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MOULDING PROCEDURE FOR THE PREPARATION OF INFRARED GLASSY MICROLENSES AND PRISMS BASED ON ARSENIC SULPHIDE CHALCOGENIDE GLASS

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A new procedure for the production of infrared lenses and prisms based on As_2S_3 chalcogeniude glass has been devised. Infrared components are obtained with the size in the range 100-1500 micrometers. The procedure allows for getting various curvature radii of the micrometer lenses, ranging from planno-convex to spherical ones.

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1. Introduction

Micrometer lenses and, especially infrared ones, are important for optoelectronic circuits and represent the essential components for the control of light [1] in photonic technology [2].

The preparation of micrometer and nanometer size lenses is still in its infancy and more effort is dedicated from the practical point of view [3].

Various procedures have been used to get microlenses. Saitoh and Tanaka [4] devised a two step procedure to form As_2S_3 lenses on the end of the optical fibers.

Later, several experiments were carried put in order to get microlenses and macrolens arrays on the same substrates [5]. Manevic et al. [6] used gap microlithography for the fabrication of chalcogenide of the microlens arrays.

Popescu et al. [7] patented a procedure or getting microspherical lenses based on As_2S_3 with the purpose to apply them as beam homogenizer in laser infrared diodes. The procedure consists in using coarse powder of As_2S_3 glass that is transferred rapidly through a heated space above the softening temperature T_g. During the powder falling, the grains soften and, due to the surface tension the small droplets take a spherical shape. A gentle cooling by falling in water allows for preserving the ball shape got above the softening temperature down to room temperature.

Pressure melting of glass is a method especially for obtaining aspheric and complex optical elements [8].

In this paper we report the recent results related to the production of various kind of microlenses and prism using a moulding procedure with gentle elimination of the aluminum moulding substrate by dissolved of the aluminum support.

2. Materials and method

Firstly glassy As_2S_3 chunks have been obtained by grinding in a porcelain mortar with a pestle, thus getting a convenient size of the grains. The size must correspond roughly to that of the lens we intend to prepare.

Secondly, a special matrix has been prepared by drilling special location of micrometer size on the surface of an aluminum plate. The whole operation was finished by careful polishing and eliminating of the remaining at the surface.

We have prepared several aluminum plates with several imprints on them. Different hard knifes with rounded ends have been used. Thus we created on the aluminum surface a set of holes of different sizes and shapes.

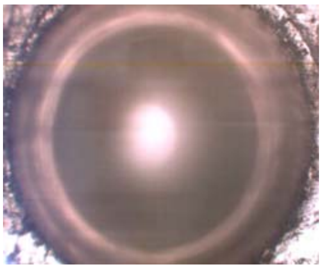


Fig. 1. The planno-convex moulded micrometer lenses (x10)

In the following stage we filled the holes one by one with chunks of glassy arsenic sulphide of appropriate size.

The plate thus prepared has been introduced in a furnace (MSR 2 – Malvern Research) feed by a flow of Argon, 99,999 % purity, to avoid oxidation and loss of material, especially as SO_2 gas.

The temperature was slowly raised at ~360 ^{o}C. After softening, the glass flows and takes the shape of the moulding plate.

After careful, slow cooling down to room temperature the samples were taken off the furnace. The glassy lenses are strongly fixed on the matrix. The adherence of the material is so high that it is impossible to free the lenses by mechanical method without damaging the small pieces.

After several trials we have found the right procedure for getting non-damaged lenses. We put the plate in a 4 % HCl solution and let the vessel to be dissolved in a time of several hours (as a function of the mass of aluminum to be dissolved.

Finally the microlenses have been collected at the bottom of the recipient, were washed and preserved in a dry place. The diluted hydrochloric acid didn't attacked the As-S glass as demonstrated by the visual inspection of the lenses

3. Results

In order to carefully investigate the quality of the lenses we used the scanning electron microscope investigation. A SEM microscope of type Zeiss EVO 50 XVP.

Figure 1- 4 shows the shape of the obtained micolenses. The dimensions of the microlenses can be easily estimated from the micrographs.

The order of magnitude of the microlens size is, as presumed, 150 - 1500 μm. The microspheres are almost perfect, excepting some particles of dust visibile in the SEM image.

