters and composition, structure is done. The main applications of such thin films are in photo voltaic and thin film displays.**

Key words – **thin films, sputtering, flexible substrates, organic substrates.**

I. INTRODUCTION

In the last years there is an increasing interest of using flexible substrates in electronics. Usually the investigations are provided mainly in three directions:

- Materials for substrates [1];
- Technology for deposition of different films [2];
- Circuit application [3] ;
- Problems appearing in the time of technology processes [4].

The application of flexible substrates is usually in organic light – emitting displays [5, 6], thin film transistors [7-9], sensors [10, 11] and microelectronic modules [12, 13]. The advantages of polymers substrates are mainly in there multiple elastic deformation, easy mechanical shaping, wide range of polymer materials, low cost and est.

The use of polymer materials in integrated circuits is difficult because organic can not be included into the microelectronic processes. Polymers have low temperature stability and low resistance against concentrated chemicals which limited their application in integrated circuits.

It is clear that the choice of polymer substrate is very wide, the combination substrate and deposited films depends on the specific technology - method of deposition, equipment, parameters of the processes.

[1]Pavlik Rahnev – Technical College, Assen Zlatarov University, Y. Yakimov Str. 1, Burgas 8010, Bulgaria, E-mail: pavlikrahnev@abv.bg

[2]Silvija Letskovska - Burgas Free University, San Stefano 62, 8000 Burgas, Bulgaria, E-mail: silvia@bfu.bg

[1]Dimitar Parachkevov – Assen Zlatarov University, Y. Yakimov Str. 1, Burgas 8010, Bulgaria, E-mail: parashkevov@abv.bg

[2]Kamen Seimenliyski –Burgas Free University, San Stefano 62, 8000 Burgas, Bulgaria, E-mail: silvia@bfu.bg

The question in front of this work is to check the combination of different flexible substrates and different thin films deposited in one and same technological cycle as well as the electrical parameters of the films compared with common used quartz substrates.

II. CHOICE OF MATERIALS

2.1. Flexible substrates.

As it was described above there is a wide choice of materials used in the technology – stainless steel (metal), polymers (polyimide, polyester, Teflon, polystirol) and flexible special glass based materials.

The main parameters of the substrates are directly connected with properties of the deposited films and prepared circuits:

- Structure of the films;
- Parasitic capacitance;
- Power dissipation.

TABLE I
SUBSTRATE MATERIAL

Parameter	Stainless steel	Teflon (Du Pont Trade Mark)	Polyimide	Polyester	Sital (CT-50-1)
R_{iz} (ohm)	-	$>10^{10}$	$>10^{10}$	$>10^{9}$	$>10^{9}$
ε (-)	-	2-3	2-3	2-3	5
λ (W/mK)	30	1.2	1.5	1.5	6
T_{max} (^{0}C)	>1000	150	150	150	400

From Table I is seem that polymer materials are good insulators, but with low thermo conductivity.

This will cause problems in device and circuit with high power dissipation.

The sizes of the experimental substrates are as follows;

- Thickness – 0.2÷0.5 mm;
- Linear dimensions – 60x48 mm (2"x2") as a standard for glass and ceramic substrates.

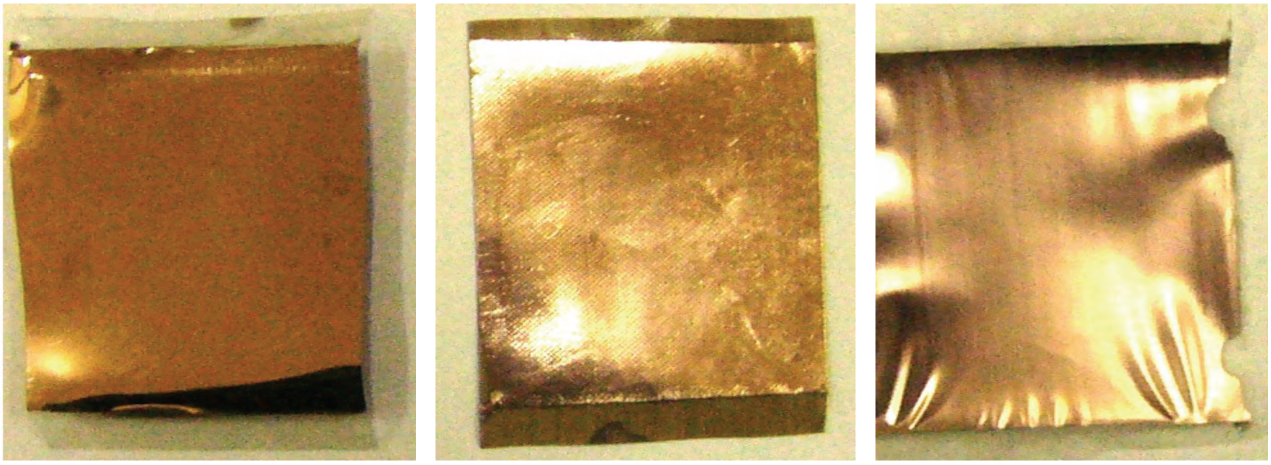

Fig. 1. Organic substrates after thermal evaporation.

