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Technical note

MICROSPHERES, PLANOCONVEX MICROLENSES AND OPTICAL FIBRES BASED ON GLASSY As_2S_3

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Microspheres and planoconvex lenses (50 ÷ 400 μm in diameter) based on glassy As_2S_3, an important infrared material, have been produced by a special flame melting technique. Glassy fibres of 45 μm in diameter, with the length of 10-20 cm have been drawn from melt. The morphological properties of these optical elements have been investigated.

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1. Introduction

The chalcogenide glasses exhibits a variety of photoinduced phenomena that have been used in applications [1-10]. Photon-mode phenomena as photo-induced refractive index changes and photo-doping have been used for producing optical components, as e.g. grating, waveguides and microlenses [11-13]. Micro-optical lens lets produced by photo-expansion in chalcogenides have been firstly reported by Ramanchandram et al. [14]. Saitoh et al. [15,16] reported a microlens attached onto fibre ends, which is fabricated using a photolithographic technique, i.e. light illumination and successive etchings. As_2S_3 films and He-Ne lasers are used for the fabrication. The laser light is coupled into and propagated in mono-mode optical fibres. The other end is covered by a chalcogenide film. Then, the light induces specific photostructural transformations in the film, and a microlens is formed. In this process, the microlens is automatically and accurately positioned on the fibre core. Selective etching of chalcogenides and its application for fabrication of diffractive optical elements have been reported by Vlcek et al. [17]. The possibility to use chalcogenide glass as a photoresist in high resolution lift-off photolitography, and the fabrication of gratings in As-Se-Te films have been demonstrated by Veinguer et al. [18]. The possibility of getting complex lenses in chalcogenide glasses by moulding, gives a great flexibility to design high performance and low cost optics for thermal imaging [19].

We have tried to produce separate microlenses to be coupled with the fibre ends using a glueing procedure. A new technique for producing microlenses has been developed and the results are reported. A simple drawing procedure for getting optical fibres with the diameter situated in the micrometer range, and based on As_2S_3, is outlined and the results are reported.

2. Experimental

The flame melting method was developed by us with the purpose to fabricate microlenses based on As_2S_3. The method consists in the following steps:

Firstly, fine As_2S_3 powder was obtained by milling a chunk of As_2S_3 glass in a porcelain mortar. The powder was sieved and a minute fraction was used in the experiments.

Secondly, the fine powder was sprayed in the direction of the gas flame. The yellow colour of the flame ensures a moderate temperature necessary to melt the microparticles of As_2S_3, during their displacement in air. After traversing the flame region the melted particles fall into a vessel

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containing distilled water. In the case of high flame temperature the smallest particles are evaporated instantaneously and a green-yellow smoke is released.

During the flight through the flame every particle melts and, due to the surface tension, the drop takes the spherical shape. After immersion in water the liquid spheres become solid. If the liquid particles falls directly on a solid dry plate then the drops are quenched, and take a planoconvex shape.

An other technique to get convex lenses was, also tried. In a special aluminium plate has been shaped ovoidal holes. These holes were filled by arsenic chalcogenide glass and the plate was heated above the melting point of the material. Finally, the cooling in air of the plate maintained the shape of every lens whose curved surface was formed, due to surface tension, in the molten state.

The drawing of the fibres was performed from the As_2S_3 melt, by using a metallic wire with a narrow tip.

3. Results

3.1. Microspheres and microlenses.

Fig. 1a, b shows convex lenses produced in the alveolar holes of an aluminium plate. Microspheres with typical diameters of 172 ÷ 282 μm have been obtained and shown in Fig. 2 a-d. The microlenses are homogeneous and of optical quality. The curvature of the lenses depends on their diameter, due to the concurrent action of weight and surface tension during splashing of liquid drops on solid, cool substrate.

Fig. 1.a,b Various shaped convex microlenses based on As_2S_3 glass (450 μm diameter).

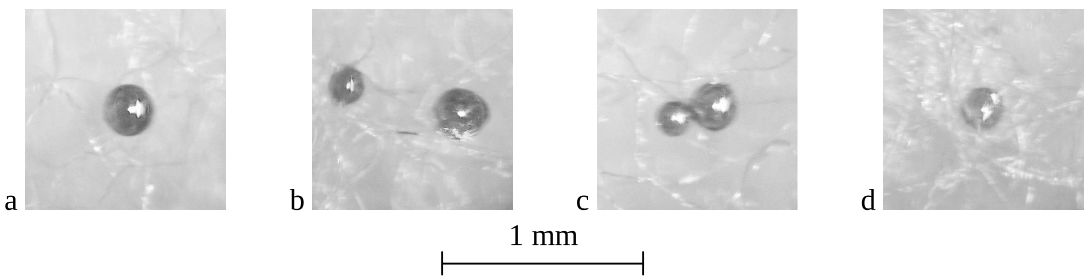
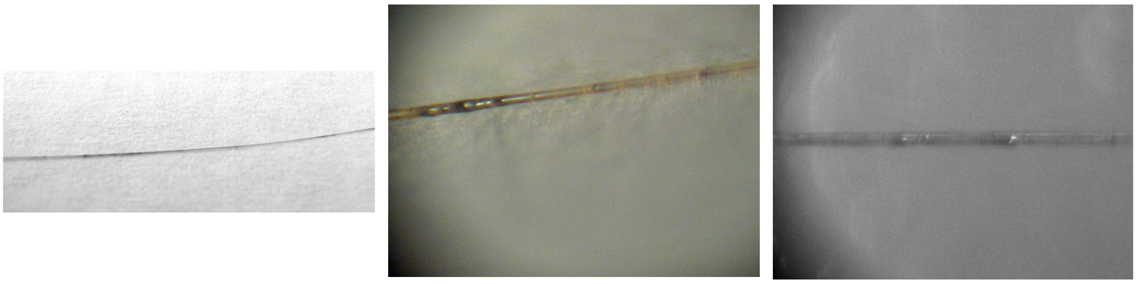


Fig. 2. As_2S_3 microsphere and planoconvex microlenses.
a. diameter: 254 μm
b. diameter: 179 μm; 282 μm
c. diameter: 172 μm; 234 μm
d. diameter: 212 μm

3.2 Chalcogenide fibres

A typical chalcogenide fibre drawn from the melt is shown in Fig. 3a, b and c.



a. b. c.

Fig. 3 a, b, c The fragment of a chalcogenide fibre (As_2S_3) with diameter of 45 μm, drawn from melt.

Photos were taken using a HP PhotoSmart 945 digital camera adapted to a stereoscopic microscope (50 ×magnifications).

It is remarkable the uniformity of the thickness, while the surface exhibits defects related to the formation of bulges. These defects do not affect the function of the fibre as optical waveguide, but the optical losses could be influenced.

4. Conclusions

Good quality chalcogenide microspheres of diameter situated in the range: 50 ÷ 400 μm, convex and planoconvex microlenses down to 50 μm in diameter have been produced by a new method: flame melting.

Thin optical fibres based on As_2S_3 have been drawn from melt. The fibre diameter reached 45 μm. The morphology of the fibres, and of microlenses was studied in the high resolution optical stereoscopic microscope. The homogeneity of the fibres seems to be limited to short length. The main defects are related to the formation of inflated regions, due probably to the fluctuation of the temperature of the melt during drawing.

A large fraction of microlenses produced by flame melting method are red colour, homogeneous, optically transparent. Some microlenses exhibits yellow colour due probably to a composition change during heating. The change of colour is accompanied by the modification of the refractive index.

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