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NON-LINEAR BEHAVIOUR IN SILVER – ARSENIC SULFIDE SYSTEM

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Non-linear phenomena have been observed in the Ag(paint)-As_2S_3 system. This behaviour is useful in rectifier devices and in dynamical switching devices based on chalcogenides.

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1. Introduction

There is a continuous interest in switching devices based on chalcogenide materials [1]. An important contribution to the science of amorphous chalcogenide field is the discovery of the anisotropy in amorphous chalcogenide films [2]. The structural anisotropy occurs only between the directions between the film plane and normal to it. At the same time the structure and physical properties film plane are isotropic. It is obvious from the experimental results that the optically active structural units are highly unstable with respect to the heat treatment and the time after preparation. This is shown by the irreversibility of the optical anisotropy and its spontaneous relaxation in the dark at room temperature. It is quite naturally to expect various changes in the physical properties of the samples. The whole structure of the films is quite different from the bulk structure. Few informations are available on the atomic-scale structure of the films.

We have evidenced in the junction of silver paint with As_2S_3 a strong non-linear effect in the electrical characteristics.

2. Experimental

2.1. The non-linear system.

Firstly a copper film (~ 200 nm) in thickness has been deposited by magnetron sputtering on a carefully cleaned glass plate. In the following step a thin arsenic sulphide film (~ 1.2 μm) has been deposited on the copper electrode by thermal evaporation. As a final step a small disk (1 mm in diameter) of silver paint (SPI #5001) was deposited on As_2S_3. The system was leaved in a clean place at the room temperature to be slowly dried. Then the system has been illuminated for 60 minutes with light emitted by a halogen lamp (P=100 W) model Alpha-Optika CL-01 cold light generator with CL-11 double flexi arm, which containts sub-gap light as well as higher wavelengths.

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2.2. The electrical measurements.

The configuration of the heterojunction Ag(paint)-As_2S_3 was investigated with the help of a Keithley 2611A System SourceMeter with two tungsten tips [3]. One tungsten tip was attached to the copper electrode and the other directly to the illuminated arsenic sulphide layer or on top of silver electrode.

Firstly the measuring of the I(U) characteristics of the device was made in the absence of silver. One tungsten tip was attached to the copper electrode and the other directly to the illuminated arsenic sulphide layer. The results are shown in Fig. 1a. The I(U) characteristics are symmetrical and the switch is stable in time and resists to many switches.

If the silver paint is added, the characteristics strongly change. The curves become asymmetrical and a hysteresis loop appears on the side related to a negative polarization (Fig. 1b). On the positive side of the characteristic a much weaker hysteresis cycle is visible.

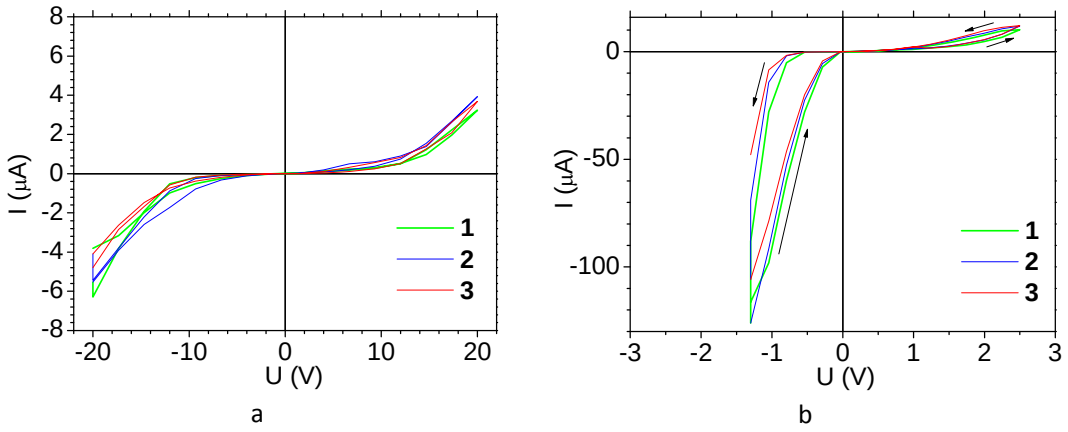

Fig. 1. The I(U) characteristics of the chalcogenide systems:
a. As_2S_3 / Cu, b. Ag (paint) / As_2S_3) / Cu

3. Discussion

The strong and non-linear characteristic of the configuration Ag (paint)-As_2S_3-Cu is challenging. The behaviour with low current in the forward bias and strong current (highly conducting state) in reverse bias, is related to the junction between silver paint and amorphous chalcogenide. The hysteresis loop can be due to the fine structural arrangements in the oriented layers. Thus, during the electrical field action it seems that the energy related to the structural arrangement is released or added as a function of the applied electrical field. In the presence of an electrical field the ferroelectrical order may be induced and a cycle is obtained. The dipoles that appear at the junction Ag-As_2S_3 determines the appearance of the electrical hysteresis in the junction. In the positive part of the graph (Fig.1b) the hysteresis is weaker. The change of the structure by intervention of silver is similar to phase change which is reversible in relation to the applied electrical field.

We must remark that double cycles are obtained for several degrees above the Curie temperature in $BaTiO_3$ [4]. Multiple cycles obtained on the same titanate are characteristic of substances that may exists in several ordered states: in the presence of the measurement field and close to the temperature of transition of one form to the other, a cycle is obtained that corresponds to the lower temperature phase for weaker fields: as an extension of the basic cycle ends, there are two other satellite cycles on the side of higher temperature phase [5].

In other systems, as e.g. in the PbS/PZT system [6], similar behaviour is present. The structure can be considered as a serial connection of two capacitors, one is formed by the top

ultrathin PbS layer, the other is formed by the thicker porous PZT matrix doped with PbS in the pores.

The non-linear element based on hetero-junction Ag-As_2S_3-Cu exhibit different conduction behaviour in direct and reverse polarization. This very strong non-linearity makes the system useful for applications as a rectifier. By using the two conducting states a dynamical switching device is possible to be built.

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