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# $A^{V}B^{VI}C^{VII}$ Semiconductor Materials for Sensing Applications

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**Summary:**
One-dimensional crystalline materials like SbSI from $A^{V}B^{VI}C^{VII}$ are attractive for application in different mechanical, electrical, optical sensing structures, while a number of two-three component glasses are excellent for patterning. In this paper we present the results obtained by investigations on interconnections between thin layer technology conditions, substrate materials and thin film structures in the direction of obtaining surface structures with different dimensions, applicable for spot- or two-three dimensional sensitive elements.

**Keywords:** Advanced materials, nanostructures, technology.

## Introduction

There has been a growing interest in one-dimensional crystalline materials and structures, made on their basis due to the intensive developments in electronics, photonics towards nano-sized functional elements, enhanced parameters and applicability. Materials from the $A^{V}B^{VI}CV^{II}$ system, like SbSI, BiSI are crystalline while AsSI is usually amorphous glass, all of them are wide-band gap semiconductors photosensitive in 500- 700 nm spectral range. Materials from As-S-I system are amorphous, glassy, with most popular $As_2S_3$ composition used for very efficient amplitude-phase optical recording media [1,2]. The last may be combined with gold nanoparticles to increase efficiency and incorporate plasmonic effects when the structure is illuminated by resonant wavelength laser beam. An example of laser induced interference pattern on such a structure is presented on Fig.1.Iodine in ternary glass composition may decrease the stability of layers for optical recording, but some very stable, needle-like crystalline elements containing compositions are available. Especially, crystalline SbSI, BiSI are attractive due to the pronounced unidirectional, needle-like structure. SbSI is of main interest due to fact that it is ferroelectric , with the temperature of the ferroelectric phase transition close to 295 K. [3].

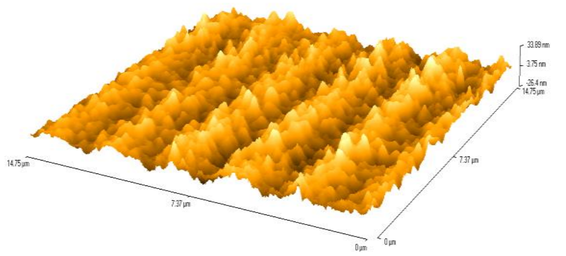


*Fig.1. Surface relief recorded by laser beam on $As_2S_3$-AuNP layer*

Such materials are attractive for fundamental research as well as prospective for applications in the fields of ferroelectricity, microelectronics and optoelectronics, as microcapacitors, sensors, solar cell and ultrasound devices [4,5, 6].Continuing our researches in thin film technology of multicomponent chalcogenide semiconductors we performed investigations on interconnections between thermal deposition technology, substrate structure including gold nanoparticles, thermal and e-beam, laser treatment with formation of one-two dimensional structural elements on the surface of separate layers or combined structures.

## Technology and methods

Thermal evaporation in vacuum, mostly in special small-volume cells was performed from previously crashed $As_2S_3$ glass (if optical recording is required on the final structure) or single-crystalline, 5-10 mm long or crashed SbSI or BiSI (see Fig.2), what enables fast evaporation-condensation in thin layers on the surface of different substrates. Among the simplest were pure silica glass and silica glass covered by nanometers-thick gold layers, or gold nanoparticle-islands of 100-200 nm size (see Fig.3). More complex element may include $As_2S_3$ sub-layer as well. Optical microscope, dual beam scanning electron microscope type Thermo Fisher Scientific-Scios2 (FIB-SEM, Waltham, MA, USA), Horiba LabRam Raman spectrometer, AFM with green laser excitation were used for investigations of structure, it's transformations induced by annealing, laser and e-beam treatments.

*Fig.2. Crashed SbSI crystals used for thin film thermal deposition.*

Micrometer-thick SbSI layers were deposited on pure silica-glass substrates or on the glass, preliminary covered with a layer of gold nanoparticles with average dimensions in 30-100 nm range (see Fig.3).

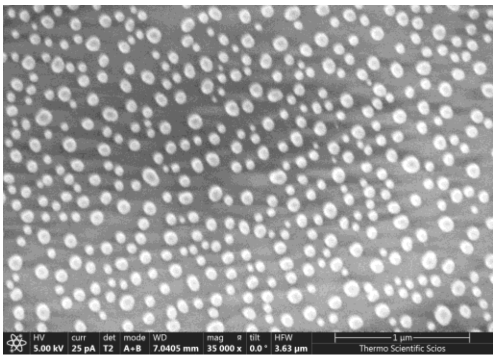


*Fig.3. AuNP layer on the glass substrate.*

The next step was the SbSI layer deposition.

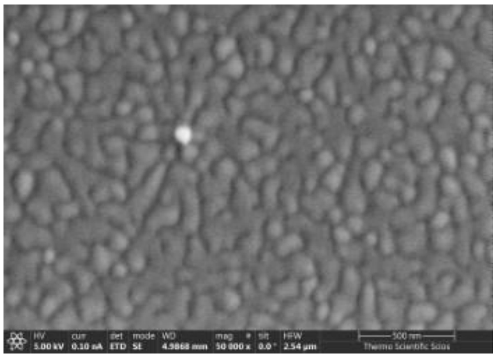


*Fig.4. SbSI layer deposited on AuNP covered substrate.*

## Results

The main result of this experimental cycle consists in establishment of experimental conditions for rather simple fabrication of multicimponent, multifunctional thin layer structures from $A^VB^{VI}C^{VII}$ system, which may be used for optical, electrical, mechanical and thermal sensing elements creation, with special accent on possibilities of focused laser-beam recording point-, line-, or two-dimensional structures, photonic crystals. Presence of gold NPs with resonant plasmon excitation in the 510-600 nm spectral range enhances these processes, as it was shown by combined focused laser beam recording - Raman spectra measurements.

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