A Study of Tellurite Glasses for Electro-optic Optical Fibre Devices

by

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A thesis submitted in fulfilment of the degree of Doctor of Philosophy

in the
Faculty of Science
School of Chemistry & Physics

November 2011
Declaration of Authorship

I, Sean Manning, declare that this thesis titled, ‘A Study of Tellurite Glasses for Electro-optic Optical Fibre Devices’ and the work presented in it are my own. I confirm that:

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List of Publications

1. Manning, Sean; Ebendorff-Heidepriem, Heike; Heike Monro, Tanya Mary.
   **Sodium Zinc Tellurite Glass: a Candidate Material for Core/Clad Fibres for Electro-optic Devices.**
   Proceedings of the 9th Pacific Rim Conference on Ceramic and Glass Technology (PACRIM9), held in Cairns, Queensland, Australia July 10-14 2011.

2. Manning, Sean; Monro, Tanya Mary; Munch, Jesper; Ottaway, David John.
   **Improved maker fringes data analysis using genetic algorithms.**

3. Manning, Sean; Ebendorff-Heidepriem, Heike; Monro, Tanya Mary; Munch, Jesper.
   **Tellurite glasses for photonic devices with enhanced nonlinearity.**
   Proceedings of the 8th Pacific Rim Conference on Ceramic and Glass Technology (PACRIM8), held in Vancouver, British Columbia, Canada May 31- June 5 2009.

4. Manning, Sean; Monro, Tanya Mary; Munch, Jesper; Ottaway, David John.
   **On the application of genetic algorithms to maker fringes analysis.**
   18th Australian Institute of Physics (AIP) Congress Conference, held in Adelaide, South Australia Nov 30-Dec 5 2008.
“It doesn’t matter how beautiful your theory is, it doesn’t matter how smart you are. If it doesn’t agree with experiment, it’s wrong.”

Richard P. Feynman
Optical fibre devices that can control light via the application of electric fields are of enormous technological interest. These so called electro-optic devices have potential applications in many varied places, such as data systems, pulsed lasers and sensing technologies.

We have identified tellurium dioxide (tellurite) based glasses as being especially suitable for electro-optic fibre devices owing to their large nonlinear coefficients and high crystallisation stabilities. Furthermore, tellurite glass is compatible with the extrusion technique for producing optical fibre preforms, this being a fabrication strength of our research group.

We developed tellurite glasses based on the general formula $10\text{Na}_2\text{O}.\text{xMO}.(90-x)\text{TeO}_2$ with M=Magnesium, Zinc and Barium and $x = 5, 10, 15$ and $20$. Raman spectroscopy was utilised to determine the structure of the glasses under study, from which definite compositional trends were observed. Further, we measured physical, thermal and optical properties of these glasses that are critical for the design of electro-optical optical fibres. Certain of these properties displayed compositional trends that were correlated with the structural data, thus indicating physical origins for the properties. This information can thus be used to guide future glass composition design.

We investigated thermal poling as a potential post processing technique for inducing second order nonlinearities thereby enhancing the efficiency of the electro-optic effects. The Maker fringes technique was applied to measuring the induced second order nonlinearities. We have made refinements to the standard way in which these measurements are made, both in terms of the experimental technique as well as the analysis of the data.
We developed computational models of optical fibres with internal electrodes for determining the properties, such as optical attenuation resulting from the presence of internal electrodes. The results of these computations in combination with the measurements of the glass properties are used to guide the design of prototype electro-optic fibres. Finally, we developed various techniques for the fabrication of electro-optic fibre devices, such as optical fibre preform extrusion, fibre drawing techniques and electrode insertion.
Acknowledgements

First and foremost I would like to thank my supervisors Tanya Monro and Jesper Munch for their guidance, support and advice. Both have contributed heavily to forming the physicist I have become. Additionally, much thanks and appreciation must go to Heike Ebendorff-Heidepriem and David Ottaway who provided me with invaluable co-supervision, if however unofficially, their experience and guidance was greatly appreciated.

During my PhD I had the pleasure of working with so many great people, all of whom helped me at some stage or other, whether directly or in spirit. People such as: Adrian Selby, Aidan Brooks, Alastair Dowler, Blair Middlemiss, Bob Nation, David Hosken, Eric Schartner, Herbert Fu, Ka Wu, Keiron Boyd, Kevin Kuan, Kristopher Rowland, Matt Heintze, Matt Henderson, Michael Oermann, Mifta Ganja, Murray Hamilton, Nikita Simakov, Peter Veitch, Shahraam Afshar, Trevor Waterhouse, Neville Wild, Roger Moore and Tilanka Munasinghe.

I also had the fortune to travel far and wide to meet some fantastic collaborators such as: Walter Margulis and Oleksandr Tarasenko at ACREO, Steve Madden, Barry Luther-Davies and Khu Vu at ANU and Kathleen Richardson at Clemson University.

Finally, I would like to acknowledge my Wife and kids for their love and support. They are the stabilising force in my life and I’d be lost without them.

Thank you.
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For my wife, who deserves a PhD in patience.