974

Additive Pulse Compression Modelocking Using Nonlinear Polarization Evolution

M.H, Ober, M. Hofer, F. Haberl, M.E. Fermann, A.J. Schmidt and J.D. Minelly+

Abteilung Quantenelektronik und Lasertechnik, IAEE
Technische Universität Vienna
Gusshausstr. 27/359/9, A-1040 Vienna, Austria
Tel. (0222) 58801 Ext. 3879

+Optical Fibre Group
Southampton University
Southampton SO9 5NH, U.K.

Single-mode rare-earth-doped fibers[1] are an ideal medium for the generation of ultra-short pulses. Long interaction lengths for nonlinear processes allow a very effective exploitation of nonlinear intra-cavity pulse-shaping mechanisms and allow to mode-lock the full glass laser bandwidth even in the presence of dominant inhomogeneous broadening. Stable femto-second pulse generation in fiber lasers generally requires the presence of both passive frequency- and amplitude modulation to be present in the cavity[2]. Passive frequency modulation is obtained by self-phase modulation in the presence of overall negative group velocity dispersion (-GVD) and amplitude modulation is induced by an intra-cavity nonlinear pulse- shaping mechanism[2]. In a slightly linearly birefringent fiber non-reciprocal pulse shaping is most conveniently obtained by using nonlinear polarization evolution[3]. In this a polarizer is inserted into a dispersioncompensated fiber laser cavity. By differential excitation of the (linear) polarization eigenmodes of the fiber passive amplitude modulation is then obtained via cross and self-phase modulation. The required polarisation evolution in the fiber is selected by pressing the fiber piezoelectrically and dispersion compensation is achieved by using a prism pair.

Due to residual etalons in the cavity a weak modulation from an inserted $LiNbO_3$ amplitude modulator was required to start the passive pulse forming process. Once the polarisation in the fiber was properly adjusted and pulses were obtained the modulator was switched off and stable pulses generated for hours without need for any further adjustments. We used a length of 24 cm of standard silica fiber doped with 1700ppm Nd^{3+} and a core diameter of 5μm. With 130mW of absorbed pump power we obtained 10mW of modelocked power at 1.064μm even after months of using exactly the same fiber piece. The details of this cavity design and possible improvements will be discussed at the conference. The obtained pulse widths as a function of overall GVD are shown in Fig. 1. It may be seen that modelocked operation is possible with both positive and negative GVD. Note that an internal pulse-compression factor of $\approx$ 10 was measured between the longest and shortest pulse present in the cavity. An autocorrelation trace obtained for the shortest generated pulses is shown in Fig. 2. Assuming a $sech^2$ shape a pulse widths of 45$fsec$ is obtained with a time-bandwidth product of 0.45. We also succeeded in obtaining femtosecond pulses from high gain neodymium-doped soft-glass (F2/F7) fibers and preliminary results will be presented at the conference. In summary we have obtained the shortest pulses produced from a solid-state laser so far (to our knowledge) and have demonstrated modelocking in soft-glass fibers for the first time. We believe that due to the unique simplicity of the system fiber lasers have great potential for future all solid-state femtosecond lasers.