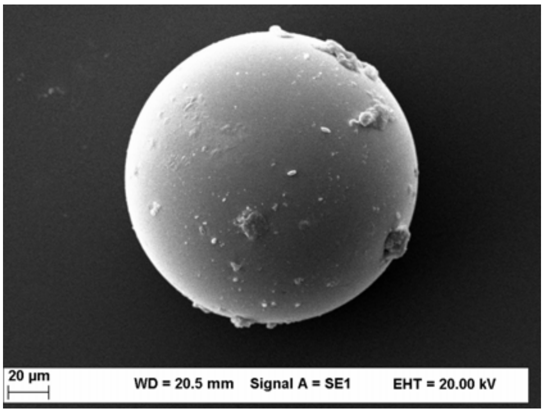


Fig. 2. Microsphere of diameter 145 micrometers

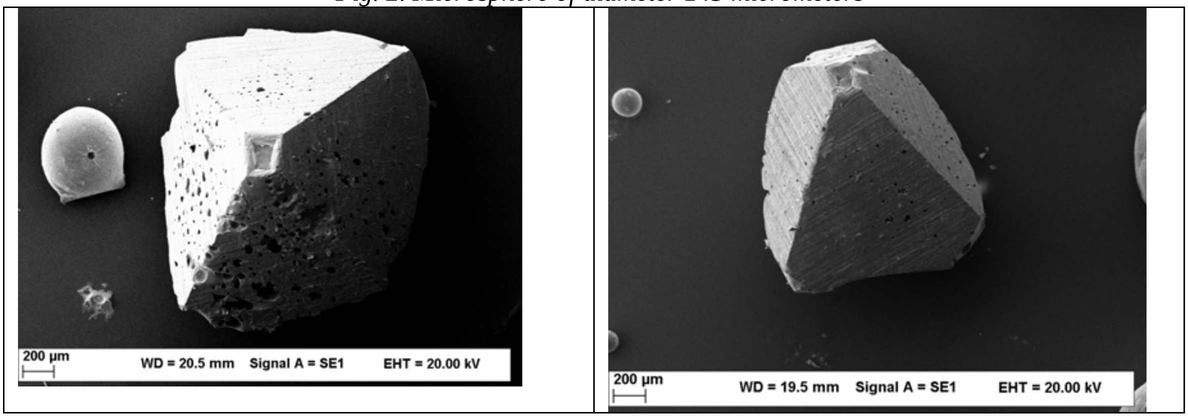
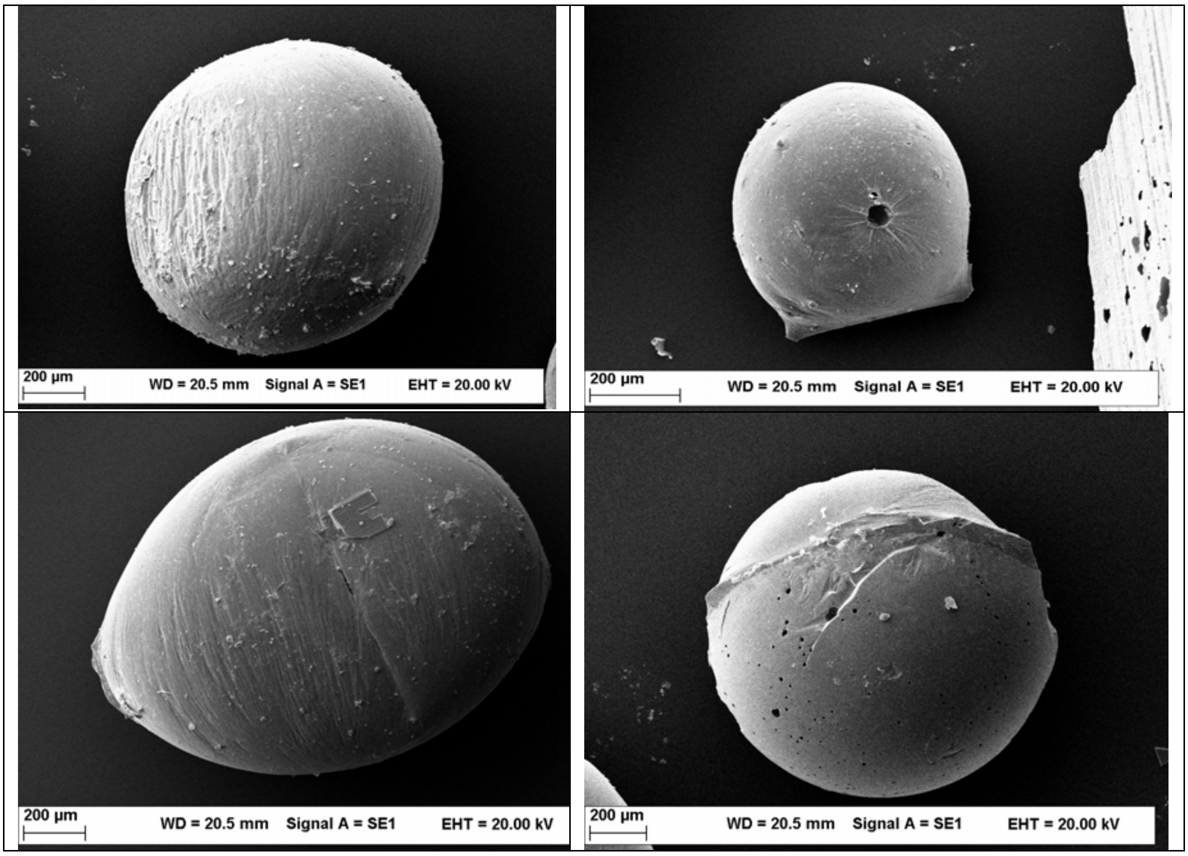


