Recent Studies on Nonlinear Crystals Generating Mid-Infrared Parametric Light

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1. Context

Nowadays, there is a real need in all solid-state sources able to emit a high energy and tunable coherent light in the mid-infrared range, for various applications. It is the case of spectroscopy and detection of molecules from the atmosphere, for example.

The best alternative is the generation of parametric light from a second order frequency down-conversion process in a nonlinear crystal. In such a process, signal and idler beams, at the corresponding wavelengths λ_s and λ_i, are generated using as a pump beam with a monochromatic wavelength λ_p emitted by a commercial laser [1, 2].

The requested performances of nonlinear crystals are the widest transparency range, a high damage threshold, phase-matching conditions and large associated nonlinear coefficients, over the mid-infrared [2].

2. Nonlinear crystals are not satisfactory

However, the choice of crystals with such performances is rather limited. For an emission of mid-infrared parametric light covering Band II of transparency of the atmosphere (2 μm - 5 μm), $KTiOPO_4$ (KTP) and a periodically poled $LiNbO_3$ (PPLN) are the two crystals mainly used. It is ZnGeP2 (ZGP) or $CdSiP_2$ (CSP) crystals when the emission covers Band III (5 μm - 8 μm) [1].

Then, the selection of new nonlinear crystals remains of prime importance but it relies on their full characterization especially of the optical properties mentioned above.

3. Our unique methods to evaluate new the nonlinear optical properties of crystals

By using the sphere and slab methods we developed many years ago, we provide direct measurements of conversion efficiencies under phase-matching conditions [3, 4].

Recently they were also recorded out-of phase-matching conditions by using our newly implemented tunable fringes method.

All these data can be used *per se*. But they also lead to the determination of the main parameters of the studied crystal with the best accuracy *i.e.* the value of the principal refractive indices as a function of wavelength [4], and the magnitudes [3] and relative signs of all the non-zero elements of the second-order electric susceptibility.

Using the main parameters, we also calculate tuning curves associated with maximal conversion efficiency for the generation of mid-infrared parametric light in a device using the crystal.

4. The full characterization of the new BGSe nonlinear crystal

With our unique methods, we recently fully characterized the nonlinear optical properties of the new $BaGa_4Se_7$ (BGSe) nonlinear crystal that is transparent between 0.47 and 18 µm [3, 4].

The goal of this talk is to give an overview of this work, and to show our calculations for the generation of mid-infrared parametric light using the main parameters of BGSe we determined.

References

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