편광 해석을 통한 2차 비선형 위상변화 측정

Nonlinear ellipsometric method for measuring second order cascaded phase shift

김홍기, 이왕근, 차명식
부산대학교 유전체물성연구소
hkikim@unitel.co.kr

There have been many studies on the intensity dependent nonlinear phase shift that arises from the $\chi^{(2)}$: $\chi^{(2)}$ cascading processes. To measure the cascaded phase shift(CPS), several experimental methods have been used such as Z-scan[1] and interferometric measurement[2]. But these methods require a well-defined spatial/temporal beam profile and interferometric stability, respectively. In this paper, we propose a new method for measuring CPS associated with second harmonic generation(SHG) which is not sensitive to the beam profile and mechanical stability.

A $KNbO_3$(5mm long) single crystal was used as the sample for demonstration of this method. The experimental setup is schematically described in Fig.1. The 1064nm beam from a Q-switched Nd:YAG laser was used for SHG in the crystal. Wavevector mismatch for the SHG was controlled by temperature around the phase matching temperature(189.25 ℃). The input beam was linearly polarized at 45° with respect to the a-axis of the crystal, in which it is separated into two orthogonal components. The vertical component(polarization parallel to the c-axis) does not experience second order nonlinear interactions because only d_{31}-coefficient is activated in this specific configuration, while the horizontal one participates in the second order processes, SHG($\omega+\omega \rightarrow 2\omega$) and down-conversion($2\omega-\omega \rightarrow \omega$). Therefore, the CPS is generated only in the horizontal component. A Soleil-Babinet compensator was used to compensate the linear birefringence. A cross polarizer(-45°) was placed in front of the detector. In this configuration the CPS Φ is calculated as $\cos\phi = (\frac{1}{2} - I_{out})(1+T)/\sqrt{T}$, where T and I_{out} are the transmittance due to the fundamental depletion just after the sample and the normalized signal at the detector of the fundamental intensity, respectively. To eliminate spatial averaging effect in the beam profile, we measured the output fundamental intensity at the peak by imaging the exit plane of the sample to the analyzer plane with a magnification of ~10, where a small pinhole was placed. We also avoided temporal averaging by detecting the peak of the ~10ns optical pulse signal. Fig.2 shows CPS versus wavevector mismatch(Δk) at various ΓL. Here, $\Gamma = \frac{2\pi}{\lambda}\frac{d_{31}\,|E|}{\sqrt{n_\omega n_{2\omega}}}$, where λ and E are the fundamental wavelength and input electric field amplitude, respectively, L is the interaction length, and n_ω and $n_{2\omega}$ are refractive indices at the fundamental and second harmonic frequency, respectively. The experimental results agree well with theoretical calculations from the coupled wave equations for ΔkL>0, but in the other region is not. For this resion we guess that in ΔkL<0 beam energy is not strictly conserved along the beam propagation direction because of noncolinear phase matching only in one side of phase mismatch. So a significant change in the CPS due to such noncolinear interaction can be expected at high intensity.

As a conclusion, this method has advantages over the Z-scan and Mach-Zehnder interferometric methods in view of spatio-temporal beam profile and mechanical stability requirements.

References

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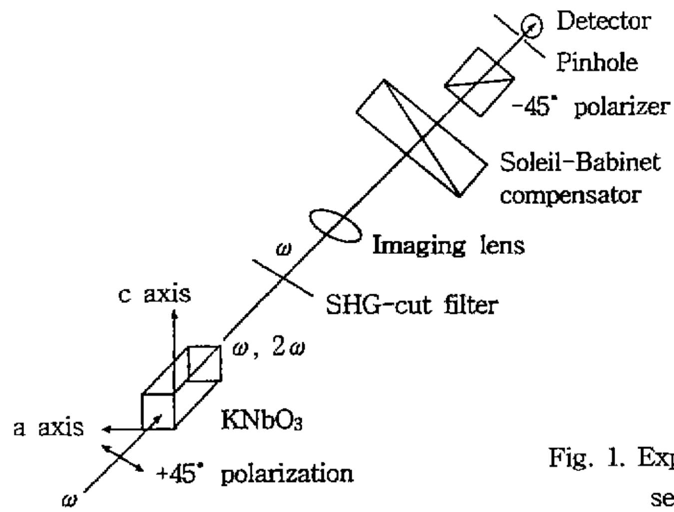

Fig. 1. Experimental setup for measuring second order cascaded phase shif

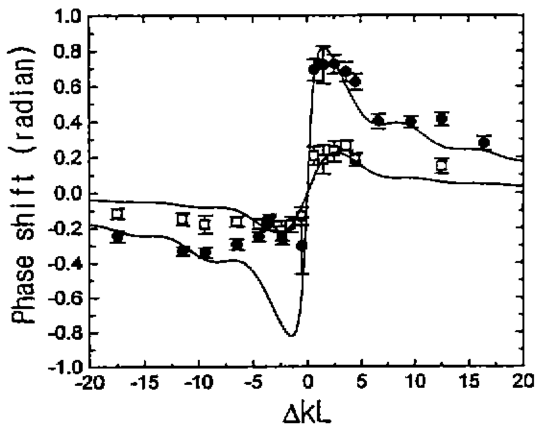

Fig. 2. Cascaded phase shift versus ΔkL for ΓL=0.88(squares) and 1.97(circles). Curves are from theory.