FK3 Singly resonant synchronously pumped optical parametric oscillator using potassium titanyl phosphate

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Although potassium titanyl phosphate (KTP) has been widely used to double 1.06-μm radiation, little work has so far been directed toward its use in an optical parametric oscillator (OPO). Doubly resonant oscillation in a KTP OPO has been reported.[1] Here we report the first demonstration of a singly resonant synchronously pumped OPO using KTP.

KTP provides an interesting candidate for a synchronously pumped OPO, since with its low walk-off for 0.532-μm pumping and its high nonlinearity, it offers the possibility of practical realization of cw mode-locked operation in a singly resonant oscillator. It is with this ultimate possibility in mind that we investigated the performance of a KTP synchronously pumped OPO.

So far we have used a much larger spot size than the limiting value imposed by walk-off, since in these initial investigations the main aim has been to establish the threshold and damage-free operating intensities. This has resulted in a much higher pump power requirement than would be necessary for the optimum focusing scheme, and we have, therefore, pumped with the amplified and frequency doubled output of a mode-locked and *Q*-switched Nd:YAG laser. After amplification the energy available was ~35 mJ in a ~150-ns (FWHM) train of about twenty-two pulses, each of ~85-ps FWHM. This was then doubled in a DKDP crystal, resulting in ~5 mJ of 0.532-μm radiation being available at the input of the KTP crystal.

The 6-mm long crystal was of Chinese origin (Anhui Institute). It was located at one end of the OPO resonator, which had an optical length closely matched to that of the laser oscillator to allow synchronous pumping. Both mirrors had high (>99%) reflectivity over most of the tuning range, so singly resonant operation had to be enforced by Brewster plates inserted in the resonator. As the interaction was type II, the generated waves had orthogonal polarizations, and the Brewster plates transmitted one while attenuating the other.

Oscillation threshold was observed for a pump train of ~1.8 mJ, which with a pump spot size of 0.35 mm in the crystal, corresponded to a peak intensity (on-axis, of the most intense pulse) of ~650 MW cm^{-2}. This agrees well with the value of 580 GW cm^{-2} calculated using the analysis of Brosnan and Byer.[2] This value can be considerably reduced since the reflection loss in this resonator from uncoated surfaces was ~50%/round trip.

The following measurements were made while operating at ~3 times above threshold, which corresponded to a peak intensity of ~2 GW cm^{-2}. This is considerably higher than the more pessimistic damage limits quoted for KTP of ~400 MW cm^{-2}, but there has been no sign of damage after over 30 h of operation.

Our investigation of the tuning range has been confined to rotation of the crystal in the *x-y* plane, since this preserves the low walk-off condition. An angle change (internal) of 15° tuned the oscillator from 1.04 to 1.09 μm. This agrees well with values calculated using refractive indices generated by the Sellmeier equation after Fan *et al.*[3] Monitoring pump depletion gave an overall energy conversion efficiency of up to ~30% with a peak value of ~40%.

Current efforts are now being directed to operation with much tighter focusing, so that threshold pump power can be greatly reduced. **(12 min)**

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3. T. Y. Fan, C. E. Huang, B. Q. Hu, R. C. Eckardt, Y. X. Fan, R. L. Byer, and R. S. Feigelson, Appl. Opt. **26,** 2390 (1987).