주기적으로 분극반전된 $LiNbO_3$ 결정에서 광매개증폭

Optical Parametric Oscillation in Periodically Poled Lithium Niobate Crystal

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Optical parametric oscillator(OPO) has been used to generate coherent and tunable laser source with birefringent phase-matching technique in various nonlinear materials. In birefringent phase-matching, the output wavelength is controlled with angle or temperature tuning of the refractive index. However these tuning methods have several limitations such as restriction of tuning wavelength due to reasonable angular and temperature tuning ranges, Poynting vector walk-off which limits the interaction length, and thermal stabilization time. In addition, birefringent phase-matching cannot operate with the largest element of the nonlinear susceptibility(d_{33}). Quasi-phase matching(QPM), in which the nonlinear susceptibility is periodically modulated, is an alternative technique to birefringent phase-matching for compensating phase velocity dispersion in frequency conversion applications. The advantages of QPM are that any interaction within the transparency range of the material can be noncritically phase matched at a specific temperature and utilization of d_{33} nonlinear coefficient. The QPM method was suggested by Armstrong et. al. in 1962[1], but experimentally demonstrated for second harmonic generation[2] and OPO[3] in 1990s because of technical difficulty of making periodic grating structure in ferroelectric crystals. In this paper we report an OPO operation by use of QPM in a bulk periodically poled $LiNbO_3$(PPLN) crystal. The experimental setup is shown in Fig. 1.

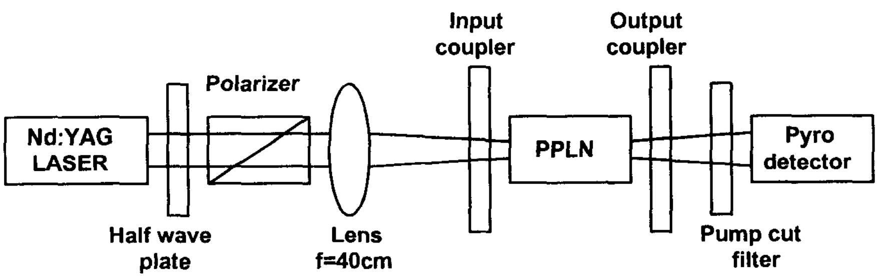

Fig. 1. Experimental setup for PPLN OPO.

The PPLN crystal(0.5mm thick, 19mm long) for the OPO experiment was fabricated by Crystal Technology Inc. with electric field poling process, and consisted of seven different grating periods from 25.9μm to 28.7μm in 0.5μm steps. The pump source was a Q-switched Nd:YAG laser operating at 1.064μm with 10ns pulse width and repetition rate of 10Hz. The laser was loosely focused to a 170μm beam waist in the PPLN. The two cavity mirrors as a singly resonant oscillator(SRO) were flat and separated by 23mm. The mirror reflectivities at the signal wavelength were 99% and 95% for the input and output coupler, respectively, with about 10% reflectivity for the pump wavelength. We controlled the output signal wavelength from 1.36μm to 1.46μm at room temperature by translation of the crystal through the resonator using different grating periods. The measurement of the signal energy at 1.36μm(corresponding period of 25.9μm) with varying pump energy is shown in Fig. 2. The OPO threshold was 0.3mJ and maximum energy conversion efficiency was about 11% at input energy of 0.9mJ which is just below the optical damage threshold.

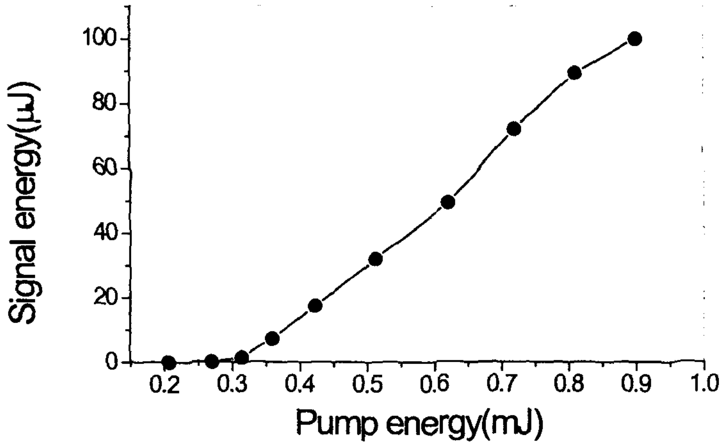

Fig. 2. OPO output signal energy versus input pump energy at signal wavelength of 1.36μm.

In summary, we have demonstrated a widely tunable(1.36μm~1.46μm) QPM OPO using multigrating(grating period of 25.9μm~28.7μm) bulk PPLN crystal fabricated by electric field poling.

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Reference

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