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Review of erbium fibre laser based nonlinear optics in periodically poled lithium niobate (PPLN)

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Abstract

Recent developments in the use of erbium doped fibre laser to carry out nonlinear optical experiments in periodically poled materials are reviewed. The increased peak-powers and pulse energies available from improved rare-earth doped fibre designs coupled with the high nonlinearities available in periodically poled lithium niobate (PPLN) have allowed a range of interesting and novel experiments to be carried out. This paper reviews the progress in this area and highlights the opportunities it provides.

The advent of high power lasers based around erbium doped optical fibres together with the development of highly nonlinear materials such as PPLN is resulting in a convergence between nonlinear optics and the capabilities of optical telecomm components. The low cost of components available for use at 1.55 microns together with efficient fibre laser sources pumped by laser diodes makes it an attractive combination for the commercial exploitation of nonlinear optics. We will review the work carried out to date on the combination of erbium fibre sources with PPLN.

A range of experiments have been carried out, with the simplest being highly efficient second harmonic generation in PPLN starting from a nanosecond pulse erbium fibre laser (83% single pass conversion efficiency). This high conversion efficiency is a result of careful control of the laser temporal profile. At such high conversion efficiencies parasitic back conversion processes are seen to occur.

In terms of complexity, the next simplest experiments have involved optical parametric generation and optical parametric amplification, in these experiments very high single pass gains (around >90dB) are obtained resulting in new, and as yet unexplained optical phenomenon, in particular, a frequency shift of around 0.7nm in optical parametric amplification at 1.3 microns.

The final class of experiments reported has involved optical parametric oscillators (OPOs) either directly pumped at 1.5 micron or pumped using a cascaded scheme with the second harmonic of the fibre laser being used to pump the OPO. Such devices have many attractive features including, simplicity, high conversion efficiencies, and most notably pump tunability where a small degree of pump tuning leads to a much larger signal tuning (typically a factor of 8 was achieved).