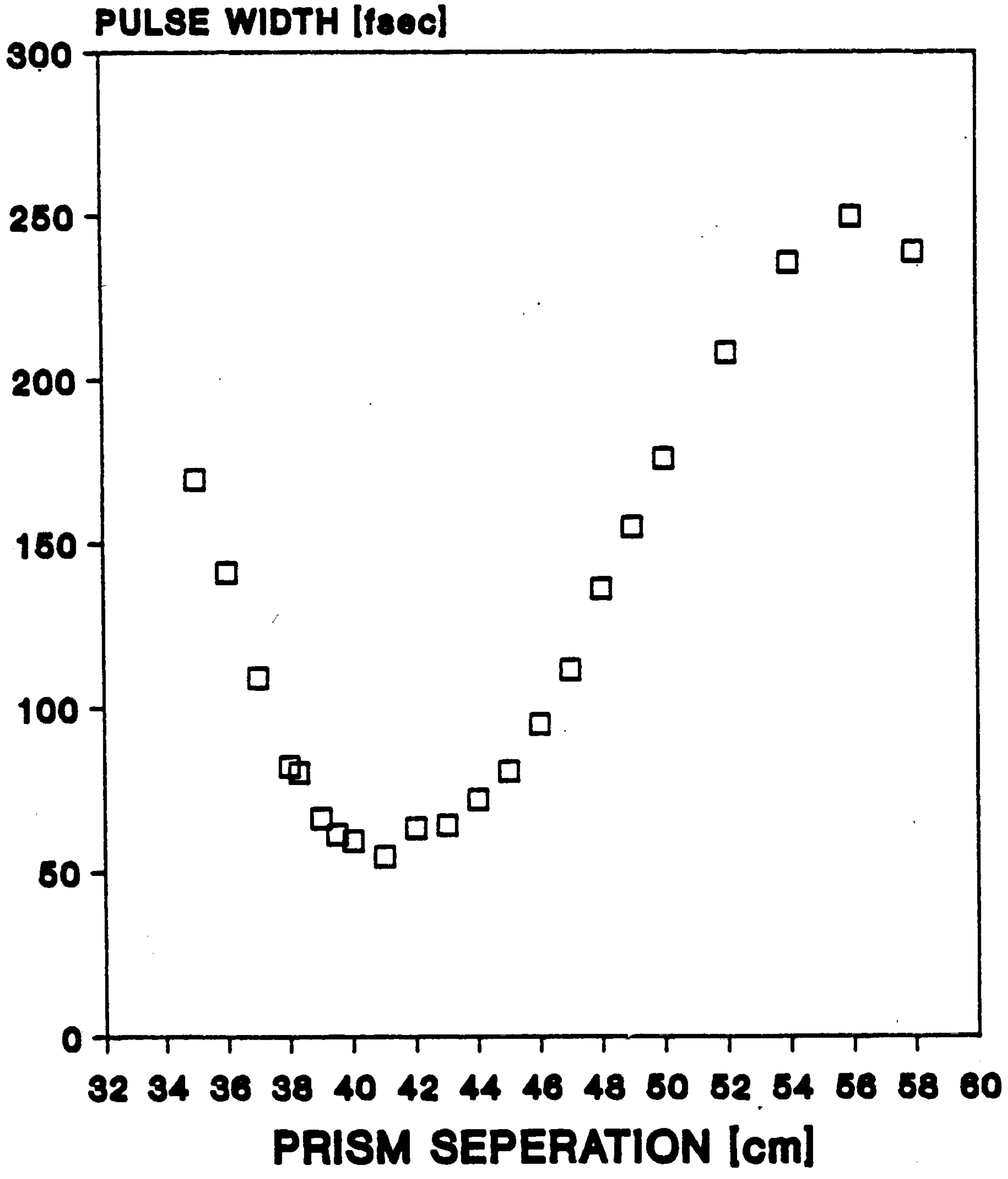
This work was supported by the Fonds zur Förderung der wissenschaflichen Forschung in Österreich, project Nos. P8024-TEC