Fig. 3. Pyramidal microlens

Fig. 3 shows different planno-convex lenses with different curvature radii.



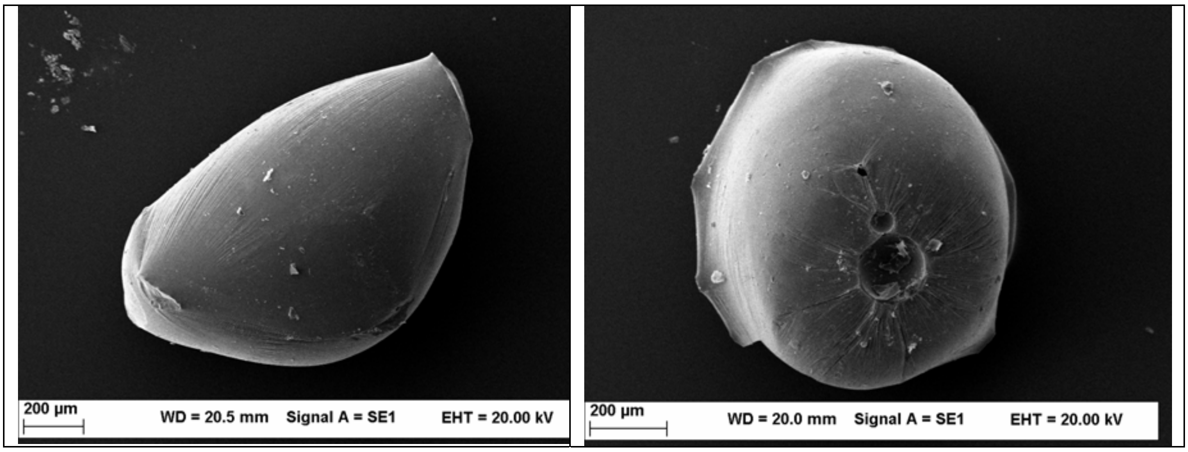


Fig. 4. Different planno-convex microlenses

4. Discussion

A careful analysis of the lenses evidences good surfaces but also some defects due to impurities or wrong polishing of the matrix.

Therefore, only good polishing and clean surfaces of the matrix could help in getting perfect lenses.

On the other hand the temperature of treatment is important, because higher temperature could lead to the evaporation of some sulphur in a violent way, with the formation of bubbles of various sizes. If the temperature is too low, the flowing effect is insufficient to make the glass to reproduce exactly the hole shape in short time. As a consequence, prisms with rounded edges or distorted lenses are obtained.

Cha et al [9] have examined the effect of temperature on the moulding of chalcogenide glass for infrared (IR) lens fabrication and evaluate a muolded chalcogenide glass lens. Both the adhesion of the chalcogenide glass to the mould's surface and lens breakage depended on the initial heating temperature and on the moulding temperatures in the glass moulding process. In addition, the moulded chalcogenide glass lens was evaluated based on transcription characteristics of the mould's surface, IR transmittance, and x-ray diffraction patterns. From the analysis results, we verified that the chalcogenide glass lens for IR imaging application could be fabricated by well-controlled temperature conditions.

Various curvature radii of the optical microlenses can be obtained by adjusting the shape of the holes aluminum substrate.

Work is now in progress to eliminate the shortcomings of the method and to patent high quality optical micro-elements

5. Conclusions

A simple and practical procedure has been developed in order to produce microlenses and prisms based on infrared chalcogenide glass of As_2S_3. The procedure can be exended to other type of infrared glasses by tuning the preparation conditions to every type of glass.

Acknowledgement

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