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The modification induced by UV radiation in spherical microlenses made of glassy arsenic sulphide

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Spherical arsenic chalcogenide glass microlenses have been attached to optical fibers. The assembly was subjected to UV-radiation for different time intervals in different conditions of temperature. As a consequence, the focusing of the beam changes due to the modification of the refractive index, and of the structure, induced by photo-melting followed by crystallization. In the same time for high irradiation times the habitus of the lens changes into a prismatic one due probably to photomelting of the glass accompanied by a crystallization process.

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The application of optical fibers in communications is now under intense development. For advanced applications low cost optical passive devices are needed: switches, splitters, multiplexors, etc. The beam focusing is of high interest [1,2]. The behaviour of the lens, especially the change in shape and, in general, of the morphology under high light intensity is very important for the stability of the optoelectronic system during working cycle.

The influence of light illumination on the morphology and structure of amorphous and trigonal selenium has been investigated by Poborchii et al. by optical microscopy and micro – Raman spectroscopy in [3]. They demonstrated the athermal origin of photomelting of selenium.

The light irradiated As_2S_3 film has been shown to exhibit photofluidity as shown by Hisakuni and Tanaka in [4] and anisotropic deformation [5].

Yu – Cheng Lin et al. in [6] developed a compact – size D lens for fiber collimator for fiber communication and microscopic devices.

We have produced micrometer size lenses made of chalcogenide glass (As_4S_4) based on a patented procedure [7-9]. These lenses have been fixed to the end of glass optical fiber by special optical glue of type F-65 (lens bond) with refractive index 1.55 and T_g~100°C. Before attaching the lens the optical fiber was cut and polished with a special polish kit. Fig. 1 shows two configurations with the corresponding dimensions of the optical fiber and microlens.

A visible pen-laser diode (VSPOS, λ = 650 nm) has been used as a light source.

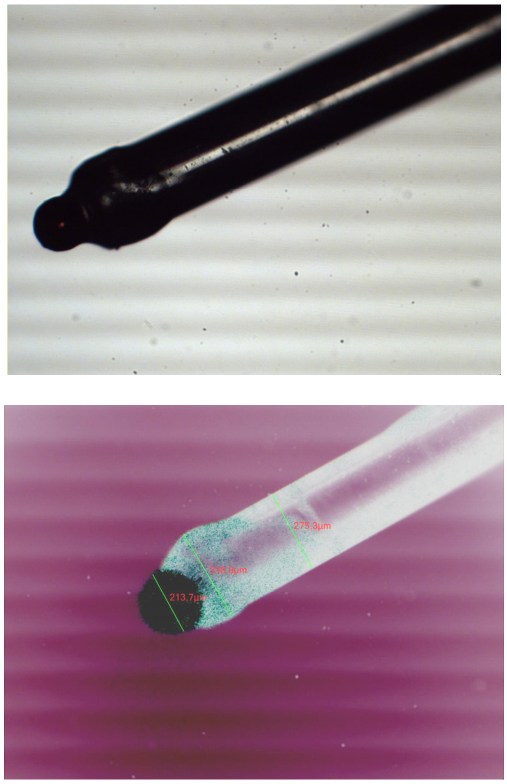

Fig. 1. a) Chalcogenide microlens glued on the optical fiber b) System dimensions.

The application of a laser diode beam lead to a dispersion of the beam in front of the lens. This is due to high refraction index of the lens (2.43) and the small curvature radius. The focusing point is thus situated inside the lens. Figure 2 shows the top of the optical fiber with the spherical lens glued on it, illuminated by the laser-diode beam.

It is remarkable the absence of any focusing effect of the chalcogenide microlens, in front of the system. Only scattering of light is evidenced.

Fig. 2. The scattering of the transmitted light by spherical microlens attached to fiber. The fiber head with the lens was irradiated in the beam of an ultraviolet (UV) lamp under the condition: a) 5-7 cm distance, temperature 52 °C released by the UV beam, b) 2.5 cm distance (100 °C in the beam at the position of the microlens).

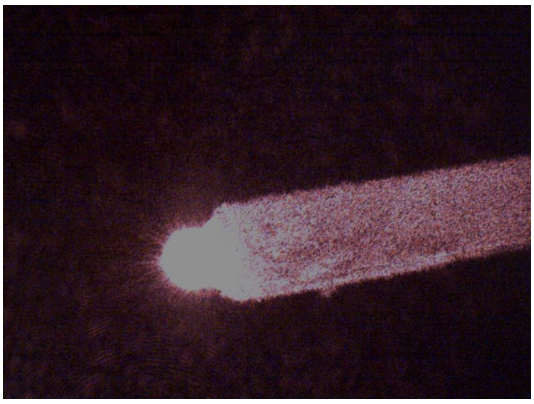

Fig. 3. a) The hexahedral shape of the microlens after the irradiation process. b) The focusing of the beam through the hexagonal microlens (at the edges the light seems to be more concentrated).

After irradiation the system was tested for light transmission. The micrographs taken before and after irradiation have been recorded in a Medline microscope provided with CCD camera XLI. Fig. 3 a and b show the results. Fig. 3a shows the lens profile after irradiation. Fig. 3b evidences the focusing of the light beam at the front of the lens, due to the change of the structure of the microlens.

The image of the chalcogenide microlens after treatment in conditions b shows a surprising result. The lens takes a hexagonal profile that indicate a possible crystallization of the lens. (Fig. 3a).

After connecting the fiber to the laser-pen source, the light is scattered by the lens with stronger emission at the edges of the lens.

Fig. 4. The natural habitus of the realgar crystal (originating from Perou) (the realgar, As_4S_4 is red, the yellow concretions are orpiment – As_2S_3; the facets are octogonal).

The regular morphology of the spherical microlens after UV treatment is probably due to photocrystallization of the amorphous chalcogenide microsphere attached to the end of the fiber. Figure 4 shows an example of crystalline habitus of realgar, on a case of a mineral sample originating from Perou. The theoretical prismatic habitus of the monoclinic crystal of realgar is shown in Fig. 5. Large facets (with (010) orientation), of octagonal morphology are similar to those of the natural crystals [10] (Fig. 4) and to the experimental profile of the UV irradiated microlens.

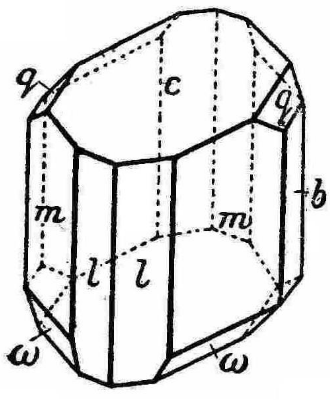

Fig. 5. The theoretical habitus of the prismatic realgar crystal. c(001), m(110), l(210), b(010), q(011), ω(111).

Further studies, especially electron diffraction will give the possibility to explain what happened in the microlens during ultraviolet irradiation. If a well oriented single crystal was obtained on the top of the optical fiber, then, the crystal optical anisotropy could be used in practical applications for beam splitters or even multiplexors. The restructuring of the chalcogenide glasses by electron beam irradiation [11] could be an other source of potential applications by exploiting the interaction light-chalcogenides glasses.

In conclusion, the combination of the UV irradiation and thermal heating could produce profound transformation in the spherical chalcogenide microlenses, accompanied by photo-thermo-crystallization. New applications in optoelectronics are thus envisaged.

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