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Novel Second Harmonic Generation Optical Devices by using Nano-Domain Engineering

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1. Introduction

An excellent ferro-dielectric optical-crystal $LiNbO_3$ (LN) has 180-degree Domain Structure. If this structure can be controlled to the utmost by ***Nano-Domain Engineering*** [1-5], the new functional-devices such as the efficient nonlinear optical devices, a super high-capacity memory and photonic crystal modulators are realized [6-7]. In this report, the status of the nano-domain engineering is briefly mentioned. We demonstrate a newly developed a fine domain inversion technique to have used the $LiNbO_3$ lamina substrate called ***a Terrace Substrate*** and ***the AFM technique*** with the conductive needle and wide scanning area. ***The latest SHG blue lasers*** of the next generation are shown.

2. A newly developed terrace-substrate

When the thickness of the LN crystal becomes thin, the domain inversion voltage is proportional to decrease, and the domain size becomes small. This scaling rule may stand up, but the influence of the thickness does not clear. Recently, we made a sheer board crystal substrate with about 2μm thickness using dicing machine processing [6]. The example of the terrace substrate is shown in figure 1. The terrace thickness is 2~8μm, width is 100~500μm and the length is more than 20 mm, and the both surface of the terrace is smooth.

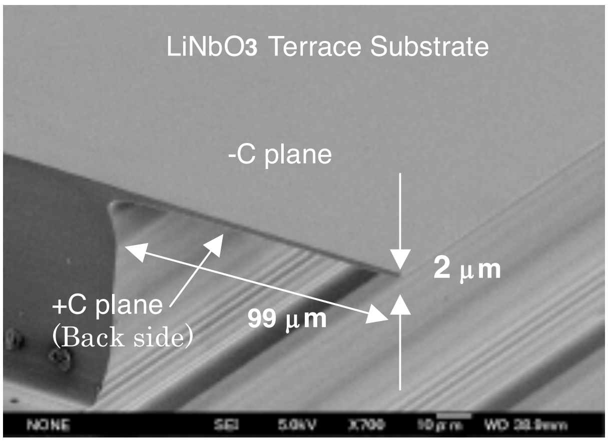

Fig.1. A newly developed terrace substrate by using a dicing saw.

3. Domain inversion by using the AFM

The experiment was performed on the domain inversion by using this substrate, putting a conductive needle of the AFM on the crystal and applying the voltage. The example is shown in figure 2. In case of show with period of 0.8~1.5μm, a domain inversion area with 200nm~2μm width is obtained. Also, because etching speed by etchant depends on the polarity of the plus-c plane or minus-c of the domain inversion, a smooth polarization-reversal pattern is gotten, according to the wet etching as shown in figure 2. In the technique, the threshold voltage of domain inversion is 6V/μm (6kV/mm), this value is near the bulk value (S-LN, 6kV/mm). The scaling rule stands up perfectly. Incidentally, as for the minimum domain inversion size, the dot of uniformly at the substrate thickness of 4μm pierced 50nmΦ is obtained [6].

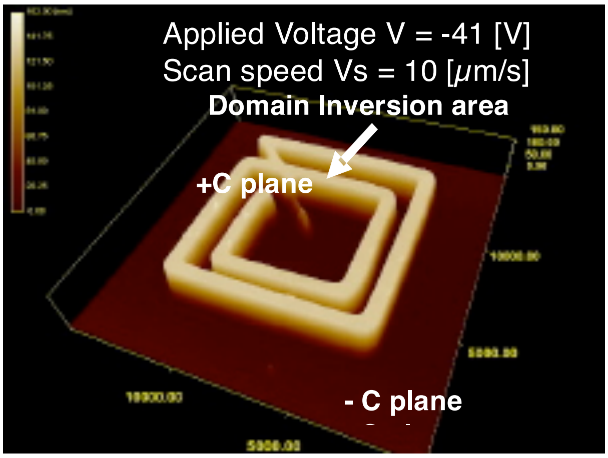

Fig.2. Etching pattern of Domain-inversion by the AFM.

4. Developed QPM-SHG Devices

Using these technologies, a quasi phase matched second harmonic generation (QPM SHG) optical devices [2] have been fabricated. An example is shown in figure 3. The wavelength of the SHG light can be chosen in the period of the domain inversion. Actually, we fabricated a 3.5μm period sample as shown in figure 4.

