Final Report Summary

Fabrication and characterisation of waveguides capable of guiding in the mid-infrared spectral region

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This project set out to fabricate and characterise waveguides capable of guiding in the mid-infrared spectral region. This spectral region, extending from 2-10 µm, is particularly interesting for optical sensing applications due to the presence of absorption bands of the vibrational modes of molecular species. HWU utilised its existing expertise in the field of ultrafast laser waveguide inscription to fabricate Mid-IR waveguides in novel Chalcogenide glasses.

The fabrication method used for this project is an unconventional waveguide fabrication technique, using focussed ultrashort laser pulses to directly micro-modify the refractive index of bulk materials. This direct-write technique relies on nonlinear multi-photon processes to create permanent refractive index changes within the bulk of a transparent material, enabling three-dimensional structures to be produces by simply translating the bulk material through the focus of the laser pulse train.

We chose to fabricate waveguides using Chalcogenide glasses as a substrate material. Chalcogenide glasses are particularly interesting materials, as they exhibit excellent transparency well into the mid-infrared, making them useful for passive and active infrared optics. They are also highly nonlinear, making them useful for a wide range of applications such as supercontinuum generation – the creation of ultra-broadband light from a narrow band pump laser source.

Initially, waveguides were fabricated in a Germanium Sulphide based glass. A range of waveguides were fabricated, with the aim of finding an optimal parameter range. The waveguides were shown to guide well in the infrared, and were also characterised using a Mid-IR Optical Parametric Amplifier (OPA). Broadband supercontinuum generation was observed spanning 600 nm, extending into the mid-IR was achieved by guiding 1500 nm laser pulses inside the waveguide. Further supercontinuum generation was achieved when tuning the OPA to a wavelength of 2.4 µm, giving an output spectrum extending from the near infrared to approximately 3 µm. This continuum radiation is particularly suited for broadband absorption spectroscopy of molecular species.

Finally, waveguides were fabricated inside a superior chalcogenide glass – Gallium Lanthanum Sulphide. This material has significant benefits over the glass used in the initial experiments, and in particular has a much improved transparency throughout the Mid-IR spectral region. The fabricated waveguides were particularly encouraging for efficient low-loss Mid-IR guiding and supercontinuum generation for sensing applications.

A summary of our achievements:

- Waveguides fabricated inside GeS based glass
- Able to demonstrate high quality guiding, and supercontinuum generation
- Waveguides fabricated inside superior GLS glass
- Initial guiding experiments encouraging, great potential for high performance devices

Delivered by the Scottish Optoelectronics Association
Co-funded by: Project part-financed by the European Union, Europe and Scotland Making it work together
The Scottish Government
Scottish Enterprise