3127

Lead-silicate optical nanowires

G. Brambilla, X. Feng, D.J. Richardson,
Optoelectronics Research Centre,University of Southampton,Southampton SO171BJ, UK. E-mail:gb2@orc.soton.ac.uk

Only recently, a technique to manufacture optical fibre nanowires with sufficiently low propagation losses for optical applications has been published [1]. Due to the small surface roughness and high diameter uniformity required to achieve low propagation losses, to date the totality of work in the area has focused on the production of silica optical fibre nanowires. For many applications requiring tight mode confinement and/or large optical nonlinearity it would be desirable to make the nanowires from compound glasses, such as lead-silicates, which have nonlinear refractive index (n_2) that can be as high as 50 times that of silica. Here we report what we believe to be the first successful fabrication of low-loss compound-glass optical wires.

In order to fabricate nanowires from lead-silicate fibres we needed to make only a relatively minor modification to our standard silica fibre taper fabrication rig [2]. Since compound glasses have a substantially lower softening temperature than silica (T_g's of 400-600 rather than ~1600^{0}C), we replaced the flame burner on our existing silica fibre taper rig with a current controlled graphite microheater. This microheater, operable in the temperature range T=200^{0}C to 1700^{0}C, provides far greater temperature control than a burner at the lower processing temperatures required to soften compound glass. Tapers with a uniform waist diameter and taper transitions of well defined length and shape were produced by controllably scanning the microheater over lengths of several tens of mm along the initial compound glass fibre. The fibre was pulled during the heating to form a taper of a well defined diameter profile by two translation stages each providing submicron precision. The typical lengths of the taper waists used in this work were of the order of several tens of millimetre, up to 100mm. The total loss of the taper (fibre input facet to fibre output facet) was continuously monitored during the fabrication process by injecting a known amount of light at 1.55 μm from a fiberised laser source into the taper and measuring how the total throughput power changed during the process.

The starting fibre was fabricated at the ORC using the extrusion technique and two commercially available lead-silicate glasses (Schott F7 and F2) for core and cladding respectively. The fibre numerical aperture (NA), background loss (α), outer (OD) and core (ID) diameters were ~0.12, ~1dB/m, 260μm and ~6μm respectively. The processing temperature was ~520 ^{0}C. Fig. 1 shows a Scanning Electron Micrograph (SEM) picture of a typical LS nanowire. The good stability of our fabrication rig allowed the manufacture of long nanowires (up to 100mm) with small diameters (down to 90nm) with good uniformity. The diameter uniformity in the region of minimum waist has been sampled along few millimiters and was within the SEM resolution (~5nm). The real time loss measurements are presented in Fig. 2. It is to be noted that the average loss per unit length reported in the graph is an underestimate since it does not take into account the loss of the conical fibre tapers into and out of the nanowires. For the smallest radii (~240nm) the loss at 1.55μm is a fraction of a dB/mm, slightly higher than that we originally measured in ref. 2 for silica telecom fibres. We hope to be able to improve on this by further optimisation of the process.

In conclusion, we have presented a simple method to fabricate nanowires from compound glass fibre. Low transmission loss in the near IR region has been achieved in nanowires fabricated from lead-silicate optical fibres.

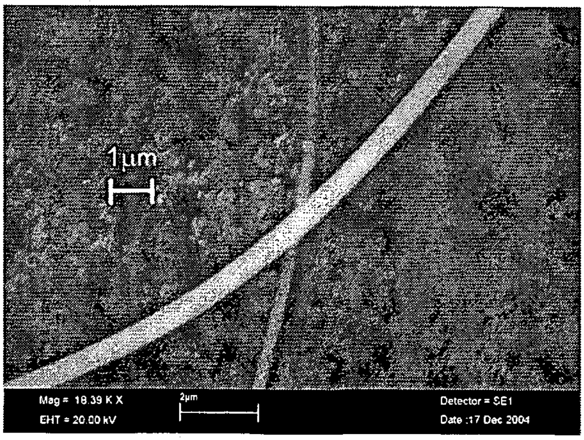

Fig. 1 SEM picture of two nanowires with radii r~150nm and 300nm.

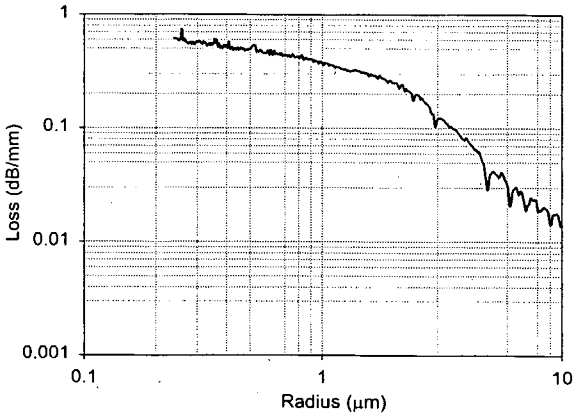

Fig. 2 Loss measurement at λ=1.55μm. The length of uniform waist for the smallest radius and processing temperature were ~60mm and 520 ^{0}C respectively

References

1 L Tong, RR Gattass, JB Ashcom, S He, J Lou, M Shen, I Maxwell, and E Mazur, Nature 426, 816 (2003).
2 G Brambilla, V Finazzi, and DJ Richardson, Opt. Exp. 12(10), 2258 (2004).