【Grant-in-Aid for Specially Promoted Research】

Science and Engineering

Title of Project : Fusing nanomaterials and strong electric field nonlinear optics for new advances in photonics

Yoshihiko Kanemitsu
(Kyoto University, Institute for Chemical Research, Professor)

Research Project Number : 19H05465 Researcher Number : 30185954

Keyword : Optical properties of materials, nanomaterials, strong electric field nonlinear optics, high harmonic generation, terahertz spectroscopy

【Purpose and Background of the Research】

Sophisticated high-power laser techniques are becoming a fundamental part of new photonics research, with recent advances in high intensity and ultrashort pulse laser technology opening up new avenues of optical science. Irradiating solids with strong laser pulses can introduce new nonlinear optical phenomena, such as high harmonic generation, which produces multiple frequencies of the incident laser's frequency. Ultrashort (attosecond) pulsed light sources covering a wide range of wavelengths from the infrared to X-ray have many potential technological applications. Strong optical pulses dramatically change the electronic states of solids, inducing phenomena such as Zener tunneling. In this research, we study the nonlinear optical properties of solids with novel electronic states and nanoscale structures by means of advanced laser techniques. We promote the development of new high-field photonics and foster future applications into material phase control, optical switching, and spectroscopic analysis.

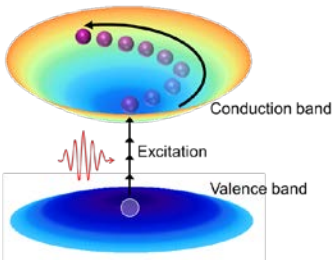

Fig. 1 Strong field-induced optical phenomena caused by accelerated carriers in the band.

【Research Methods】

Our investigations into the optical response of new solid materials draw on our strong research background in nanomaterials science. Using ultrafast coherent spectroscopy, we aim to discover new optical phenomena of nanomaterials generated under high fields. Electronic motions and states in solids and nanomaterials are altered using high electric field optical and terahertz pulses. Modern high-field science and photonics are furthered through the precise control of the phase and polarization of these pulses.

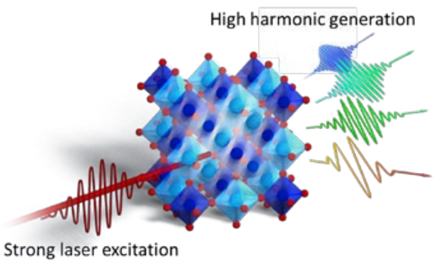

Fig. 2 Schematic of high harmonic generation from electrons driven by strong laser excitation.

【Expected Research Achievements and Scientific Significance】

Advanced laser technologies are expected to revolutionize current research and open up new disciplines of study. While initially developed for atomic and molecular systems, we will extend the study of strong-field nonlinear phenomena to include nanomaterials. Examining the fundamental physics of nanomaterials is expected to lead to new spectroscopic technologies, new material control technologies, light processing technologies, and light energy conversion technologies, etc., which will dramatically advance optical science research and impact on a wide range of research fields.

【Publications Relevant to the Project】

- H. Tahara, Y. Kanemitsu *et al.*, "Harmonic quantum coherence of multiple excitons in PbS/CdS core-shell nanocrystals", *Phys. Rev. Lett.* **119**, 247401 (2017).
- Y. Sanari, Y. Kanemitsu, H. Hirori *et al.*, "Zener tunneling breakdown in phase-change materials revealed by intense terahertz pulses", *Phys. Rev. Lett.* **121**, 165702 (2018).

【Term of Project】 FY2019-2023

【Budget Allocation】 429,300 Thousand Yen

【Homepage Address and Other Contact Information】

https://www.scl.kyoto-u.ac.jp/~opt-nano/index-e.html