Brief information about the project

Name of the project	AP14871061: «Structure and electronic processes in semiconductor films with phase memory, modified by simultaneous incorporation of different chemical nature impurities», 0122PK00882.
Relevance	Scientific and practical recommendations for obtaining a promising competitive material based on modified $Ge_2Sb_2Te_5$ (GST) CGS thin films for efficient multilevel recording of electrical and optical information. As a result of the project, new scientific results will be obtained that are of great fundamental importance for the development of the physics of materials with phase memory. At the same time, the scientific potential of young scientists involved in the project will increase significantly. Thus, the implementation of the project will provide a contribution to solving urgent problems of socio-economic and scientific and technical development of the Republic of Kazakhstan.
Purpose	To reveal the regularities of structural transformation and electronic processes during the glass-crystal phase transition in chalcogenide semiconductor films modified by the simultaneous incorporation of impurities of different chemical nature (nitrogen and bismuth) to explore the possibility of effective use of these materials for optical and electrical information recording.
Objectives	*Task 1.* Obtaining of bismuth-modified GST thin films with an amorphous structure (a-GST<Bi>) by RF magnetron co-sputtering. Study of the phase composition of films in the amorphous and crystalline states and the transformation of their structure upon annealing and laser irradiation. *This will make it possible to reveal the optimal Bi concentration in α-GST<Bi> films, which ensures the preservation of the composition of the films under the transition from the amorphous to the crystalline state.* *Task 2.* Obtaining by RF magnetron sputtering of nitrogen-modified thin GST films with an amorphous structure (a-GST<N>). Study of the structure, phase composition, electronic properties of films in the amorphous and crystalline states. Study of the transformation of the structure of α-GST<N> films upon annealing and laser irradiation and the effects of switching and memory. *This will make it possible to obtain data on the temperature of the phase transition of the α-GST<N> film structure to the crystalline state, the transformation of the α-GST<N> films structure under annealing and laser irradiation, the parameters of the switching and memory effects and to reveal the optimal nitrogen concentrations in the films for efficient multilevel recording of information.* *Task 3.* Obtaining thin GST films, modified simultaneously with nitrogen and bismuth impurities, with an amorphous structure (a-GST<Bi+N>) by the RF magnetron co-sputtering method. Study of the structure and electronic properties of films in the amorphous and crystalline states, the transformation of their

	structure upon annealing and laser irradiation and the effects of switching and memory in these films. Analysis of Bi and N impurities influence on the energy spectrum of the electronic states in α-GST films. Development of scientific recommendations for obtaining α-GST<Bi+N> films for effective recording of optical and electrical information. *This will make it possible* ***for the first time:*** *to obtain data on the effect of bismuth and nitrogen on the temperature of the phase transition of the α-GST<Bi+N> film structure to the crystalline state, the data on the transformation of their structure upon annealing and laser irradiation, the parameters of the switching and memory effects and to reveal the optimal composition of α-GST<Bi+N> films for efficient multilevel optical and electrical recording of information. The analysis of obtained results will make it possible to reveal the physical foundations of the combined effect of impurities of different chemical nature on the energy spectrum of electronic states in semiconductor materials with phase memory.*
Expected and achieved results	Scientific and practical recommendations for obtaining a promising competitive material based on modified $Ge_2Sb_2Te_5$ (GST) CGS thin films for efficient multilevel recording of electrical and optical information. As a result of the project, new scientific results will be obtained that are of great fundamental importance for the development of the physics of materials with phase memory. At the same time, the scientific potential of young scientists involved in the project will increase significantly. Thus, the implementation of the project will provide a contribution to solving urgent problems of socio-economic and scientific and technical development of the Republic of Kazakhstan.
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List of publications with links to them	1. A.S. Zhakypov, Zh.K. Tolepov, G.A. Ismailova, S.L. Peshaya, M.N. Ualkhanov. Changes in the structure of nanosized amorphous $Ge_2Sb_2Te_5$<Bi> films under laser irradiation // BULLETIN EKTU. – 2022, Vol. 3, P. 104-111. DOI 10.51885/1561-4212_2022_3_1041. 2. K.N. Turmanova, G.A. Ismailova, Zh.K. Tolepov, S.L. Peshaya, M.N. Ualkhanov. Influence of the size effect on the structure and optical Properties of thin GST films in amorphous and crystalline states // BULLETIN EKTU. – 2023, Vol. 1, P. 234-240. DOI 10.51885/1561-4212_2023_1_234. 3. O.Yu. Prikhodko, G.A. Ismailova, K.N. Turmanova, A.V. Kolobov, Zh.K. Tolepov, A.S. Zhakypov, S.L. Peshaya, A.S. Kapanov, S.Ya. Maksimova. Structure and properties of $Ge_2Sb_2Te_5$ thin films modified with silver and bismuth impurities / Proceedings of the international conference “Amorphous and microcrystalline semiconductors” (AMS13). -2023, Russia, St. Petersburg. – 2023, p. 59. www.ioffe.ru/AMS/AMS13ю. 4. O.Yu. Prikhodko, G.A. Ismailova, A.S. Zhakypov, A.V. Kolobov, K.N. Turmanova, R. R. Nemkaeva, S.Ya. Maksimova, Zh. K. Tolepov, S. L. Peshaya. Structural transformation of thin $Ge_2Sb_2Te_5$<Ag> films produced by ion-plasma co-sputtering under laser irradiation // Journal of Electronic Materials. -2023. ORIGINAL RESEARCH ARTICLE, https://doi.org/10.1007/s11664-022-10204-w.
Patents	-
Video	VID-20231010-WA0070.mp4