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Theoretical Study on the Dual-wavelength Second Harmonic Generation with Transverse Gradient Nested Optical Superlattice

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Abstract Dual-wavelength second harmonic generation with transverse gradient nested optical superlattice is investigated. The ratio of SHG of two fundamental wavelengths can be controlled by adjusting the position of incident light. This study shows that the efficiency of SHG is related to the temperature and coherent length of the nested structure.

1. Introduction

With the development of nonlinear optical technology, researchers are not satisfied with the periodic structure of crystals to achieve a single quasi-phase matching. Lots of optical superlattices have been reported to achieve multiple quasi-phase matching in a specific domain reversal structure on a single crystal, such as dual-periodic, quasi-periodic, non-periodic and aperiodic[1-4]. As the regularity of the domain structure is weakened, optical superlattice can provide abundant reciprocal lattice vectors, which makes the multiple quasi-phase matching process more flexible and efficient. Although the structures mentioned above can achieve multiple wavelengths second harmonic generation (SHG) simultaneously, however, the multi-wavelength frequency doubling scheme does not involve the efficiency controlled and the output ratio of each fundamental wave. In this letter, we propose transverse gradient nested optical superlattice structure to obtain the dual-wavelength frequency doubling simultaneously. The ratio of SHG of two fundamental wavelengths can be controlled by adjusting the position of incident light. And the study shows that the efficiency of SHG is related to the temperature and coherent length of the nested structure.

2. Structrue and theoretical analysis

The schematic diagram of a nested transverse gradient optical superlattice is shown in Fig. 1. The black and white region is the positive and negative domain, respectively. The periodic structure of superlattice is constituted with triangular positive domain, trapezoidal negative and positive domain, and triangular negative domain. The domain of optical superlattice is transverse gradient nested by coherence length of (e point) and 2 (a point). The coherence length of the fundamental wavelength is calculated as:

$$l_c = \lambda / 4\left(n_{2\omega} - n_{\omega}\right) \quad \text{.....(1)}$$

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With the small signal and the slowly varying approximation, the conversion efficiency of SHG is proportional to, d_{reff}^2 , and the relatively effective nonlinear coefficient d_{reff} is defined as [5]:

$$d_{reff}(\lambda) = \left| \frac{1}{L} \int_0^L d(z) e^{i\Delta k(\lambda) z} dz \right| \quad \text{.....} \quad (2)$$

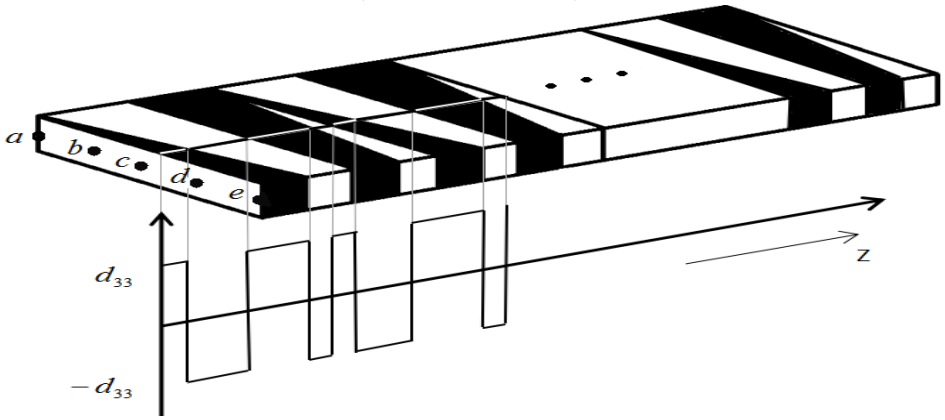


Fig.1 The structure of transverse gradient nested optical superlattice

3. Simulations and results

In this paper, the crystal used is 1% MgO-doped LiNbO3, and we discuss the output of dual-wavelength frequency doubling type0 (e + e→e) in crystal. When the temperature of crystal is controlled at 114oC, for the wavelengths of 1.06um and 0.86um, the coherence length is 3.3148um and 1.6574um, respectively.

