observed in [5]. To overcome this problem, the grating should produce substantially longer pulses, thus reducing the peak power of the amplified pulses before recompression.

In conclusion we have demonstrated a diode pumped, all-fibre scheme for chirped pulse amplification. The pulses were recompressed to subpicosecond durations with maximum average powers of ~5mW and peak powers of 1.7kW, which were effectively limited by the effect of self-phase modulation in the experimental configuration employed. This nonlinearity severely limited the operation of the device and to fully utilise the high power capability inherent to the system, considerably longer chirped pulses will be required. These improvements are being investigated, incorporating a diode pumped amplifier with a 30dBm average power delivery capability.

Following submission of this manuscript, a similar experimental scheme was reported by Galvanauskas *et al.* [6]. However, our configuration employs low loss gratings, does not exhibit high loss on output coupling (through using our novel fibre polarisation division multiplexer [4]) and has the capability of substantial high output power operation.

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Enhanced photosensitivity in lightly doped standard telecommunication fibre exposed to high fluence ArF excimer laser light

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Indexing terms: Excimer lasers, Photorefractive effect

The core refractive index of Corning SMF-28 optical fibre exposed to ArF laser pulses increases with the square of the fluence per pulse. Bragg gratings with a refractive index modulation amplitude higher than 10^{-3} have been obtained. This is an order of magnitude improvement over previously reported values for this type of fibre in the absence of treatment to enhance the photosensitivity.

Photosensitivity in germanium-doped silica fibres was discovered by observing the formation of Bragg gratings in fibres exposed to intense blue light at 488nm from an argon ion laser [1]. Subsequently, the origin of the phenomenon [2] was linked to the presence of an absorption band near 242nm occurring in oxygen deficient germania glass [3] through the two-photon dependence of the induced refractive index changes [4]. Later, highly efficient grating writing techniques were developed using in-band bleaching with ultraviolet light [2, 5]. A widely used interpretation for the photosensitive effect consists of the photogeneration of carriers by bleaching of the 242nm band, with subsequent trapping of the carriers at different defect sites, thereby changing the ultraviolet absorption spectrum [6]. Refractive index changes are associated with these absorption changes through Kramers-Kronig causality. Apart from using special fibres with a higher germanium concentration, it was discovered that the process could be enhanced by flame brushing [7], or by low temperature hydrogen loading [8]. More recently, new experiments have shown different photosensitive mechanisms in which ArF excimer laser light with a wavelength of 193nm is used to induce refractive index changes in doped silica fibres and waveguides [9, 10]. In these cases, carriers are photogenerated by absorption in the tail of a band located near 185nm which is also associated with oxygen deficient bonds [3, 10]. In this Letter, we report yet another type of photosensitive process for *untreated* silica fibres with a small germanium dopant concentration, such as Corning SMF-28 telecommunication fibre. Because the linear absorption at 193nm is small in this fibre, a very efficient nonlinear process is possible, leading to refractive index modulations reaching 10^{-3} in untreated fibre. This value represents an improvement of one order of magnitude over reported results for this fibre (in the absence of sensitising treatment) [7].

A Lumonics excimer laser filled with an ArF gas mixture and operating at 50pulse/s with a fluence per pulse of $60 mJ/cm^2$ was used in the experiments. A focusing system was used to vary the fluence incident on the fibre between 230 and $1200 mJ/cm^2$. Bragg gratings were imprinted in SMF-28 fibres with a zero-order-nulled phase mask [5], and the reflectivity of the gratings was monitored in real time during the exposure. The time evolution of the refractive index modulation calculated from the reflectivity is plotted in Fig. 1 for four different writing fluences. With this mask, the maximum index modulation achieved is 9.1×10^{-4}. Furthermore, we have verified through microscopic observation and the evaluation of short wavelength loss to cladding modes that the index modulation obtained is definitely of type I, i.e. a uniform refractive index increase across the fibre core, and not type II which implies a damage mechanism at the core-cladding interface exposed to the incoming light beam [11].

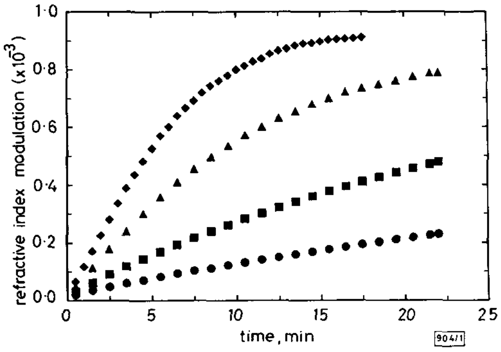

Fig. 1 *Growth of refractive index modulation against writing time for Bragg grating resonant at 1.56µm in SMF-28 fibre using ArF excimer laser operating at 50pulse/s*

