High-efficiency, broadly tunable, tandem optical parametric oscillators

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Outline

Experimental layout of the 1-μm Nd:YLF pump laser

Simultaneous difference-frequency and parametric generation in the KTA OPO

Injection-seeding of single-frequency radiation

4-kHz-repetition-rate Tandem OPO

Summary
Tandem OPO design

1053-nm Nd:YLF MOPA

Angle-Tuned KTA OPO

NCPM CdSe OPO

1.5 - 3.6 μm

3 - 5 & 8 - 12 μm

Nd-doped seed laser

IR seed source

IR seed source
Q-switched Nd:YLF ring laser with image rotation and injection locking
Seeded Tandem OPO experimental setup

Nd:YLF MOPA System

1-μm cw seed laser

Beamsplitter

KTA OPO

1.55-1.65-μm seed laser

2.1 - 3.6 μm
KTA OPO idler

CdSe OPO

3-5 μm & 8-12 μm
output

Piezo-translator

3-5 μm & 8-12 μm
output
KTA OPO wavelengths and output energies at 200-mJ pump

Signal range 1573 - 2066 nm
Idler range 2167 - 3184 nm

Output pulse energy (mJ)

Wavelengths (μm)

Total energy
Signal energy
Idler energy
Signal wavelength
Idler wavelength
Phase-Matching Angles of OPO and DF crystals

Signal Wavelength (um)

Theta (degrees)

1053 nm pump, KTA crystal

- OPO crystal
- DFG crystal
Idler and DFG wavelengths vs signal wavelengths
Idler pulse energy w/t DFG: 12.5 mJ @ Degenerate Angle $\Theta = 61^0$

Idler and DFG pulse energies: 15 mJ and 1.25 mJ, respectively.

Signal wavelength 1688 nm

DFG wavelength 2800 nm

Idler wavelength 4255 nm
KTA OPO Pumped by seeded and unseeded MOPA

![Graph showing KTA OPO total output energy (mJ) vs. Pump energy (mJ)]

- **Seeded pump**
- **Unseeded pump**
Interferograms of the KTA OPO signal beam

KTA OPO cavity mode spacing: 3.75 GHz
- Signal: 1557.68 nm
- Idler: 3250.24 nm

Fabry-Perot interferometer:
- Resolution: 0.75 GHz
- Free Spectral Range: 21.5 GHz

KTA OPO seeded
\( \delta \nu < 0.75 \text{ GHz} \)

KTA OPO unseeded
\( \delta \nu \approx 10 \text{ GHz} \)
Oscilloscope traces of idler output pulses
4 kHz Diode-Pumped Nd:YLF MOPA design
KTA OPO output vs 1-μ pump power at 4 kHz PRF
Summary

- We have demonstrated a single-frequency, broadly tunable OPO source.
- Difference-frequency generation between the KTA signal and idler provided a 20% increase of the idler.
- Injection seeding of the laser source provided a 10% increase of the OPO efficiency.
- A 50% enhancement was achieved when the pump wavelength was resonant for the OPO cavity.
- We have demonstrated a highest-pulse-rate CdSe OPO ever operated.