A Novel Spectroscopy Technique Based on Difference-Frequency Generation of Infrared Light

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We study a novel nonlinear spectroscopy technique based on infrared-resonant third-order difference-frequency (ITD) generation. With an infrared light on resonant with vibrational state of molecules, it can create a coherence that is subsequently probed by a near infrared light through a two-photon process. As a result, the third order nonlinearity result in two different process, which are infrared-resonant third-order sum-frequency (ITS) generation and infrared-resonant third-order difference-frequency (ITD) generation. Wavelength of ITD is usually in the visible range and it contains information of vibrational states. Therefore, ITD can be used to identify molecules and it can be detected with a silicon detector, which is much more convenient compared with the detection of infrared light. Moreover, by using an ultrafast laser, ITD can be extended as a time-resolved spectroscopy technique to study dynamics of molecular vibrational states. We report experiments to demonstrate ITD spectroscopy. We used a femtosecond laser system to generate infrared pump and near infrared probe field. ITD is generated from some plastic samples, such as a thin low density polyethylene (LDPE) film (Fig. 1). The results show some similarities to that of ITS. However, due to the difference of phase matching condition, the signal of ITD will be different to that of ITS. ITD is also demonstrated to be useful in chemical imaging with a mixture of plastic beads.

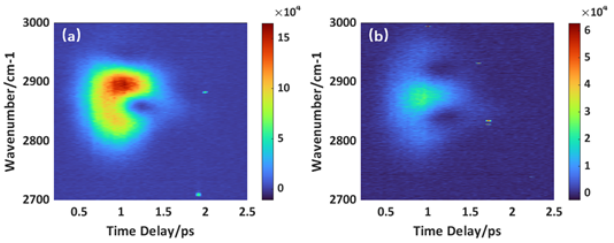

Figure 1: (a) ITS. It is generated from a thin LDPE film. (b) ITD. It is generated from the same spot as that of ITS measurement. Except the central wavelength, all the other settings of spectrometer are the same. The pump light is centered around 2950 cm^{-1}. The probe field is centered at 1047 nm