7th Workshop on Nanotube Optics and Nanospectroscopy (WONTON 2018)

Report of Contributions

https://indico2.riken.jp/e/wonton2018

Contribution ID: **0** Type: **Invited Talk**

Stacking-dependent Interlayer Couplings in 2D Materials

Wednesday, July 11, 2018 9:30 AM (30 minutes)

Summary

Primary author: Prof. KAIHUI, Liu (Peking University)

Presenter: Prof. KAIHUI, Liu (Peking University)

Contribution ID: **1** Type: **Invited Talk**

Diameter-dependent optical absorption and energy transfer from encapsulated dye molecules to single wall carbon nanotubes

Wednesday, July 11, 2018 4:10 PM (30 minutes)

Summary

Primary author: Prof. CAMBRÉ, Sofie (University of Antwerp)

Co-authors: Dr FERGUSON, Andrew J. (National Renewable Energy Laboratory); Dr ARIAS, Dylan H. (National Renewable Energy Laboratory); Dr BLACKBURN, Jeffrey L. (National Renewable Energy Laboratory); Dr CAMPO, Jochen (University of Antwerp); Mr DEFILLET, Joeri (University of Antwerp); Dr JOHNSON, Justin C. (National Renewable Energy Laboratory); Dr IHLY, Rachelle (National Renewable Energy Laboratory); Mr VAN BEZOUW, Stein (University of Antwerp); Prof. WENSELEERS, Wim (University of Antwerp)

Presenter: Prof. CAMBRÉ, Sofie (University of Antwerp)

Contribution ID: **2** Type: **Poster**

Photophysical properties of porphyrin–single-walled carbon nanotube linked systems with various spacer lengths

Monday, July 9, 2018 6:45 PM (15 minutes)

Primary author: Prof. UMEYAMA, Tomokazu (Kyoto University)

Co-authors: Prof. IMAHORI, Hiroshi (Kyoto University); Dr BAEK, Jinseok (Kyoto University)

Presenter: Prof. UMEYAMA, Tomokazu (Kyoto University)

Session Classification: Poster Session

Contribution ID: **3** Type: **Invited Talk**

Molecular design for photoluminescence modulation of locally functionalized single-walled carbon nanotubes

Monday, July 9, 2018 11:10 AM (30 minutes)

Summary

Primary author: Dr SHIRAKI, Tomohiro (Kyushu University)

Presenter: Dr SHIRAKI, Tomohiro (Kyushu University)

Contribution ID: **4** Type: **Contributed Talk**

Conservation law of angular momentum in Raman spectroscopy using circularly polarized light

Tuesday, July 10, 2018 10:00 AM (20 minutes)

Summary

Primary author: Prof. SAITO, Riichiro (Tohoku University)

Co-authors: Dr TATSUMI, Yuki (Tohoku University); Dr KANEO, Tomoaki (Tohoku University)

Presenter: Prof. SAITO, Riichiro (Tohoku University)

Contribution ID: **5** Type: **Poster**

Phonon Assigning of G-band from Suspended Single-walled Carbon Nanotubes

Wednesday, July 11, 2018 6:45 PM (15 minutes)

Summary

Primary author: Mr TANAKA, Yuichiro (Department of Physics, Tokyo University of Science)

Co-authors: Mr KATO, Takashi (Department of Physics, Tokyo University of Science); Mr YOSHINO, Kazuki (Department of Physics, Tokyo University of Science); Prof. CHIASHI, Shohei (Department of Mechanical Engineering, The University of Tokyo); Prof. HOMMA, Yoshikazu (Department of Physics, Tokyo University of Science)

Presenter: Mr TANAKA, Yuichiro (Department of Physics, Tokyo University of Science)

Session Classification: Poster Session

Contribution ID: **6** Type: **Poster**

Thin films from carbon nanotubes of highly tuned structure and properties

Monday, July 9, 2018 6:45 PM (15 minutes)

Due to remarkable electrical, thermal, optical and other properties of carbon nanotubes they have attracted significant interest from research groups all over the world. However, to implement them in the real life, we still need better methods to control their structure at the nanoscale and also techniques to turn these highly defined materials into macroscopic ensembles. In this contribution, I will present results of our work how we have attempted to solve these problems. I will share our recent advances on the front of sorting CNTs by electrical character and chirality [1,2]. I will also show a method developed by us, which enables formation of free-standing thin films from any type of CNTs including that of monochiral nature [3,4]. The obtained materials are very promising for a wide range of electrical and optical applications.

