Broadband Second harmonic generation by birefringent phase matching in an X-cut LiNbO3 thin film membrane

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SUMMARY OF ABSTRACT

We propose an X-cut LiNbO3 non-linear waveguide based on a thin film membrane. The structure allows second harmonic generation by birefringence phase matching between the two fundamental modes TE00 (SHG) and TM00 (Pump) at telecom wavelength. We demonstrate a competitive conversion efficiency compared to a quasi-phase-matched configuration with the advantage of a broadband response of 100nm and high manufacturing tolerance.

Keywords: Nonlinear Optics, Lithium Niobate Thin Films, Second Harmonic Generation

1. ABSTRACT FOR TECHNICAL REVIEW

The conversion of optical frequencies is a key process in many devices, for example, for realizing intricated photon sources for optics, for MIR spectroscopy, and more generally for obtaining new wavelengths from laser sources.

The most common approach for frequency conversion in LiNbO3 is based on periodically inversing its polarity (PPLN - Periodically Poled Lithium Niobate). This technique leads to a high conversion efficiency of 2600%/W/cm² at the telecom wavelength. However, it is limited by a short conversion bandwidth, typically of a few nanometers. On the other hand, another approach comes to increase this bandwidth by cascading different poling steps in order to scan multiple SHG wavelengths (step-chirped PPLN). Thus, they could reach 100 nm bandwidth, but at the expense of the conversion efficiency of 9.6%/W/cm².

To satisfy both the bandwidth and efficiency criteria, we propose a frequency doubling/twin photon generator based on a ridge waveguide suspended on a thin film (Membrane) and on modal phase matching between the two fundamental modes TE00 (SHG) and TM00 (Pump). The two interacting waves have a perpendicular polarization which facilitates their separation. Moreover, the device enables 100 nm broadband conversion with a competitive efficiency 55%/W/cm².

The proposed structure significantly reduces the technological constraints. In fact, it supports 200nm of variation in ridge width if the propagation length is equal to 1mm. By exploiting the thermal dispersion of the extraordinary refractive index, we can compensate a height uncertainty over 200nm.

To achieve this frequency conversion, the thickness of the LiNbO3 film must be around 2µm, which is not achievable with standard thin-film technologies limited to sub-micron thickness. Hence the advantage of the technique we are using to thin the waveguide until achieving a thickness below 2µm, with insertion losses as low as 2.8dB.