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Light- and voltage-controlled capacity of Cu-As₂S₃-Cu thin film cells for photodetection

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Amorphous As₂S₃ thin films have remarkable electrical and optical properties, which make them solid candidates for a variety of applications and keep up the scientific interest to study them, even after decades from the first results [1]. This composition has its optical absorption edge around the 500 nm, and shows a high optical transmission in the infrared (IR) and mid-infrared (MIR) spectral domain [2]. From structural point of view, a-As₂S₃ has a quite sparse network, able to accommodate certain ionic or atomic species [2].

The behaviour of thin a-As₂S₃ film deposited onto a thin Ag layer, and illuminated with 532 nm wavelength green laser light has already been studied. These bi-layer structures change their structural and optical properties upon illumination with this monochromatic green light [2, 3]. In many technological solutions there is a tendency to substitute silver with copper.

An example is the *mixed ionic-electronic conduction* or *MIEC*-type materials, which are constituents of phase-change memory (PCM) structures. Copper is known to be less diffusive than silver, so it is better controllable in the fabrication process of microelectronic structures and devices. J.W. Burr and co-workers discuss this problem in a review dedicated to access devices for non-volatile crossbar memory arrays [4].

The structure of the a-As₂S₃ thin films has been extensively studied and modeled during the past decades [5-12], and it is considered now being an aggregate of building units and fragments at molecular level, which makes it to resemble to the molecular glasses. Thus, we assume the hypothesis, according to which the Cu⁺ ions, which may form along the Cu-As₂S₃ interfaces, will interact mostly along the interfaces of these structural building units [13].

Microstructural properties can be studied experimentally by broad-band *dielectric spectroscopy* (DS) which is equivalent to the impedance spectroscopy (IS). This is a nondestructive method which allows distinguishing between the different charge transport mechanisms or relaxation processes [14-17].

In order to see the behaviour of the Cu/As₂S₃ interface as well as that of the a-As₂S₃ thin film from between the bottom and top Cu electrodes, the sample has been contacted with thin Cu wires to larger sample support, provided with millimeter sized gold contacts on alumina surfaces. For these DS measurements we have used, a high resolution *Alpha analyzer* (Novocontrol) equipment to measure the complex impedance, $Z(\omega) = Z'(\omega) + i Z''(\omega)$. The measurements have been performed in the frequency range of 10 – 10⁶ Hz. The test signal had an amplitude of $u = 20$ mV.

Considering that the amorphous As₂S₃ thin films have their structure built up from several kinds of building units at molecular level [5-12], similar to the molecular glasses, it seems plausible to understand the above electrical measurements results, that in this heterostructure we have a superposition of electrical charge distribution from the surface of the structure (from the contacts), as well as from the many internal interfaces of the structure. This charge distribution is influenced also by the polarization voltage applied on the heterostructure's contacts.

Based on these results so far, we understand that the heterostructure's response to the testing signals used, is mainly of electronic nature, with a contribution of almost free Cu⁺ ions coming from the Cu/As₂S₃ interface. We also noticed that the external voltage and the ambiental light have opposite effects on the resistance as well as on the capacity of the heterostructure: they both increase, if external voltage is applied, but they decrease upon the presence of light shining on the structure. In transitory regime the profile of the resistance change in time shows a very large characteristic time, while the capacity changes very quickly, almost instantaneously. These features may support useful applications, and these thin film cell structures might perform e.g. as photodetectors.

Acknowledgements

This work has been supported by the Romanian Ministry of Education and Research through the Project PN-16480102.

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Formation and properties of glasses in the system of BaCl₂-Bi₂O₃-TeO₂

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Glass formation in BaCl₂-Bi₂O₃-TeO₂ was investigated by melting of starting mixtures in open silica tubes in flame. Chemically pure (purity 3N+) BaCl₂, Bi₂O₃ and TeO₂ were used as starting compounds. Large glass forming area is located near TeO₂-rich corner of the ternary diagram and reaches up to 30 BaCl₂ – 30 BiO_{3/2} – 40 TeO₂ composition. Bulk samples were obtained by pouring the melt in brass mold; the solidified glasses were annealed at the temperature near their glass transition temperature (T_g) and then slowly cooled down to room temperature. The T_g of these glasses determined by differential scanning calorimetry at heating