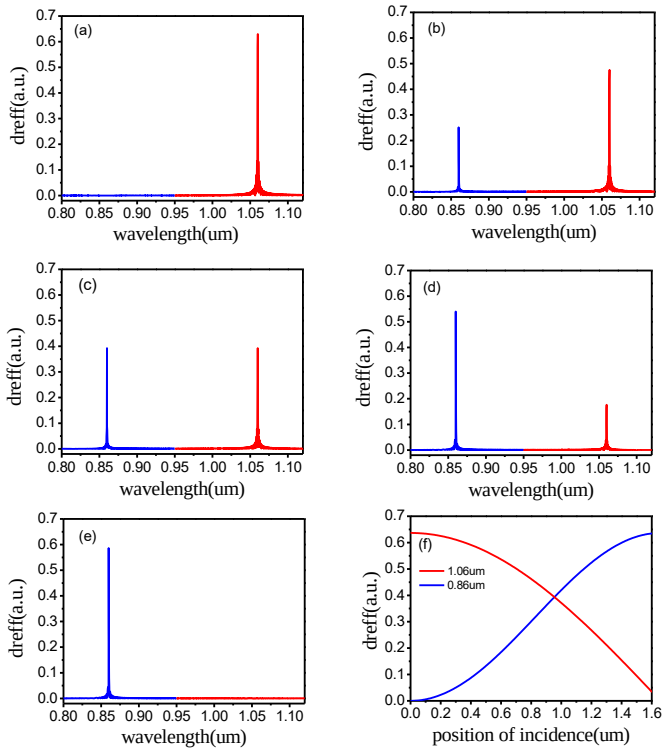


Fig.2 The output ratio of dual-wavelength SHG in the position of a-e (a-e) and the evolution graph of SHG efficiency (f).

Fig.2 shows the different intensity ratio of SHG efficiency spectrum with the altered crystal positions of a, b, c, d, e and SHG efficiency evolution curves of the two fundamental wave when the position of incident light changed.

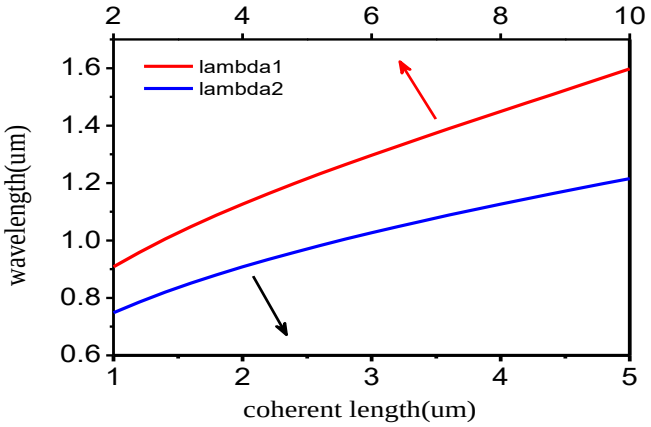


Fig.3 Fundamental wavelengths increase with rising coherence length of optical superlattices

The influence of the domain length error on the conversion efficiency is shown in Fig.5. When the unit domain length, four times of coherence length, is 6.6296um, the conversion efficiency d_{reff} are 0.395 for both fundamental waves with the incidence position of point c. It can be seen that the conversion efficiency is decreased with the increase of the domain error, and the tolerance of domain length are 11.6nm and 20.3nm for 0.86um and 1.06um, respectively.

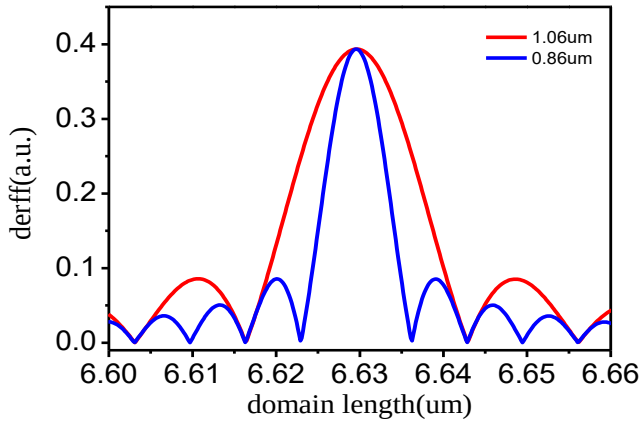


Fig. 4. Conversion efficiency curve via domain length.

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