



THE UNIVERSITY
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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

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First author refereed conference papers (accepted for invited talk):

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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 μ 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 La³⁺-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 Er³⁺-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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Figure 102: Setup used for the density measurements. The weight of the billet and the reduction in this weight when it is submerged in the suspended beaker of water are measured. 184

LIST OF ABBREVIATIONS

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

GLOSSARY

Glass viscosity – viscosity of the supercooled glass melt.