Picosecond Pulse Generation and Propagation in Erbium Doped Optical Fibres

by

Paul Bollond

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Abstract

This thesis is concerned with the generation of picosecond pulses and their propagation through both resonant and non-resonant media. This was achieved by constructing a passively modelocked Erbium doped fibre laser (EDFL) which was used to study pulse propagation through sections of standard communications grade optical fibre, dispersion shifted optical fibre, and also through an Erbium doped fibre amplifier (EDFA) module.

The EDFL produced a train of ~ 2 psec pulses at 4 MHz, tunable over the erbium gain band (1520 - 1570 nm). The laser was constructed from commercially available components and had the property of stability combined with low pump power requirements to produce ~50 Watt peak power pulses. The laser cavity geometry included a nonlinear optical loop mirror, which has the property of efficiently switching high peak power pulses, and allowed pulsed operation without the aid of any high-speed electronics.

An EDFA module of identical geometry to that used in the laser was also constructed, and this was probed using the pulses from the EDFL. The traditional temporal and spectral measurements were found to be inadequate to allow a complete description of the pulse amplification process to be developed. To overcome this problem the technique of frequency resolved optical gating (FROG) was applied for the first time to optical fibre research, and allowed an indirect measurement of the electric field of the pulse. This complete description of the pulse was used in a numerical model to describe pulse propagation in an optical fibre. Fundamental propagation terms in the model were treated as free parameters in a minimisation scheme, which could be determined for a fibre under examination. This technique was shown to be accurate when used to examine pulse propagation through both standard and dispersion shifted optical fibre.

A comprehensive numerical model was developed for the EDFA, and it was apparent from this model that a pulse propagating through an optimised EDFA encounters an atomic inversion distribution which is a strong function of distance along the amplifying fibre. It was also shown from the experimental results that the EDFA exhibited resonant dispersion, which is characteristic for propagation through an atomic medium on resonance.

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Abbreviations

APC	Angled Polished Connector
ASE	Amplified Spontaneous Emission
BBO	β-Barium Borate
CW	Continuous Wave
DS	Dispersion Shifted
EDF	Erbium Doped Fibre
EDFA	Erbium Doped Fibre Amplifier
EDFL	Erbium Doped Fibre Laser
ESA	Excited State Absorption
F8L	Figure of Eight Laser
FROG	Frequency Resolved Optical Gate
FWHM	Full Width at Half Maximum intensity
GSA	Ground State Absorption
GVD	Group Velocity Dispersion
MFD	Mode Field Diameter
MI	Modulational Instability
NA	Numerical Aperture
NALM	Nonlinear Amplifying Loop Mirror
NLSE	Nonlinear Schrödinger Equation
NOLM	Nonlinear Optical Loop Mirror
OMA	Optical Multichannel Analyser
PC	Polarisation Controller
SAM	Self Amplitude Modulation
SHG	Second Harmonic Generation
SMF	Single Mode Fibre
SPM	Self Phase Modulation

SS	Self Steepening
WDM	Wavelength Division Multiplexer
WPS	Weak Pulse Shaping
ZDW	Zero Dispersion Wavelength