The 63rd iCeMS SEMINAR

CeMI Seminar Series 18

Thu 25 Nov 2010
14:00–16:00

Venue: 2nd floor Seminar Room (#A207)
Main Building iCeMS Complex 1
Kyoto University

1st Lecturer: **Prof. Charles Schmuttenmaer**
Department of Chemisty
Yale University

"Using Time-Resolved THz Spectroscopy to Study Carrier Dynamics in TiO_2-based Nanomaterials"

2nd Lecturer: **Prof. Juraj Darmo**
Institute of Photonics
Technische Universität Wien

"Terahertz time-domain spectroscopy of quantum cascade lasers"

Contact: iCeMS Tanaka Lab at tanaka-g@icems.kyoto-u.ac.jp
Hosted by: iCeMS (Institute for Integrated Cell-Material Sciences), Kyoto University

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Abstracts for November 25th iCeMS Seminar

Prof. Charles Schmuttenmaer

Nanostructured TiO_2 films are a promising low-cost, high-surface-area electrode material for solar cells and solar fuel production. TiO_2 nanoparticles (NPs) have already proven successful as the photoanode in dye-sensitized solar cells (DSSCs). On the other hand, TiO_2 nanotubes (NTs) offer the advantage of directed electron transport, and are expected to have higher electron mobility. However, to date, they have not outperformed the NPs.

Measuring the photoconductivity in these materials is a challenging problem because of the inherent difficulty of attaching wires to nanometer-sized objects. Furthermore, picosecond (ps) carrier dynamics play an important role in efficient charge separation and transport, but the low temporal resolution of traditional methods such as time-of-flight and intensity modulated photocurrent or photovoltage spectroscopy used to determine their photoconductivity precludes their use in studying sub-ps to ps dynamics.

Time-resolved THz spectroscopy (TRTS), on the other hand, is a non-contact electrical probe capable of measuring photoconductivity on a sub-ps to nanosecond (ns) timescale. In essence, materials with high conductivity strongly absorb THz radiation, while those with low conductivity do not. With THz spectroscopy, not only can the average time-dependent conductivity properties be measured, but also the complete frequency-dependent, complex-valued conductivity (i.e., real and imaginary components), all on a sub-ps timescale, and without attaching any probe wires to the sample. The use of TRTS to study transient photoconductivity in nanocrystalline colloidal TiO_2 NPs and TiO_2 NTs will be discussed.

Prof. Juraj Darmo

Last five decades can be called as an era of the semiconductor laser. This device small by size, but big by performance become an inevitable part of the everyday life starting from the laser in the computer pointing device, through the lasers in the telecommunication systems, DVD players and finishing with lasers for solid-state lightning. The quantum cascade laser entered this stage in 1994 when the wavelength restriction of bulk semiconductor based laser was overcome using inter-subband transitions in the semiconductor heterostructure. Engineering of those transitions in the form of the quantum cascades (QC) has allowed reaching emission at the mid-infrared and later at the far-infrared wavelength. Major disadvantage of today´s QC laser is its low operation temperature. Therefore, current scientific effort is focused on the development of QCL with the high output power and higher operation temperature. Reaching these goals the detailed knowledge of processes in the QC laser is required. Recently, we have developed a technique to study such processes even in the lasing QCL devices.

A review of our recent work on the terahertz time-domain spectroscopy of QCL is presented with focus on the used technique itself and on the measurement of the gain and laser cavity loss. Different QC laser designs are compared with respect to the observed spectral gain bandwidth, at its dependence on the operation temperature. Such results help to identify problems of different schemes of the intersubband transition used for QC laser and enable to improve QC laser design.

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