# CHALCOGENIDE MICROSPHERE FABRICATED FROM FIBRE TAPER-DRAWN USING RESISTIVE HEATING

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## Introduction

Over the last decade extreme interest for microsphere resonators has increased rapidly due to their very high quality Q factors, the ease with which they can be manufactured and their versatility in terms of materials and dopants for plenty of passive and active devices. Futhermore, microsphere resonators have the potential to add significant functionality to planar lightwave circuits when coupled to waveguides where they can provide wavelength filtering, delay and low-power switching, and laser functions [1].

Recently, chalcogenides are rapidly establishing themselves technologically superior materials for emerging application in non-volatile memory and high speed switching [2] and have been considered for a range of other optoelectronic technologies. Chalcogenide glasses offer a wide wealth of active properties, an exceptionally high nonlinearity, photosensitivity, the ability to be doped with active elements including lanthanides and transitional metals and are able to form detectors, lasers and amplifiers and offer semiconductor, optical, acousto-optic, superconducting and opto-mechanical properties. Unlike any other optical material, they have been formed in to a multitude of form: such as optical fibres, thin films, bulk optical components, microsphere resonators, metamaterials and nanoparticles, patterned by CMOS compatible processing at the sub micron scale. To date, most studies on microsphere resonators have utilized silica microspheres fabricated by melting the tip of an optical fibre with the resulting stem attached to the microsphere used as a tool to place the sphere in the required location while characterizing the microsphere. In this paper high quality chalcogenide ($As_2S_3$) microspheres with diameters down to 74 μm are directly fabricated from the taper-drawn using a resistive heating process. A reasonable high quality factor greater than $10^5$ near the wavelength of 1550 nm is demonstrated with an efficient coupling using a fibre taper with a diameter of 2 μm.

## Experiments

The chalcogenide fibre used in the experiments is a commercial step-index multimode fibre provided by Oxford Electronics, it has have an $As_2S_3$ core (OD=180 μm) and $As_xS_{1-x}$ cladding of lower refractive index (OD=275 μm). Our approach for directly fabricate chalcogenide microsphere is illustrated in Fig .1. First, we use a microheater to heat a chalcogenide fibre mentioned above to a certain temperature (~200$^o$C) for melting the end of chalcogenide fibre and move the fibre towards the microheater. When the fibre immerses on the microheater through local melting area, we withdraw the fibre at a speed of 0.1~1m/s to draw wires from the melt until breakage of the wire. When the process is finished, a microfibre with considerable length is formed at the freestanding side of the chalcogenide fibre. At last, the microsphere is fabricated by heating the tip of a taper-drawn microfibre when the tip is close to the microheater at a higher temperature compared with the transition temperature of chalcogenide material, such as 500$^o$C, the surface tension pulls the melted glass tip into a spherical shape, thereby creating a microsphere resonator on the top of the tapered microfibre.

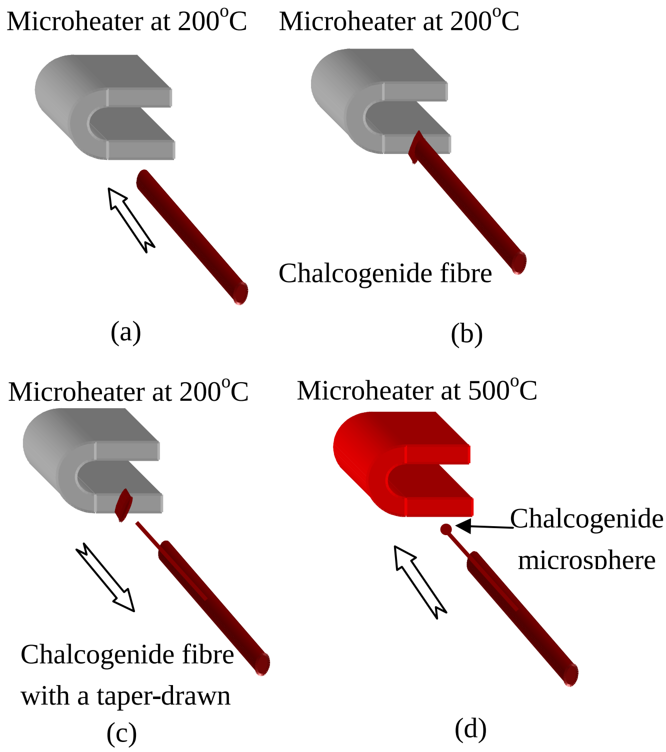


Fig. 1. Schematic diagram illustrating the fabrication process of microsphere from chalcogenide fibre. (a) A chalcogenide fibre is moved towards microheater heated at a temperature of 200°C; (b) The fibre end is immersed on the surface of microheater through local melting. (c) A portion of molten glass is left on the surface of microheater and a tapered microfibre is formed at the end of the fibre when the fibre is withdrawn. (d) A microsphere is formed at the freestanding side of the taper.

## Results and discussion

Fig. 2 (a)~(d) show the top view of the lead-silicate glass microsphere resonators with diameters of 74 µm, 98 µm and 109 µm, respectively.

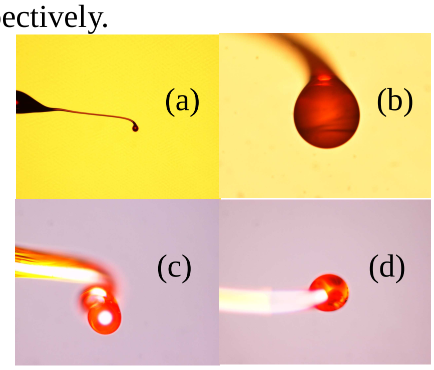


Fig. 2. (a) Microscope image of a chalcogenide fibre with a taper-drawn and a microsphere at the end of taper, three chalcogenide microspheres fabricated by the tapers showing good surface quality and diameters of (b) 74 µm, (c) 98 µm and (d) 109 µm.

A tapered silica fibre with a waist diameter d of ~2 µm was used to couple light into the microsphere using the well-established evanescent field coupling technique [3]. Fig. 3 shows the spectrum over a short wavelength range, showing the *Q* nature of the observed resonance dips, a FWHM of 16 pm was found, corresponding to a *Q* factor of circa $10^5$.

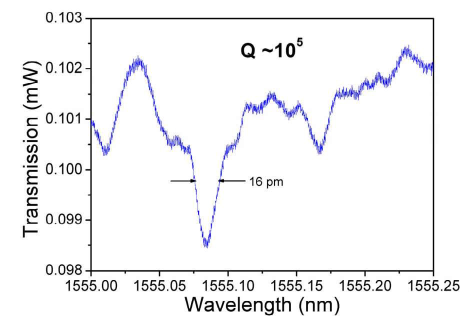


Fig. 3. One of the measured resonance dips near 1550 nm.

## Conclusion

In conclusion, the fabrication of chalcogenide microspheres has been demonstrated. Whispering gallery mode resonances have been observed and a Q factor close to $10^5$ was observed at ~1.55 µm. We believe that this microsphere will provide a simple fabrication technique and an ideal building-block for several applications including highly integrated optical switches, modulators, ultrasmall optical filters, microlasers, and optical biosensors.

## References

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