Microstructured Tellurite Glass Fibre Laser Development

by

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CONTENTS

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 3μm, where tellurite glass is transparent. To test the lasing potential of fabricated tellurite glass microstructured fibres, lasing at 1.5μm 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. Monro, "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. Monro, "Extruded microstructured fiber lasers", Submitted to Photonics Technology Letters

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

M. Oermann, D. Ottaway, H. Ebendorff-Heidepriem, P. Veitch, T.M. Monro "Tellurite Glass for use in 2.3μm Thulium Fibre Lasers" IQEC/CLEO Pacific Rim 2011, Sydney, August 2011

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

M. Oermann, D. Ottaway, H. Ebendorff-Heidepriem, P. Veitch, T.M. Monro "Microstructured Erbium Doped Tellurite Fibre Laser" 19th Australian Institute of Physics Congress/35th Australian Conference on Optical Fibre Technology (ACOFT/AIP), Melbourne, December 2010

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

M.R. Oermann, H. Ebendorff-Heidepriem, Y. Li, T.M. Monro, "Spectroscopy of erbium in La^{3+}-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. Monro, "Simultaneous infrared and visible emission in Er^{3+}-doped ZBLAN fibre", International Commission for Optics (ICO), Sydney, July 2008

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Conference abstracts (accepted for oral presentation):

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

Michael R. Oermann, Heike Ebendorff-Heidepriem, David Ottaway, Peter Veitch, Tanya M. Monro, “Tellurite glass microstructured fibre laser development”, PACRIM 2011, Cairns, July 2011

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LIST OF ABBREVIATIONS

**CoEP ` **	**C**entre of **E**xpertise in **P**hotonics (component of IPAS)
CR	**C**ross **R**elaxation
CW	**C**ontinuous **W**ave
DSC	**D**ifferential **S**canning **C**alorimetry
EDFA	**E**rbium **D**oped **F**ibre **A**mplifier
ESA	**E**xcited **S**tate **A**bsorption
ET	**E**nergy **T**ransfer
ETU	**E**nergy **T**ransfer **U**pconversion
FEM	**F**inite **E**lement **M**odelling
FSM	**F**undamental **S**pace Filling **M**ode
FTIR	**F**ourier **T**ransform **I**nfrared
GSA	**Ground State Absorption**
IPAS	**I**nstitute for **P**hotonics and **A**dvanced **S**ensing
IR	**I**nfra**r**ed
JO	**J**udd **O**felt
LMA	**L**arge **M**ode **A**rea
MOF	**M**icrostructured **O**ptical **F**ibre
NA	**N**umerical **A**perture
OSA	**O**ptical **S**pectrum **A**nalyser
PBG	(**P**bO-**B**i$_2$O$_3$-**G**a$_2$O$_3$) glass composition
PTFE	**P**oly**t**etra**f**luoro**e**thylene (Teflon)
QCW	**Q**uasi-**C**ontinuous **W**ave
SEM	**S**canning **E**lectron **M**icroscope
SMF	**S**ingle **M**ode **F**ibre
TZN	**(T**eO2-**Z**nO-**N**a$_2$O) glass composition
TZNL	**(T**eO2-**Z**nO-**N**a$_2$O-**L**a$_2$O$_3$) glass composition
UV	**U**ltra**v**iolet
WNT	(25**W**O$_3$-15**N**a$_2$O-60**T**eO$_2$) glass composition
ZBLAN	(**Z**rF$_4$-**B**aF$_2$-**L**aF$_3$-**A**lF$_3$-**N**aF) glass composition

GLOSSARY

Glass viscosity – viscosity of the supercooled glass melt.