# Record high nonlinearity in a bismuth-oxide-based glass holey fibre

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Nonlinear effects are attractive for various telecommunication applications ranging from signal regeneration and pulse compression to wavelength conversion, optical demultiplexing and spectral broadening. Therefore, there is an ever-increasing interest in the development of highly nonlinear optical fibres that could lead to the realization of compact nonlinear devices operating at low powers.

The parameter that is used to assess and quantify the nonlinear behaviour of optical fibres is the effective nonlinear coefficient $\gamma$, which is defined as $\gamma=2\pi n_2/(\lambda A_{eff})$, where $n_2$ is the nonlinear refractive index, $\lambda$ is the wavelength of operation and $A_{eff}$ is the effective mode area. It becomes apparent that for the realization of highly nonlinear fibres, both a small effective mode area and a high nonlinear refractive index are desirable. A particularly attractive approach for the development of fibres with high effective nonlinearity relies on the combination of holey fibre (HF) technology and the use of high nonlinearity compound glasses. HFs offer great design flexibility, since their optical properties rely on the specification of the size, shape and arrangement of the holes which can be tailored according to the desired application. Thus by just scaling the features of the HF profile it is possible to fabricate fibres with very tight mode confinement, and consequently very small effective mode area.

Bismuth-oxide-based glasses combine high material nonlinearity with several attractive physical properties. They exhibit good mechanical, thermal and chemical stability which facilitates easy fibre drawing, and also can be fusion spliced to silica fibres. In addition, they accept high levels of erbium doping, which has enabled the demonstration of short-length Er-doped amplifiers with a broadband emission in the past. This talk reports on the properties of extremely small core bismuth-oxide-based glass HFs. The low melting temperature of the glass has allowed extrusion techniques to be applied for the fabrication of the fibre preform. This is not only easier, compared to the stack-and-draw technique commonly used for the fabrication of silica HFs, but also allows for the implementation of structures that closely resemble air-suspended rods, an arrangement that provides maximum NA, and hence the tightest possible mode confinement.

We characterised fibres with core diameters ranging between 1.5 and 2.1 μm at the telecommunication wavelengths, in terms of their loss and effective nonlinearity. We found that they exhibited losses as low as ~2.7 dB/m, whereas the effective nonlinear coefficient of the smallest core fibre was ~1100 $W^{-1}km^{-1}$. This represents the highest ever reported nonlinearity in a HF and is three orders of magnitude higher than that of standard single-mode fibres.

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