FIBRE LASERS

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Abstract

A review is given of the continuing rapid progress of optical fibre lasers in a number of directions, including visible upconversion lasers, high power (multiwatt) lasers, single frequency lasers and mode-locked lasers.

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Rare-earth doped optical fibre lasers continue to make rapid progress in a number of directions. This recent progress will be reviewed. Particularly prominent areas of progress include upconversion visible lasers, high power lasers, and lasers operating either as single frequency devices or mode-locked devices.

Visible upconversion fibre lasers have so far been demonstrated only in heavy metal fluoride glasses, chosen for their low phonon energies so that nonradiative multiphonon decay rates from excited states are reduced. These same glass fibres (such as, so-called, ZBLAN) are being intensively developed as part of a programme aimed producing an optical fibre amplifier to operate at 1.3 μm. Improvements in fibre quality resulting from this amplifier development bring immediate benefits to the performance of upconversion fibre lasers, and demonstrations have already been given of efficient blue, green and red sources which can be pumped by infrared diode lasers.

While silica fibres and ZBLAN fibres have so far dominated the fibre laser field, there is increasing effort aimed at developing new glasses. Glasses with even lower phonon energies than those of ZBLAN offer prospects of improved performance for the 1.3 μm amplifier and also prospects for infrared fibre laser sources out to ~ 5 μm, beyond the 3.4 μm so far achieved from ZBLAN. In some circumstances multiphonon decay can be of use in rapidly channelling population into a desired level, so that a given pump/laser scheme may call for a specific, optimum value for the maximum phonon energy. An example of this occurs in Thulium doped glasses and to meet this need for a specific phonon energy maximum, intermediate between those of silica and ZBLAN, a new glass, based on lead germanate, has been developed at Southampton and successfully demonstrated as a fibre laser. Besides introducing a new class of glass fibre material, this development demonstrates the versatility of glass in allowing a broad range of material parameters to be adjusted and optimised.

Early work on glass fibres was aimed at exploiting the fact that the glass medium was passive, i.e. free from interaction with the propagating light other than simply guiding it. Rare-earth doped optical fibres have provided an important departure from this passive role and increasingly the glass fibre medium is now seen to offer active properties and a capability for having its properties modified and controlled by light. Mode-locked fibre lasers provide a good example of this trend, where the $\chi^{(3)}$ nonlinearities are exploited to shape the propagating pulses, for example into soliton pulses. Another aspect of fibres which is currently attracting much attention centres around the capability for 'writing' photorefractive gratings directly into the fibre core. These fibre gratings can provide very high reflectivity, with a narrow reflection bandwidth, and so are suitable for filters and reflectors. Used as reflectors for a fibre laser the high reflectivity and wavelength selectivity has proved very effective in enforcing narrow linewidth operation of fibre lasers well into the wings of the gain profile, thus allowing the broad tuning range to be exploited. Short fibre lasers with two grating reflectors have proved a very simple and convenient means of achieving single frequency operation. The availability of such gratings is a further significant step for fibre laser devices, towards the goal of all-fibre devices of a highly versatile nature with a broad range of functions all incorporated into the single fibre medium.