2.2. Materials for deposition.

For experimental work four different materials are chosen:

- Cu - as a good conductor;
- NiCr – typical resistive film;
- Si – typical semiconductor;
- SiO_2 – usual dielectric in MOS integrated circuits.

To estimate the parameters of the deposited film sheet resistance (Rs) is used.

III. METHOD OF VACUUM DEPOSITION AND MATERIALS

2.1. Thermal evaporation.

The evaporation in high vacuum is commonly used technology for thin films because is has simplicity and it is well known in practice. In the same time thermal evaporation has several disadvantages and difficultness such as:

- Evaporation of W, Pt, ta, Mo;
- Evaporation of alloys;
- Evaporation of compands;
- Deposition on unstable thermally organic substrates (Fig. 1).

From Fig. 1 is clear that some of the polymer materials lose their form, flatness, that is why evaporation is not suitable some organic materials.

3.2. Sputtering of thin films.

As it is clear from above the only universal method of deposition is sputtering technique.

For the provided experiments the modified high vacuum installation B55 (Hoch Vacuum Dresden) is used (Fig. 2).

The advantages of this machine are:

- Four sputtering targets;
- Rotation of substrates holders;
- Possibility of heating or cooling of substrates.

The main technology parameters are:

- Final vacuum $p < 0.5 \times 10^{-2}$ Pa;
- Argon pressure $p_{Ar} \approx 10 \div 40$ Pa;
- Sputtering voltage $300 \div 700$ V and Power ≈ 100 W.

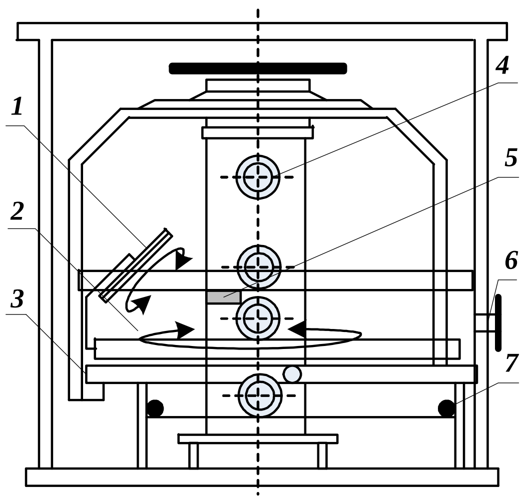

Fig. 2. Vacuum installation B55 with magnetrons.

1 - Substrate holder; 2 - Chamber heating/cooling; 3 - Rotating table; 4 – Sputtering target; 5 – Sensor for Rs; 6 – Vacuum meter; 7 – Infrared heaters.

IV. PREPARATION OF SIMPLE AND RESULTS.

The deposited materials used for the experiments have very wide range of specific resistance.

That is why for estimation sheet resistance Rs=ρ/d is better to be used.

The ratio n=L/w can change from n=100 for good conductor (Cu), n=1 for NiCr and n=0.1 for semiconductor (Si).

The final step in sample preparation is forming of the resistor patterns. For this conventional wet etching or through mask deposition are used.

Finally, the samples have topology and sections are given in Fig.3.

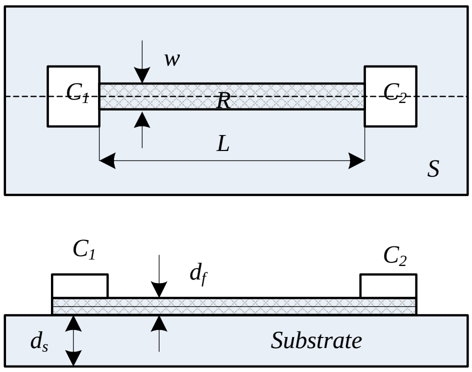

Fig. 3. Topology and cross section of samples.

The results for Rs are shown in Table II. The Rs for different materials are compared with Rs on glass substrates.

TABLE II
COMPARISON OF RS ON GLASS AND POLYMER SUBSTRATE

Substrate	**Rs (omh/sq)**		
	Cu	NiCr	Si
Glass	0.10	150	2000
Polymer	0,12	170	3000

It is clear from Table II that sheet resistance on polymers is higher compared with glass substrate. It could be a result of structure changes (defects) and some implantation into the soft organic surface.

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