Additive Manufacture of Single and Multi-Core Optical Fibres

J. Canning[1,2], Y. Chu[1,2], Y. Luo[2], G.D. Peng[2], J. Zhang[2]
[1]*i*nterdisciplinary Photonic Laboratories, UTS, NSW 2007 Australia
[2]National Fibre Facility, UNSW, Sydney, NSW 2052, Australia
Email – jcanning333@ymail.com

Additive manufacture of application specific optical preforms and fibres [1-3] will disrupt traditional fabrication using chemical vapour deposition (CVD) whether on the inside (using MCVD) or on the outside (OCVD). The most obvious reason is that CVD processes are constrained by a lathe that spins a tube into which material is sprayed and consolidated in various forms, producing single and centred core preforms from which standard optical fibres are drawn. This constraint does have important advantages in that there is a highly uniform radial symmetry to temperature and pressure properties during manufacture, which offer a great deal of structural symmetry critical for low loss scattering and generating degenerate polarisation states within an optical fibre. That also benefits some application specific fibres more than others – for structured optical fibres, for example, this permits simple radial analytical relationships describing pressure and uniformity within holes that can be integrated into a fabrication process to control their size and wall thicknesses [4]. To fabricate multicore preforms, however, multiple single core preforms are fabricated, the cores etched and then assembled into the desired layout. This is a highly time consuming and laborious process. Given the increasing desire for multi-core fibres playing a role in extending optical bandwidth in communications and data transfer [5], it will not be tolerated longer-term. Consequently, the removal of this centre constraint in preform manufacture is a necessary requirement even though this will be accompanied by other challenges. This is where additive manufacture can come into its own by removing this constraint altogether.

I review our results on fabricating single and multicore silicate preforms doped with substantive softeners such as Ge and Bi and show the added complexity that arises when drawing multiple cores. In particular, the glass softening point is reduced with increasing number of cores – more uncontrolled liquid-like diffusion of the core into the cladding material, varying with uneven strain and flow within, correlates with increasing core numbers which lowers the effective m.p. The addition of a hardener such as titanium oxide does not help. The induced asymmetry is observed as an increasing loss with increasing core number. This work demonstrates that there are unique, but solvable, challenges fabricating and drawing multiple cores simultaneously before additive manufacture produces a competitive fibre for long distance transmission applications.

References

[1] Y. Chu, X. Fu, Y. Luo, J. Canning, Y. Tian, K. Cook, J. Zhang, G-D. Peng, "Silica optical fibre drawn from 3D printed preforms", *Opt. Lett*. **44** 21, (2019) 5358 – 5361

[2] Y. Luo, J. Canning, J. Zhang, G-D. Peng, "Towards optical fibre fabrication using 3D printing technology", *Opt. Fibre Tech.* **58** (2020) 102299

[3] J. Canning, "3D Printing and Photonics", Keynote, *4th Int. Conf. Emerging Adv. Nanomat.* (ICEAN), Newcastle University, Australia, (2020)

[4] G. Tafti, J. Canning, S. Wang, Y. Luo, K. Cook, G-D. Peng, "Pressure Effects on Structured Optical Fibre Drawing by Modified Single-Capillary Modelling", *Opt. Fibre Tech*., **63** (2021) 102528

[5] G. Rademacher, R. S. Luís, B. J. Puttnam, R. Ryf, S. van der Heide, T. A. Eriksson, N. K. Fontaine, H. Chen, R. Essiambre, Y. Awaji, H. Furukawa, N. Wada, "172 Tb/s C+L Band Transmission over 2040 km Strongly Coupled 3-Core Fiber," in *Optical Fiber Communication Conference Postdeadline Papers 2020*, (Optical Society of America, 2020), paper Th4C.5.