HeXLN, the first 2D nonlinear photonic crystal

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Linear photonic crystals are crystal in which the linear susceptibility of the material (χ^1 or the index of refraction, n) is varied periodically. This periodic variation means that the modes of propagation for certain wavelength are strongly influenced by the structure. One example is a fibre Bragg grating, where the Bragg resonance reflects light within the bandwidth. The resonance condition in the crystals is often expressed in terms of k-space, where the k vector of the light must match a reciprocal lattice vector of the structure.

In a *nonlinear* photonic crystal the index of refraction is constant but the nonlinear susceptibility (χ^2) is varied periodically. A 1-dimensional example is Periodically Poled Lithium Niobate (PPLN, pronounced "piplin"). By periodically inverting the direction of the alignment of the spin, only the nonlinear susceptibility is changed. The effects of such a variation can be seen in nonlinear interaction such as frequency doubling, where the flow of energy between the fundamental and second-harmonic beam is determined by the relative phase of the two beams and the sign of χ^2. By inverting χ^2 every time the process tends to dephase due to the difference in phase velocity for the two frequencies, quasi phase matching is achieved. As in the case of a linear crystal, the condition for such a resonance can be expressed in phase space and the k-vectors of the light must match the reciprocal lattice vector (G) of the periodic pattern ($2k^{\omega}+k^{2\omega} = G$).

A *2D* nonlinear photonic crystal is patterned with a periodic structure in a plane and was first proposed by Berger [1]. Our crystal consists of a thin (0.3mm), flat (7mm x 14mm) Lithium Niobate crystal that is poled in a honeycomb or hexagonal structure with a period of 18μm (fig 1). Hence the name HeXLN (pronounced "hexlin"), for hexagonal PPLN. The reciprocal lattice for such a structure is shown on the right. The existence of lattice vectors in multiple directions allows for quasi phase matching along different paths. We pumped this crystal with short (4ps, 300kW peak power) pulses and observed simultaneous quasi phase matching along different vectors and even for several harmonics (second, third and forth).

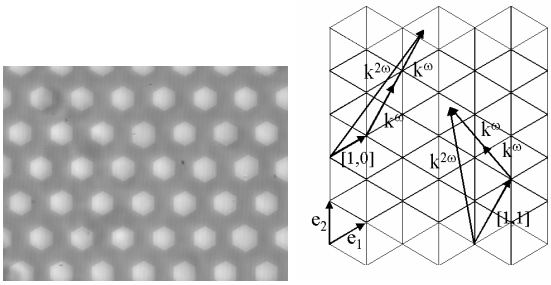

Figure 1. Hexagonal patterned $LiNbO_3$ and the corresponding reciprocal lattice with two possibilities for quasi phase matching

[1] V. Berger "Nonlinear photonic crystals" PRL vol. 81(19) pp.4136-4139 (1998)