

Glassy quaternary chalcogenides thin films in chemical and optoelectronic transducers

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Abstract: Quaternary chalcogenides are complex either crystalline or vitreous materials, four-elements containing at least one chalcogen (S, Se, Te) combined with other elements, offering tunable electronic, optical, thermal and gas sensing properties. They are of great interest for photovoltaics [1], thermoelectricity [2], optoelectronics [3] and development of chemical transducers [4]. In the present paper an extensive review of the electronic, optical and gas sensing properties of thin films of the quaternary glassy chalcogenide materials is presented and discussed, alongside with the own experimental investigations related to As-Te-Ge-S and Ag : (As-S-Ge) quaternary systems. The glassy thin films of the As-Te-Ge-S system are considered in terms of the experimentally observed pronounced surface phenomena, which largely predetermine usefulness in the development of gas transducers [4]. The synthesis technology of quaternary chalcogenides $\text{As}_2\text{Te}_{130}\text{Ge}_8\text{S}_3$, $\text{As}_2\text{Te}_{13}\text{Ge}_8\text{S}_3$ as well as the growth of thin films based on them is briefly described. The electrical DC and AC conductivities of these films have been studied in detail dependent on electrode materials, temperature, value and frequency of applied electric field. The deep analysis of spectral distribution of impedance allowed us to establish the main mechanisms of charge transport, which actually occur to depend on the physical and chemical state of the specimen surface. The obtained results clearly demonstrate that the studied chalcogenides can serve as a basis for the development of excellent NO_2 transducers, operable at room temperature by varying the impedance or capacitance, even under conditions of increased humidity of the ambient air with carbon dioxide impurities. As for Ag: (As-S-Ge) quaternary, they exhibit one of the most remarkable properties of chalcogenide glasses, which consists in the possibility of a transition to ionic mechanism charge transport and further to a metallic one. The superionic solid electrolytes based on pseudo-binary glasses $(\text{GeS}_4)_x(\text{AsS}_3)_{1-x}$ from the intermediate phase (IP) of the As-S-Ge ternary have been fabricated via photo-dissolution (PD) of Ag, and further used as the active parts of the programmable memory cells (PMC). As some compositions from the IP of the studied glassy system exhibits a strong self-organized backbone, the ionic conductivity of solid electrolytes based on them sharply increases that allows the improvement of operating parameters of programmable metallization cells, based on the same.

Keywords: Quaternary chalcogenide glasses, thin films, optoelectronics, chemical transducers.

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