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**Microstructured Tellurite Glass Fibre Laser Development**

by

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## ABSTRACT

This thesis contains a study of the suitability of tellurite glass for use in microstructured fibre lasers. This thesis looks into the possibility for lasing at around  $3\mu\text{m}$ , where tellurite glass is transparent. To test the lasing potential of fabricated tellurite glass microstructured fibres, lasing at  $1.5\mu\text{m}$  was demonstrated.

The research contained within this thesis includes: The development and characterisation of the tellurite glass composition; including modifications made to this composition to match the refractive indices of the doped and undoped glasses, reducing the glass material loss, finding the glass crystallisation stability and density as well as measuring the temperature dependence of the glass melt viscosity, of which an understanding is required for its extrusion (Chapter 2). The fabrication of microstructured tellurite fibres which included large mode area fibres, motivated by the desire to fabricate a double clad fibre and the development of small core fibres which were used in the fibre laser experiments (Chapter 3). A spectroscopic study of the erbium III doped glass including lifetimes, absorption and emission measurements (Chapter 4) and a description of the laser modelling, experiments and results (Chapter 5).



## DECLARATION

I confirm that this work contains no material which has been accepted for the award of any other degree or diploma in any university or other tertiary institution to Michael Oermann and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text.

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## PUBLICATIONS DURING CANDIDATURE

### Journal publications:

M.R. Oermann, H. Ebendorff-Heidepriem, Y. Li, T.-C. Foo, T.M. Monroe, "Index matching between passive and active tellurite glasses for use in microstructured fiber lasers: Erbium doped lanthanum-tellurite glass", *Optics Express* 17 (18), 15578-15584, August 2009

M. Oermann, H. Ebendorff-Heidepriem, D. Ottaway, D. Lancaster, P. Veitch, T.M. Monroe, "Extruded microstructured fiber lasers", Submitted to *Photonics Technology Letters*

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### First author refereed conference papers (accepted for oral presentation):

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M.R. Oermann, D. Ottaway, P. Veitch, H. Ebendorff-Heidepriem, T.M. Monroe, "Erbium-doped bulk tellurite glass laser at 1.5  $\mu$ m", Australian Conference on Optics, Lasers and Spectroscopy (ACOLS), Adelaide, December 2009.

M.R. Oermann, H. Ebendorff-Heidepriem, Y. Li, T.M. Monroe, "Spectroscopy of erbium in La<sup>3+</sup>-doped tellurite glass & fibres", Australian Conference on Optical Fibre Technology (ACOFT), Sydney, July 2008

### Co-author refereed conference papers (accepted for oral presentation):

Y. Li, M. Oermann, H. Ebendorff-Heidepriem, T.M. Monroe, "Simultaneous infrared and visible emission in Er<sup>3+</sup>-doped ZBLAN fibre", International Commission for Optics (ICO), Sydney, July 2008

H. Ebendorff-Heidepriem, T.C. Foo, Y. Li, M. Oermann, T.M. Monroe, "New tellurite glasses for erbium fibre lasers", Australian Conference on Optical Fibre Technology (ACOFT), Sydney July 2008

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M.R. Oermann, Y. Li, H. Ebendorff-Heidepriem, T.M. Monroe, "Core doped tellurite microstructured optical fibre for erbium fibre laser at 2.7 $\mu$ m", AIP Congress 2008 AOS, Adelaide, December 2008

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## LIST OF ABBREVIATIONS

<b>CoEP</b>	Centre of Expertise in Photonics (component of IPAS)
<b>CR</b>	Cross Relaxation
<b>CW</b>	Continuous Wave
<b>DSC</b>	Differential Scanning Calorimetry
<b>EDFA</b>	Erbium Doped Fibre Amplifier
<b>ESA</b>	Excited State Absorption
<b>ET</b>	Energy Transfer
<b>ETU</b>	Energy Transfer Upconversion
<b>FEM</b>	Finite Element Modelling
<b>FSM</b>	Fundamental Space Filling Mode
<b>FTIR</b>	Fourier Transform Infrared
<b>GSA</b>	<b>Ground State Absorption</b>
<b>IPAS</b>	Institute for Photonics and Advanced Sensing
<b>IR</b>	Infrared
<b>JO</b>	Judd Ofelt
<b>LMA</b>	Large Mode Area
<b>MOF</b>	Microstructured Optical Fibre
<b>NA</b>	Numerical Aperture
<b>OSA</b>	Optical Spectrum Analyser
<b>PBG</b>	(PbO-Bi <sub>2</sub> O <sub>3</sub> -Ga <sub>2</sub> O <sub>3</sub> ) glass composition
<b>PTFE</b>	Polytetrafluoroethylene (Teflon)
<b>QCW</b>	Quasi-Continuous Wave
<b>SEM</b>	Scanning Electron Microscope
<b>SMF</b>	Single Mode Fibre
<b>TZN</b>	(TeO <sub>2</sub> -ZnO-Na <sub>2</sub> O) glass composition
<b>TZNL</b>	(TeO <sub>2</sub> -ZnO-Na <sub>2</sub> O-La <sub>2</sub> O <sub>3</sub> ) glass composition
<b>UV</b>	Ultraviolet
<b>WNT</b>	(25WO <sub>3</sub> -15Na <sub>2</sub> O-60TeO <sub>2</sub> ) glass composition
<b>ZBLAN</b>	(ZrF <sub>4</sub> -BaF <sub>2</sub> -LaF <sub>3</sub> -AlF <sub>3</sub> -NaF) glass composition

## **GLOSSARY**

Glass viscosity – viscosity of the supercooled glass melt.