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Stable, singly resonant operation around degeneracy in a synchronously-pumped parametric oscillator by use of a diffraction-grating

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In recent years periodically poled lithium niobate (PPLN) has become a very useful and prominent material for use in optical parametric oscillators (OPO's) and other nonlinear optical devices. The large nonlinearity of PPLN, combined with the high peak power available from short pulse cw modelocked lasers allows a very large parametric gain to be achievable in synchronously pumped OPO's. Close to degeneracy the gain bandwidth of these devices becomes very large and, theoretically, it is possible to tune the output wavelengths over a very wide range while maintaining a fixed temperature and domain grating period. However, when OPO's are operated close to degeneracy, there is a tendency to display doubly-resonant oscillation (DRO), with its well-known undesirable features of amplitude and frequency instability. We propose the use of a diffraction grating, as a frequency-selective reflector, to enable singly resonant operation over a wide range around degeneracy.

In this paper we report on results obtained by equipping a PPLN OPO, pumped by a 4ps, 120 MHz Nd:YLF laser at 1047nm, with a diffraction grating as one of its reflectors, thus providing sufficient frequency discrimination to allow singly resonant operation very close to degeneracy. A diffraction-grating proves to be very well suited to tuning in a synchronously pumped OPO since the grating bandwidth appropriate to the spectral width of picosecond pulses is readily achieved and the grating losses are modest and easily accommodated by the high gain achievable from a synchronously pumped OPO using PPLN. Also, the broad gain bandwidth close to degeneracy offering an extensive tuning range, can be conveniently covered simply by rotating the grating. The range we have covered in this way is from 1900 to 2300nm (except for a very narrow range, ~6nm, around degeneracy). Fig.1 shows the signal tuning range achieved with a PPLN crystal of 30.4μm period, held at a temperature of 190°C. The pump depletion is also shown. The good beam quality of the signal is confirmed by a measured M^2 of 1.16. A measurement of the spectral width and pulse duration (via extra-cavity SHG auto-correlation) gives a time-bandwidth-product of 0.46, close to the calculated value of 0.44 for a Gaussian pulse. This agile and simple tuning over a wide range (~700cm^{-1} in our case) greatly enhances the practical utility of PPLN OPO's for a variety of spectroscopic applications.

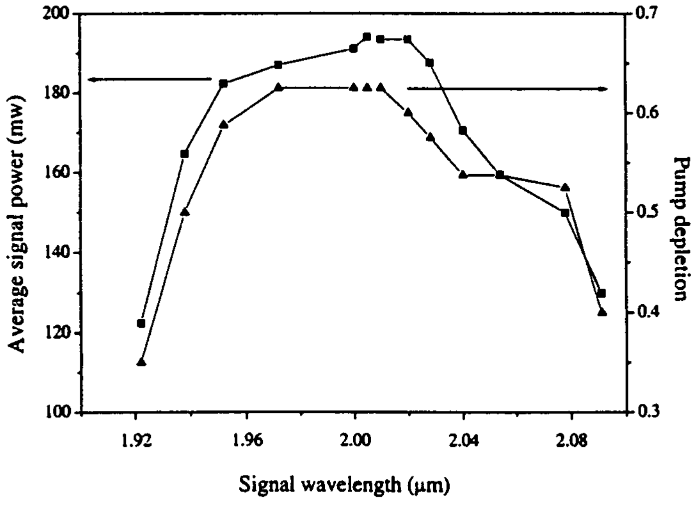

Fig.1 Average output power (squares), and pump depletion (triangles) versus signal wavelength for a PPLN crystal of 30.4μm period, held at 190°C.