Fluence per pulse incident on the fibre
● $198 mJ/cm^2$
■ $354 mJ/cm^2$
▲ $480 mJ/cm^2$
◆ $650 mJ/cm^2$

The origin of this large photosensitive effect may be clarified by plotting the growth rate of the refractive index modulation in terms of the writing fluence. If the refractive index modulation Δn increases as CI^pt (where C is a constant, I is the fluence and t is the writing time), then the growth rate $d(\Delta n)/dt$ is proportional to I^p. Fig. 2 shows the initial growth rate, calculated from the time required to reach an index modulation of 1.7×10^{-4}, and a power

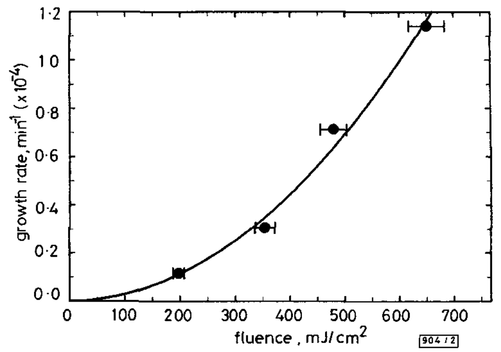

Fig. 2 *Growth rate of refractive index modulation against writing fluence*

● data
——— least squares fit CI^b
$C = 3.13 \times 10^{-10}\text{min}^{-1}$, $b = 1.98$

law fit to the data. The best estimate for the parameter b is 1.98, meaning that the refractive index modulation increases with the square of the fluence: a good indication for a two-photon process. Experiments and further data analysis are in progress to verify this hypothesis. It is possible that the two-photon process is allowed in this type of fibre because the linear absorption is very small near 193nm (less than 0.02dB/µm) [12]. Furthermore, it was verified that no noticeable absorption increase occurred at the writing wavelength during the exposure. Therefore, we believe that the carriers are generated by direct excitation in the bandgap of silica (two 193nm photons have an energy of 12.8eV, while silica has a band gap near 10eV); the carriers are then trapped at defects associated with the presence of germanium in the core. We note that no effect is observed in the pure silica cladding of the fibre for fluences below 1J/cm^2.

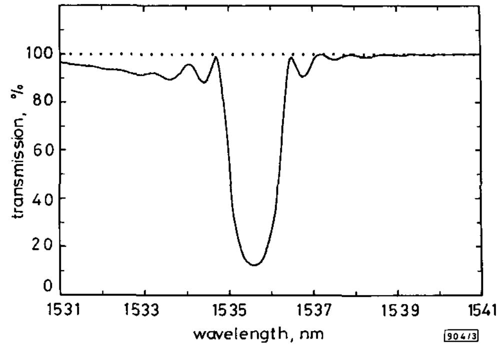

Fig. 3 *Transmission spectrum of 0.95mm long Bragg grating in SMF-28 fibre written with fluence of 650mJ/cm^2 at 50pulse/s for 30min*

To find the maximum index modulation achievable by this technique, we used a phase mask with improved zero-order-nulling to fabricate a 0.95mm long Bragg grating as shown in Fig. 3. The peak reflectivity is 87.5%, which corresponds to a sinusoidal index modulation amplitude of 1.1×10^{-3}. To our knowledge, this is the highest reported value for this fibre without treatment.

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Frequency and tuning characteristics of passively modelocked semiconductor lasers operated at 77K

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Indexing terms: Laser modelocking, Laser frequency stability, Laser tuning, Semiconductor junction lasers

The authors examined experimentally and theoretically the frequency stability and tunability of passively modelocked monolithic-cavity semiconductor lasers operating at cryogenic temperatures. Compared with their characteristics at room temperature, these lasers show an increase in the parameter range for modelocking to occur, as well as an order-of-magnitude improvement in the tuning range when operated at 77 K.

Monolithic-cavity passively modelocked semiconductor lasers have been used to efficiently generate short pulses at millimetre-wave frequencies [1 – 4]. However, their frequency and timing stabilities are limited by the random fluctuations of spontaneous emission from which the pulses originate and, therefore, the RF spectrum linewidths are typically in the megahertz range. Also, the modelocked frequencies of these lasers are determined by their cavity lengths so are fixed once the cavity is cleaved; they can be tuned typically only over a few tens of megahertz by adjusting the applied bias levels. A schematic diagram of such a monolithic-cavity laser is shown in Fig. 1 along with the theoretical gain/loss against carrier density curves at various temperatures. For the same output power, the differential gain difference between the gain and absorber section increases as the ambient temperature decreases. Therefore, improved performance for these devices at cryogenic temperatures is expected. Refrigeration is permissible for certain space and military applications and, also, the low-temperature gain characteristics of the quantum well (QW) medium can be reproduced at room temperature by proper QW band-structure