주파수 분해 광 개폐 장치와 푸리에 변환 분광 간섭계를 이용한 반사광의 위상변화량 측정법 개발

Development of a phase change measurement method using a Fourier transform spectral interferometry and a frequency resolved optical gating

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Conventional reflectivity measurement technique is one of the simplest and most popular methods used for obtaining the dielectric function of numerous optically thick solid materials. However, there is a big disadvantage of the technique. To extract the dielectric function from the spectrum, one should know both the absolute intensity and the phase change of the reflected light beam. In most experimental situations, one cannot obtain the phase information with the conventional techniques, so one needs to employ mathematical transformation techniques based on the causality relation. Such transformations cause error inevitably.

In this paper, we present an experimental method which allows us to measure the phase change of the light beam in the reflection process independently without the mathematical transformations. We used ultrashort laser pulses for the light source. The phase information of the pulses changes as they reflect on a sample surface. We present a method measuring the change of the phase information by utilizing a combinatorial technique of a Frequency Resolved Optical Gating (FROG) and a Fourier Transform Spectral Interferometry (FTSI).

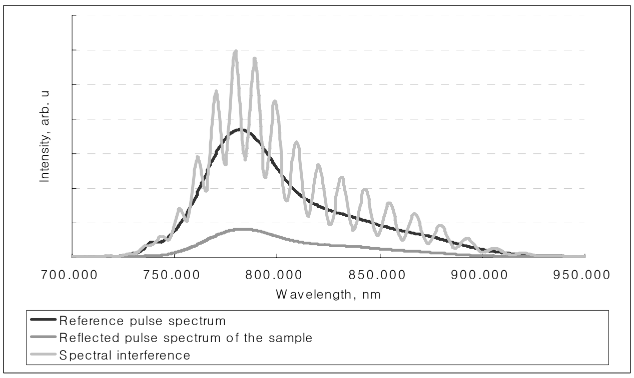

Fig. 1 Fourier transform spectral interferometry spectra of sample and reference

We describe the whole process as followings shortly. First we applied a FTSI technique to get reflected pulse parameters such as interference fringes from the sample as shown in Fig. 1. Then by inverse Fourier transforming the spectral interference data into the time domain we can separate the phase term from the intensity term as following.

$$I(\omega,\tau) = \left| \int_{-\infty}^{\infty} \left(E_{ref}(t-\tau) + E_{sig}(t) \right) e^{i\omega t} dt \right|^2$$
$$= I_{ref}(\omega) + I_{sig}(\omega) + 2\left|E_{ref}(\omega)\right|\left|E_{sig}(\omega)\right| \cos(\phi_{sig}(\omega) - \phi_{ref}(\omega) - \omega\tau)$$

Then by filtering the phase term out and by Fourier transforming the phase term only, we can determine the phase difference of the refernce and signal pulses. If we know the reference pulse's phase, we can easily retrieve the phase information as shown in Fig. 3.

To get the reference pulse's phase information, we determined the reference pulse parameters by using a FROG technique as shown in Fig. 2.

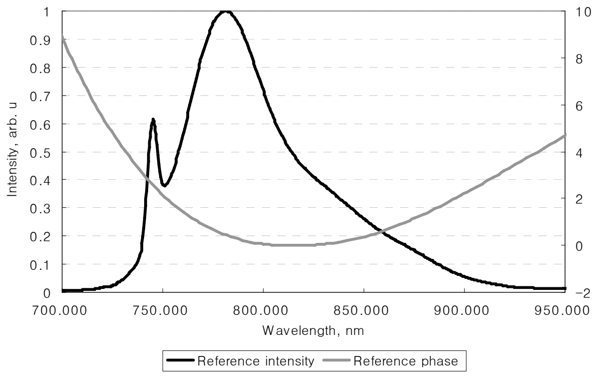

Fig. 2 Retrieved reference pulse information by FROG in spectral domain

We can finally obtain the phase change of a pulse when reflected by a sample if we compare the phase difference measured by FTSI technique and the phase of the reference pulse measured by FROG technique as shown in Fig. 3.

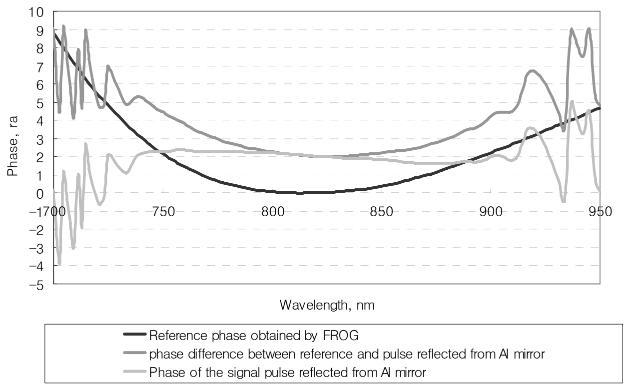

Fig. 3 Retrieved phases of the reflected pulses from the Al mirror

We will show the phase change of ultrashort pulse by the reflection on a few different materials including gold and GaAs and discuss the meaning of the change.