Endowed Research Section
– Nano-Interface Photonics –
(SEI Group CSR Foundation)

http://www.scl.kyoto-u.ac.jp/~opt-nano/NIP/index-eng.html



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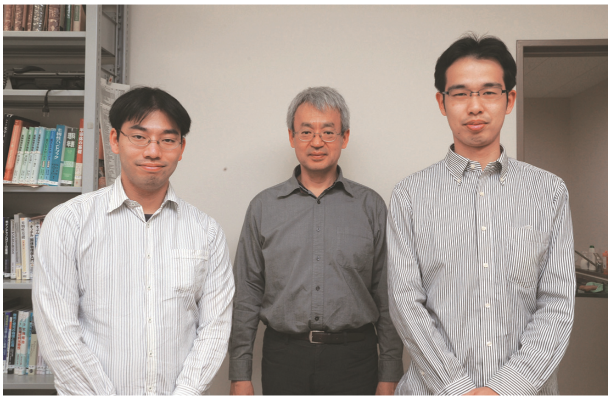
Scope of Research

Nanostructured materials are one class of the most promising candidates for future device materials because of their unique electronic and optical properties beyond the bulk crystals. Our research aim is to open up new research fields of nanomaterials science, by focusing on nano-interface as a platform to develop novel optical functionalities. We study optical properties of semiconductor nanomaterials by means of time- and space-resolved spectroscopy, leading to new solar energy conversion technologies. The main subjects are (1) photocarrier dynamics and photovoltaic effects in transition metal oxides and (2) ultrafast carrier dynamics and unique optical properties of nanocarbon materials.

KEYWORDS

Nano-interface
Photovoltaic Science
Nanocarbon Materials
Transition Metal Oxides
Laser Spectroscopy
Solar Energy Conversion



Selected Publications

Okano, M.; Matsunaga, R.; Matsuda, K.; Masubuchi, S.; Machida, T.; Kanemitsu, Y., Raman Study on the Interlayer Interactions and the Band Structure of Bilayer Graphene Synthesized by Alcohol Chemical Vapor Deposition, *Appl. Phys. Lett.*, **99,** [151916-1]-[151916-3] (2011).

Yamada, Y.; Kanemitsu, Y., Blue Light Emission from Strongly Photoexcited and Electron-doped $SrTiO_3$, *J. Appl. Phys.*, **109,** [102410-1]-[102410-4] (2011).

Kanemitsu, Y.; Yamada, Y., Light Emission from $SrTiO_3$, *Phys. Stat. Sol. (b)*, **248,** 416-421 (2011).

Yamada, Y.; Kanemitsu, Y., Band-edge Luminescence from $SrTiO_3$: No Polaron Effect, *Thin Solid Films* (in press).

Yamada, Y.; Kanemitsu, Y., Photoluminescence Spectra of Perovskite Oxide Semiconductors, *J. Lumin.* (in press).

Nanointerface as a Platform to Develop Novel Optical Functionalities

Solar energy conversion is a key technology to solve the world-wide and emergent energy problems, such as fossil fuel exhaustion and global warming. However, the conversion efficiency of practically used solar cell is still less than 30%, and thus there is a compelling need for the development of highly-efficient and cost-effective solar cells.

Nanostructured materials, such as nanoparticles, nanotubes, and nanowires, are the most promising candidates for the next-generation solar cells because of their unique electronic and optical properties beyond the bulk crystals. For example, plasmon resonance in metal nanoparticles enhances the light absorption efficiency, and carrier multiplication due to strong carrier confinement and Coulomb interactions in the semiconductor nanoparticles can improve the light conversion efficiencies.

To take more advantages of nanomaterials, it is significant to understand the role of their surface and interface. Nanomaterials have large surface-to-volume ratios, and thus their optoelectronic properties are strongly affected by the surrounding materials and interface states. This indicates that the novel optoelectronic properties can be developed by controlling the nano-interface. Moreover, in the practical nanomaterial-based devices, the energy and carrier transport processes are dominated by the characteristics of the interface between nanomaterials.

In our research group, we focus on such nano-interface as a platform to develop novel optical functionalities. Using advanced time- and space-resolved spectroscopy, we study the optical properties of unique nanomaterials and their nano-composites. Through the studies on the nano-interface photonics, we aim to open up new research fields of nanomaterials science, leading to new solar energy conversion technology.

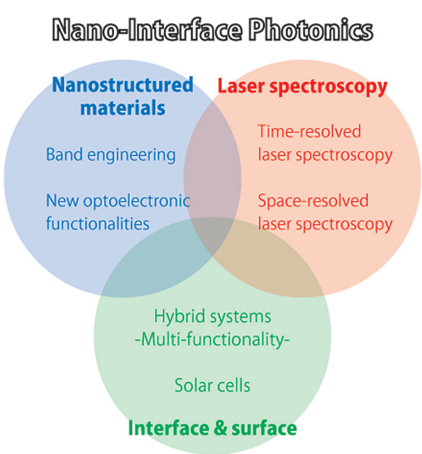


Figure 1.

Interlayer Interactions of Bilayer Graphene Studied by Raman Spectroscopy

Graphene has attracted interest because of its utility in fundamental physics research and potential device applications. We investigated the electronic band structure and interlayer interactions in graphene synthesized by alcohol-chemical vapor deposition (a-CVD) using microprobe Raman spectroscopy. The number of graphene layers was determined from the spectrally integrated intensity ratios of the *G* phonon to 2*D* phonon peaks. We found that the value of the parameter determining interlayer interactions in a-CVD bilayer graphene was less than half that of exfoliated bilayer graphene. The weak interlayer interaction in a-CVD bilayer graphene was attributed to non-*AB* stacking order.

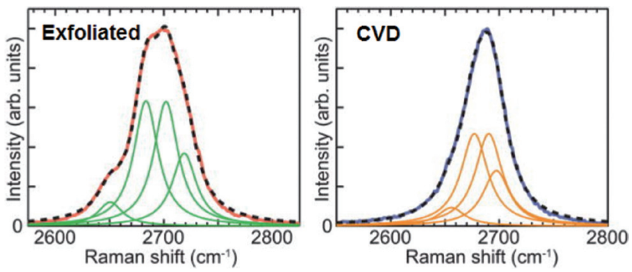


Figure 2. Raman spectra (thick solid curves), four Lorentzian components (thin solid curves), and fitting curves (dotted curves) of the 2*D* phonon band in the exfoliated (left) and the a-CVD bilayer graphene (right) at 532-nm excitation.

Photoluminescence Properties and Carrier Characteristics of Perovskite Semiconductors

Perovskite oxides and their heterostructures have attracted a great deal of attention as new device materials because they show multifunctional properties beyond conventional semiconductors. However, their carrier dynamics still remain unclear. $SrTiO_3$ is a representative perovskite semiconductor, and we recently discovered band-edge photoluminescence (PL) at 3.2 eV in electron-doped or strongly photoexcited $SrTiO_3$ at low temperatures and assigned as band-to-band radiative recombination of free electrons and holes. On the other hand, other perovskite oxides, such as $KTaO_3$ and $BaTiO_3$ show no band-edge PLs but broad PL bands in the low-energy spectral region. These unique PL properties of $SrTiO_3$ are related to the high carrier mobility at low temperatures.