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Coherent Anti-stokes Raman Spectroscopy with Dual-Wavelength Oscillation Electronically Tuned laser

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1. Introduction

Coherent anti-stokes Raman scattering (CARS) spectroscopy or imaging is used for investigating the chemical or biological dynamics in living samples without staining or fluorescent proteins. Different two wavelengths and synchronization of pulses generated from individual lasers by using optical delay line are required to obtain the CARS signal. So the excitation light source and the signal include the jitter noises occurred when the wavelengths are tuned and the pulse timing is synchronized. The stability of laser intensity is most important and required factor to obtain the CARS spectrum with high signal to noise ratio and achieve quantitative measurements of living samples.

In this study, we are demonstrated CARS spectroscopy system using a dual-wavelength oscillation electronically tuned laser to achieve higher signal to noise ratio non-staining spectroscopy. The laser has an acousto-optic tunable filter (AOTF) in the cavity as a wavelength -tuning device. Fast (1 ms) and random-access tuning was realized by applying radio frequency (RF) to the AOTF [1]. The laser can oscillate two individual wavelengths simultaneously by applying the two different RF signals to the AOTF [2]. Using this laser, we constructed CARS spectrometer without any mechanical movements. Using this system, we obtained the CARS spectrum of polystyrene and indene.

2. Experimental and Results

Dual-wavelength Oscillation electronically tuned laser

The dual-wavelength electronically tuned laser is constructed based on a Ti:Al_2O_3 laser that has typical z-fold type laser cavity. The pumping laser of the Ti:Al_2O_3 crystal was LD-pumped SHG Nd:YVO_4 laser. The pulse duration and repetition rate of the laser were about 5 ns and 30 kHz, respectively. An AOTF is placed in the laser cavity as wavelength tuning device. The oscillation wavelengths are selected by tuning RF frequencies fed into the AOTF. And pulse timing was controlled by adjusting RF power. The RF frequencies and powers were controlled by a personal computer. The tuning range was from about 700 to 1020 nm and maximum output power was about 900 mW.

CARS spectroscopy system

The configuration of the CARS spectroscopy system is shown in Fig. 1. We detected the backward CARS signal from the sample. The beams were delivered with two mirrors and a dichroic mirror and focused on a sample by using a 40X, 1.3-N. A. oil-immersion objective lens. The CARS signal is separated by a dichroic mirror. A shortpass filter is used to remove the backgrounds. Then, the CARS signal was detected by a spectrometer with an EMCCD detector.

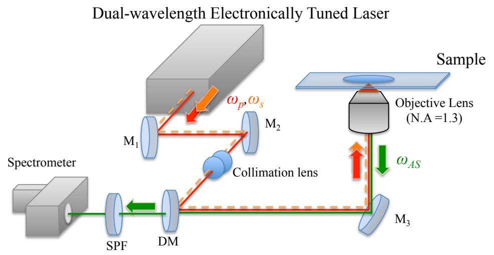

Figure 1. Schematics of CARS Spectroscopy System with dual-Wavelength Tuned Laser. DM: Dichroic Mirror, SPF: Short-Pass Filter

Results

We measured the polystyrene and the indene as samples to demonstrate the performance of the system. First, we measured the changes of the CARS signal intensities at 1000 cm^{-1} band in the polystyrene as varying the RF powers fed into the AOTF and wavelengths to demonstrate the synchronization of the pulses. In addition, we measured the CARS spectrum of indene in the range from 600 to 1800 cm^{-1}. Figure 2 shows the CARS spectrum of indene measured by the system. The wavelength of the pump beam was fixed at 750 nm and that of the stokes beams were changed from 785 to 867 nm with 0.3 nm steps. And the exposure time was totally 90 s, 300 ms per a step. We obtain the CARS signal from the samples.

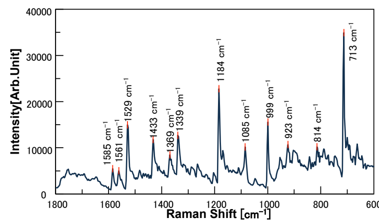

Figure 2. CARS spectrum of Indene

3. Conclusions

We achieved to construct the CARS spectroscopic system using dual-wavelength oscillation electronically tuned laser without any mechanical movements required to tune the wavelengths of the excitation beams and to adjust the pulse timing. And we achieved to obtain the CARS spectrum in the fingerprint region from indene by using this system.

References

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