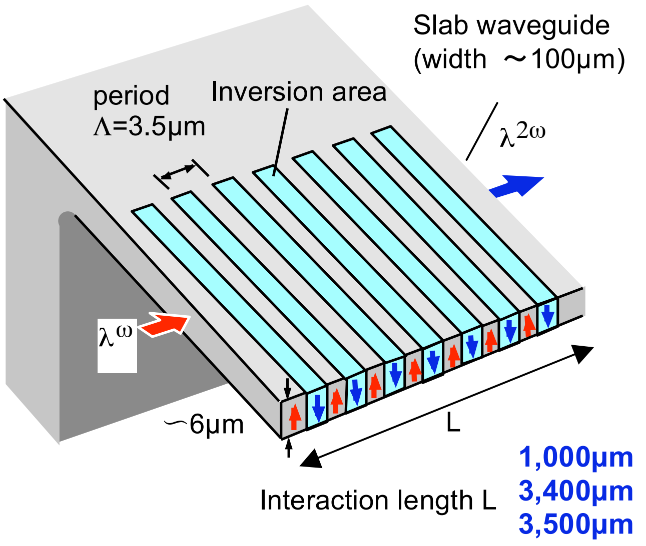

Fig.3. Newly developed QPM-SHG blue light optical device.

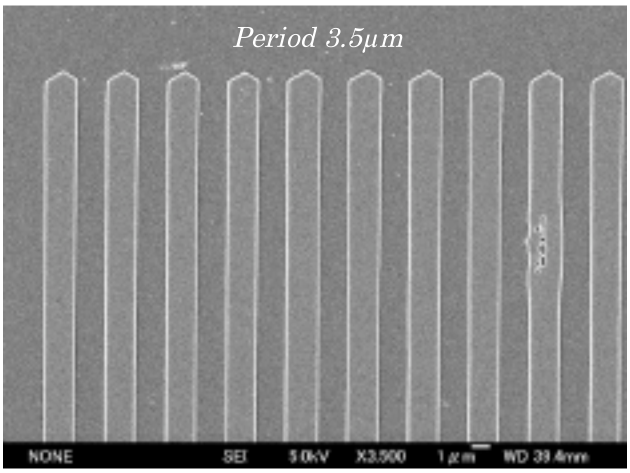

Fig.4. Fabricated Domain inversion pattern for QPM-SHG device.

The period is 3.5μm, corresponding to the domain inversion size 1.75μm wide, generates a wavelength 433nm SHG output (the blue light) by the 866nm (the infrared laser) excitation source. Generated QPM-SHG wavelength was measured by a wavelength meter. Figure 5 shows the measured wavelength data. This value is corresponding to the calculated value.

This device construction has a merit with the rising efficiency based on the mode matching when using a terrace substrate. The conversion efficiency is proportional to the square of the length of the device and the incident light power. In this device, an interaction length of slab-waveguide is more than 1-3mm. This value is relatively short. However, this length is top-data and a QPM-SHG device is fabricated for the first time by using above mentioned AFM technique with a conductive needle and wide scanning area. It is clear that newly de veloped QPM-SHG device is efficient. So the develop ment of the device is going to accelerate in the near future [7].

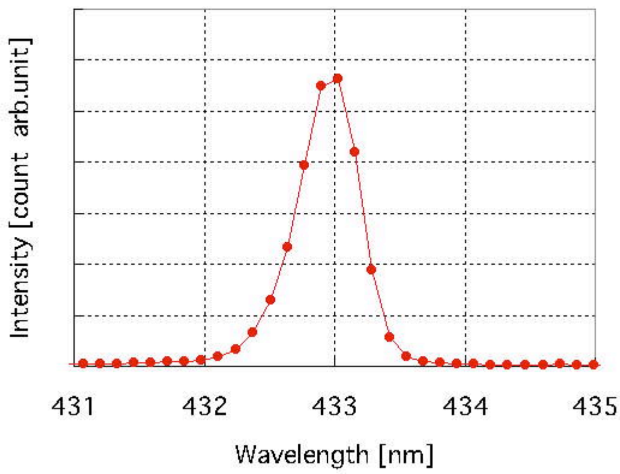

Fig.5. Measured wavelength of newly developed QPM-SHG light. Peak value is corresponding to 433nm, and a vertical axis shows the SHG intensity.

5. Conclusions

In this paper, we present our recent progress on the nano-domain engineering by using the thin-sheet LiNbO3 crystal - Terrace Substrate - and the extended AFM technique. We also demonstrate a newly developed Second Harmonic Generation optical device.

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