フォノン援用光解離による二酸化炭素の削減

Carbon Dioxide reduction process using phonon assisted photo-dissociation

Dept. Eng., Univ. Tokyo, N. Tanjeem, T. Mochizuki, T. Kawazoe, and T. Yatsui
E-mail: tanjeem@nanophotonics.t.u-tokyo.ac.jp

Carbon dioxide (CO₂) is considered as one of the major greenhouse gases responsible for global warming. The use of solar energy is most likely to be an economic solution for reducing CO₂. However, high bond dissociation energy of CO₂ (equivalent light wavelength $\lambda_{\text{dis}}=147\text{nm}$) makes it challenging to dissociate CO₂ efficiently [1]. The purpose of this research is to investigate photo-dissociation process of CO₂ with incident light energy less than its bond dissociation energy. The process is called as phonon assisted photo-dissociation [2].

When propagating light is incident on a particle with a size smaller than the wavelength of the light, a virtual cloud of photons (dressed photon) gets localized around the particle, which induces the excitation of phonons. Therefore, a molecule around that particle can absorb multimode coherent phonons and electrons of the molecule get excited from the ground state to an excited state via an intermediate state. This two or more step excitation is the basis of phonon-assisted photo-dissociation.

To induce phonon assisted process, we fabricated ZnO nanorods on sapphire substrate using a catalyst free MOVPE system [3]. The average tip diameter of the fabricated nanorods (Fig. 1) was approximately 50 nm. We put the substrate with ZnO nanorods inside a desiccator filled up with CO₂ gas and irradiated the nanorods with UV light source. Concentration change of CO₂ is understood by observing the change in absorption spectrum of CO₂ measured by Infrared spectrometer. Figure 2 shows the absorption change at wavelengths corresponding to the CO₂ molecules [4] with irradiation time using deuterium lamp and UV laser of wavelength $\lambda=213\text{nm}$ ($>\lambda_{\text{dis}}$). We found that the absorption changes significantly while irradiating with incident light of wavelength longer than $\lambda_{\text{dis}}$. The result of our experiment supports the process of phonon-assisted photo-dissociation. We are planning to conduct the experiment several times, changing the parameters- incident light wavelength, power and nanorod structure to find out the optimum condition for dissociation of CO₂.