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VUV Light Generation with CLB_6O_{10} and LB_3O_5

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1. Introduction

In recent years, vacuum ultraviolet (VUV) laser source realized by nonlinear frequency conversion is increasingly demanded in various applications in science, medicine, and industry. As we expected the short-wavelength VUV sources below 190 nm could be applied for mask inspection in future semiconductor manufacture, in this research, we attempt to generate VUV light with commercial borate crystals LiB_3O_5 (LBO) and $CsLiB_6O_{10}$ (CLBO).

2. 189 nm VUV generation

We used a Nd:YAG laser operating at a repetition rate of 10 kHz, and generate the 5ω light at 213 nm with wavelength conversions. An optical parametric oscillator (OPO) based on periodically poled lithium niobate (PPLN) was used to generate infrared (IR) of 1697.9 nm with residual 1064 nm light after the SHG stage. The 189 nm VUV light was generated via sum frequency generation (SFG) by mixing the 213 nm light with IR in the last stage borate crystal kept in the air at room temperature.

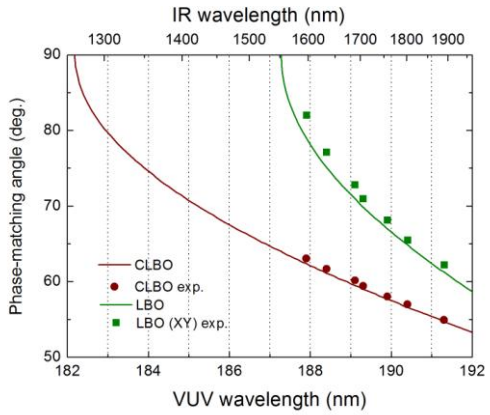

Fig. 1. Phase-matching properties at around 190 nm.

Figure 1 shows the experimental results of phase-matching angles around 190 nm for CLBO and LBO. The measured type I phase-matching angles of φ for LBO in the *xy* plane and θ for CLBO are in good agreement with the theoretical curves calculated from Sellmeier's equations. A maximum output of 11.4 mW for VUV at 189.1 nm was achieved with a 15-mm length CLBO [1]. It is expected to generate VUV until 185 nm in CLBO without serious absorption from the experimental results as shown in Fig.1.

3. 179 nm VUV generation

A Q-switched Nd:YVO_4 laser operating at a 15 kHz repetition rate was employed as the fundamental source. We used an OPO based on $KTiOPO_4$ (KTP) and several stages of wavelength conversion to generate UV at 198.8 nm. On the other hand, IR of 1799.9 nm was obtained with a PPLN OPO. At last, 179 nm VUV light was generated via SFG by mixing the DUV light with IR light in the LBO crystal kept in the air at room temperature.

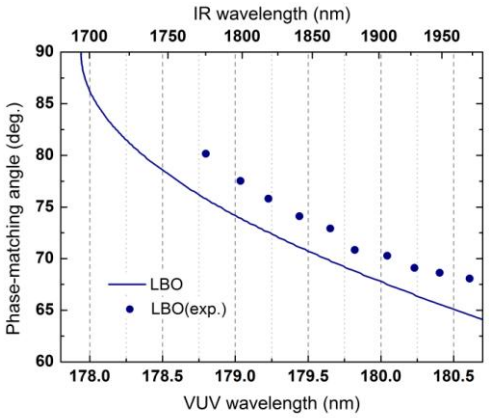

Fig. 2. Phase-matching properties at around 180 nm.

Figure 2 shows the experimental results of the type I phase-matching angles of φ for LBO in the *xy* plane. They were closed to the theoretical curves calculated from Sellmeier's equations and the value at 179.0 nm SFG was φ=77.5°. We still try to measure the output power of 179 nm which became extremely weak in the air for absorption.

4. Summary

We demonstrated the generation of VUV light with LBO and CLBO. VUV until 183 nm is expected to be generated with CLBO. And it was the first time that nanosecond 179 nm VUV pulses had been successfully generated with LBO.

References

[1] C. Qu *et al*., Appl. Phys. Express **5** 062601 (2012).