

# SHG in the UV by the QPM technique using ferroelectric fluorides

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All solid-state lasers emitting in the UV/VUV wavelength region are strongly requested to substitute currently used excimer lasers, like e.g. ArF (193 nm) or KrF (248 nm). Second harmonic generation (SHG) is achieved by well known non-linear oxide crystals such as  $\beta$ -BaB<sub>2</sub>O<sub>4</sub> (BBO), CsLiB<sub>6</sub>O<sub>10</sub> (CLBO), and LiB<sub>3</sub>O<sub>5</sub> (LBO). These show, besides solarization problems, a limited SHG wavelength  $\lambda$ , namely  $\lambda_{\text{BBO}} = 205$  nm,  $\lambda_{\text{CLBO}} = 236$  nm and  $\lambda_{\text{LBO}} = 277$  nm. Instead of non-linear oxide crystals, we propose the use of fluoride ferroelectric crystals for SHG by the quasi phase-matching (QPM) technique, which is non-critical at any wavelength.

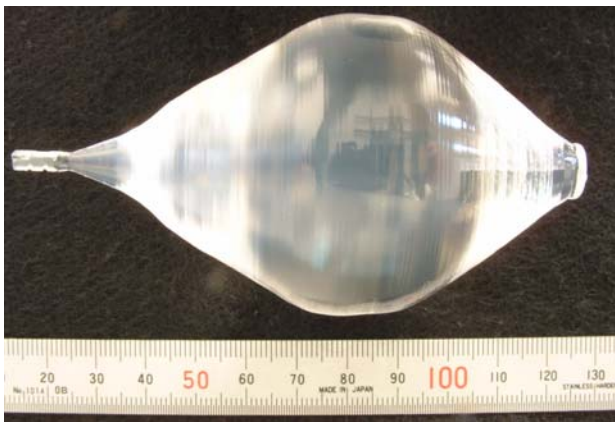


Fig.1. 2 inch BaMgF<sub>4</sub> single crystal grown by the Czochralski technique.

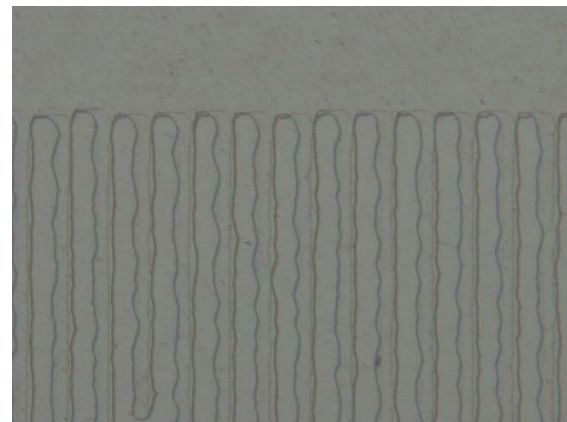


Fig.2. Periodically poled BaMgF<sub>4</sub> *c*-cut plate with a 24  $\mu\text{m}$  period.

BaMgF<sub>4</sub> (BMF) and BaZnF<sub>4</sub> (BZF) are two potential candidates currently under investigation. These fluorides exhibit a wide transparency from the VUV (cut-off < 150 nm) to the IR wavelength region (cut-off  $\approx 12$   $\mu\text{m}$ ). They belong to the same family (space group Cmc2<sub>1</sub>) and are non-centrosymmetric. We have grown single crystals by the modified-Czochralski technique, especially designed for the growth of high purity fluorides. The first 2 inch single crystal of BMF is shown in Fig.1. The ferroelectric character of these crystals was evidenced by the measurement of the polarization hysteresis<sup>1,2</sup>. The spontaneous polarization for BMF and BZF is 6 and 9  $\mu\text{C}/\text{cm}^2$ , respectively, while the coercive field is frequency dependent and follows the Ishibashi-Orihara model. By improving the purity and crystallinity the coercive field at low frequencies (< 1 Hz) was as small as 4 and 9 kV/cm for BMF and BZF, respectively. Single crystal *c*-cut plates were periodically poled (PP) with different periods for the fabrication of QPM devices. An example of a 24  $\mu\text{m}$ -period plate that has been selectively etched is shown in the photograph of Fig.2. We have recently succeeded to demonstrate SHG emission from PP-BMF crystals using 1064 nm Nd:YAG and Ti:sapphire lasers as fundamental light sources.

- 1) K. Shimamura, E.G. Vllora, et. al., Appl. Phys. Lett. 89, **2006**, 232911.
- 2) E.G. Vllora, K. Shimamura, et. al., Appl. Phys. Lett. 90, **2007**, 192909.