References

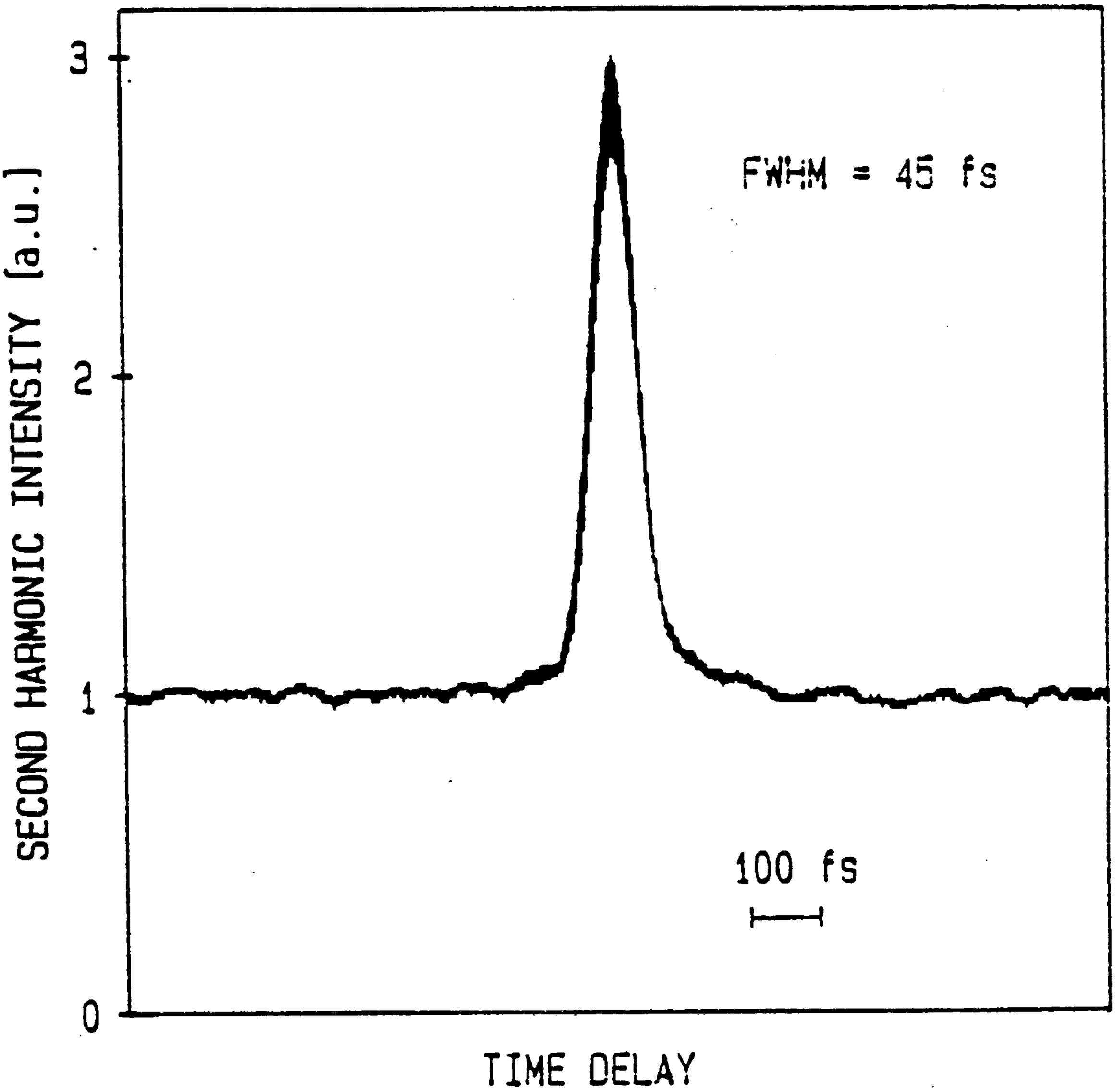
1. S.B. Poole, D.N. Payne and M.E. Fermann, Electron. Lett., **21**, 737, (1985)

2. M.E. Fermann et al., 'Additive Pulse Compression Modelocking of a Neodymium Fiber Laser', to be publ. in Opt. Lett., Feb. 91

3. M. Hofer et al., 'Modelocking Using Cross and Self-Phase Modulation', to be publ. in Opt. Lett. 1736 (1989)



1. Pulse-widths as a function of prism separation in a modelocked silica fiber laser.



2. Autocorrelation trace of a $45 fsec$ pulse (assuming a $sech^2$ shape) obtained with optimum intra-cavity chirp compensation and polarization setting.