Long-Term Radiation-Induced Improving of the Mechanical Properties in As_2S_3 Glass Probed by Nanoindentation

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The results of investigation of the mechanical properties (hardness and elastic modulus) in the unirradiated and γ-irradiated g-As_2S_3 glass (g- for glassy) using nanoindentation technique with an ultra nano hardness tester (UNHT), developed by CSM Instruments (Switzerland) [1], are reported for the first time. The main improvements of the UNHT compared to the conventional nano indenter (or NHT) design are a new tip and reference fixing system introduced in the ultra indenter head and the use of active top referencing (very low loads applied by the reference, less than 1 g), the possibility of depth and load measurements, one order less noise level, etc.; they allow us to make measurements using the UNHT with high performance.

The hardness and elastic modulus (with a Poisson ratio of the specimen of 0.29 for g-As_2S_3 [2]) values were calculated in the load-depth measurements by the method of Oliver and Pharr [3,4] with the software of CSM Instruments for the UNHT [1]. Due to the radiation-induced oxidation effect connected with appearance of As_2O_3 (arsenolite) crystals and S phases at the surface of g-As_2S_3, forming a white oxidized layer visible to the eye [5], the surface morphology of the investigated γ-irradiated sample is also examined using MIRA (Tescan) field emission scanning electron microscope with EDS detector.

It is established that the γ-irradiated g-As_2S_3 with average energy of ^{60}Co γ-quanta 1.25 MeV and accumulated dose 2.41 MGy, measured 10 years after γ-irradiation, exhibits increasing the hardness and elastic modulus values compared to the unirradiated material in the range of 200-1600 nm indentation depth. The observed long-term radiation-induced improving of the mechanical properties in g-As_2S_3 is practically the same for both irradiated samples with and without oxidized layer which was removed by washing and polishing procedures.

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