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Assorted Core Air-Clad Fibre

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We present an optical fibre with a selection of independently addressable cores of varied dimensions, each with distinct optical properties. The criteria for guidance in such structures is explored and potential applications are reviewed.

We demonstrate a new technique for fabricating an optical fibre with an array of essentially air-clad cores of different dimensions. This relies on techniques developed in the production of holey optical fibres, which are typically fabricated from stacking silica tubes around a solid silica rod [1]. When thin walled capillaries are stacked and drawn to fibre, additional cores can form at regions where capillaries meet [2] with differing sizes resulting from variations in tube thickness and diameter. Here we present such an *assorted core* fibre which contains independently addressable small cores of different dimensions (see Figure 1).

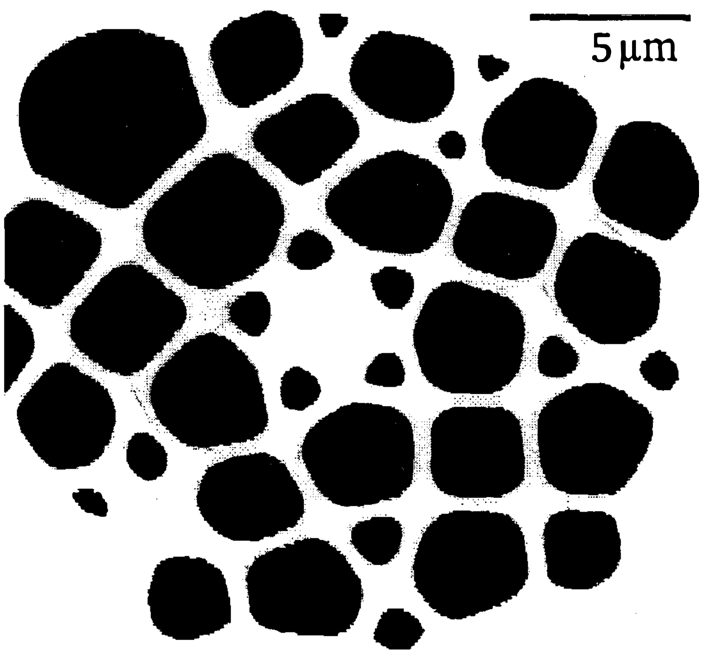

Fig. 1. SEM photograph of central region of assorted core fibre. The outer fibre diameter is approximately 180 microns.

The central region of the assorted core fibre is shown in Figs 1 and 2. In the region surrounding the central core, junctions of relatively thicker glass create a network of potential cores supported by thinner silica filaments. The subset of potential cores that guide light are referred to as secondary cores (see Figure 2). We investigated the modes supported by these cores, at wavelengths of 488nm, 633nm, and 1500nm to obtain an understanding of the range of core and support geometries which permit the guidance of light (see Table 1). The central core guides light over the whole wavelength range used, for which it is few moded. In cases where light is guided within the secondary cores it is single moded.

From our observations we find that all guidance properties can be explained by geometrical arguments. We deduce that to guide light of wavelength λ, all support structures surrounding a core must be approximately longer than 2λ and narrower than 1.2λ. These "rules of thumb" are physically reasonable as the field decays

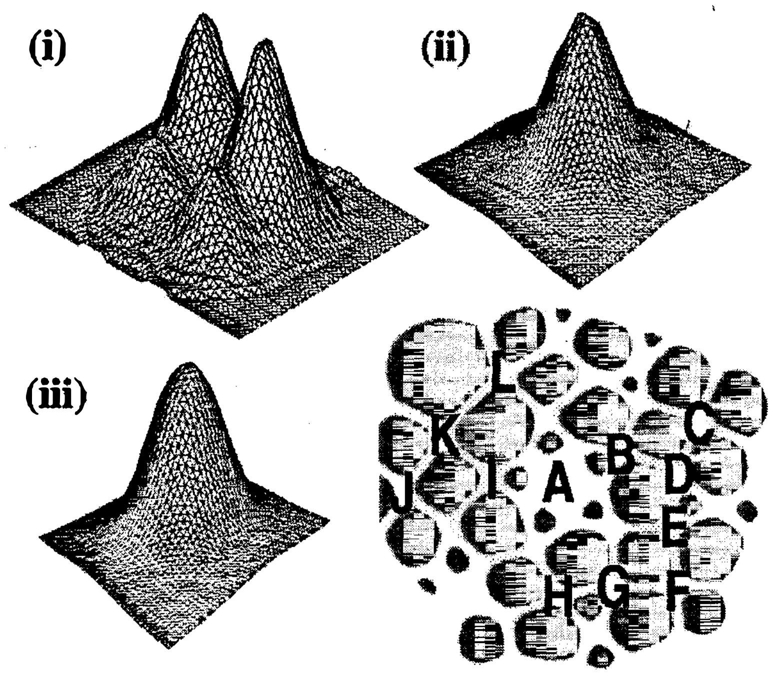

Fig. 2. SEM of fibre with (i) mode profile of core A at 488nm, (ii) mode profile of core K at 488nm and (iii) mode profile of core F at 633nm.

on the scale of the wavelength. Three illustrative examples of these rules are given here. Core K guides at 488nm and 633nm while core F only guides at 633nm, due to the fact that one support at F is too wide. Similarly, I and B guide at 488nm but not at 633nm since two of the supports are short. No secondary cores guide at 1550nm as none have long enough support structures.

Table 1. Details of core and support dimensions and light guidance (dimensions are $\pm 0.05\mu m$). • Guidance, × No guidance, ○ Leaky guidance. Cores G and H together support a single spatially extended mode in the visible wavelengths.

Core	Smallest dimension [μm]	Shortest support [μm]	Widest support [μm]	488nm	633nm	1550nm
A	3.40	-	-	•	•	•
B	1.20	1.13	0.53	•	○	×
C	1.47	2.10	0.60	•	•	×
D	1.24	1.13	0.60	•	○	×
E	1.43	1.05	0.60	○	○	×
F	1.50	1.56	0.68	○	•	×
G	1.35	1.28	0.60	○	•	×
H	1.24	1.28	0.60	○	•	×
I	1.43	1.13	0.49	•	○	×
J	1.20	1.65	0.64	•	•	×
K	1.43	2.40	0.60	•	•	×
L	1.58	2.03	0.79	×	○	×

Many applications which can be envisioned for this fibre type depend critically on the size of the fibre core and the air fill fraction. Such fibres display highly unusual properties, such as anomalous dispersion at short wavelengths and high optical non-linearity [3]. In addition, the calculated overlap between the modal field and the air for a core with the same dimensions as K is 17% at 1550nm demonstrating that these cores can act as efficient evanescent field devices [4].

The selectable assortment of cores in this fibre range in size from 1.2μm to 3.4μm and thus provide a wide range of optical properties, within a single fibre, from which it is possible to pick and choose. In future the fabrication of optical fibres with an even greater range of core sizes should be attainable by increasing the range of tube dimensions, allowing great flexibility in device design.

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