[1] D. Janas, E. Turek, T. Wasiak, G. Stando, Carbon (submitted)
[2] D. Janas, E. Turek, T. Shiraki, Nat. Nanotechnol. (submitted)
[3] D. Janas, M. Rdest, K. Koziol, Mat. & Des. 121, 119-125 (2017)
[4] D. Janas, G. Stando, Sci. Rep. 7, 12274 (2017)

Summary

Primary author: Dr JANAS, Dawid (Department of Chemistry, Silesian University of Technology, B. Krzywoustego 4, 44-100, Gliwice, Poland)

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Presenter: Dr JANAS, Dawid (Department of Chemistry, Silesian University of Technology, B. Krzywoustego 4, 44-100, Gliwice, Poland)

Session Classification: Poster Session

Contribution ID: **7** Type: **Poster**

Environmental electrometry with luminescent carbon nanotubes

Wednesday, July 11, 2018 5:15 PM (15 minutes)

We demonstrate that localized excitons in luminescent carbon nanotubes can be utilized to study electrostatic fluctuations in the nanotube environment with sensitivity down to the elementary charge. By monitoring the temporal evolution of the cryogenic photoluminescence from individual carbon nanotubes grown on silicon oxide and hexagonal boron nitride we characterize the dynamics of charge trap defects for both dielectric supports. We find a one order of magnitude reduction in the photoluminescence spectral wandering for nanotubes on extended atomically flat terraces of hexagonal boron nitride. For nanotubes on hexagonal boron nitride with pronounced spectral fluctuations our analysis suggest proximity to terrace ridges where charge fluctuators agglomerate to exhibit spatial densities exceeding those of silicon oxide. Our results establish carbon nanotubes as sensitive probes of environmental charge fluctuations and highlight their potential for applications in electrometric nanodevices with all-optical readout.

Summary

Primary author: NOE, Jonathan (Ludwig-Maximilian University Munich)

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Presenter: NOE, Jonathan (Ludwig-Maximilian University Munich)

Session Classification: Poster Session

Contribution ID: **8** Type: **Poster**

Cryogenic spectroscopy of sp3 defect states in carbon nanotubes

Monday, July 9, 2018 5:00 PM (15 minutes)

Photoactive defect states in semiconducting single-walled carbon nanotubes (CNTs) have the potential to enable novel applications in quantum photonic technologies. While early experiments have established cryogenic CNTs as quantum light emitters [1], more recent work has identified luminescent defect states as sources of single photons up to room temperature [2,3]. For chemically-engineered CNTs, sp^3 functionalization offers means to deterministically influence the corresponding trap state properties via the characteristics of the covalent side chains. Recent findings show that the incorporation of sp^3 alkyl defects into the sp^2 lattice of narrow-diameter CNTs promotes the formation of both neutral and charged localized excitons [4] with unexpectedly high quantum efficiency. Here, we report the results of our cryogenic photoluminescence studies carried out on individual nanotubes functionalized with sp^3 side-wall chemistry.

[1] A. Högele, C. Galland, M. Winger, A. Imamoglu, Phys. Rev. Lett. **100**, 217401 (2008).
[2] X. Ma, N. F. Hartmann, J. K. S. Baldwin, S. K. Doorn, H. Htoon, Nat. Nanotech. **10**, 671–675 (2015).
[3] X. He et al., Nat. Photon. **11**, 577–582 (2017).
[4] H. Kwon, M. Kim, M. Nutz, N. F. Hartmann, V. Perrin, B. Meany, M. S. Hofmann, C. W. Clark, S. K. Doorn, A. Höegele, Y. Wang, submitted.

Summary

Primary author: NUTZ, Manuel (Ludwig-Maximilians-University Munich)

Co-authors: KWON, Hyejin (University of Maryland); KIM, Mijin (University of Maryland); WANG, YuHuang (University of Maryland); HÖGELE, Alexander (Fakultät für Physik, Munich Quantum Center, and Center for NanoScience (CeNS), Ludwig-Maximilians-Universität, Geschwister-Scholl-Platz 1, 80539 München, Germany)

Presenter: NUTZ, Manuel (Ludwig-Maximilians-University Munich)

Session Classification: Poster Session

Contribution ID: **9** Type: **Poster**

Photocurrent Spectroscopy of Dye Sensitized Carbon Nanotubes

Wednesday, July 11, 2018 5:30 PM (15 minutes)

Monochiral (7,5) single walled carbon nanotubes (SWCNTs) are integrated into a field effect transistor device in which the built-in electric field at the nanotube:metal contact allows for exciton separation under external light bias. Variable wavelength spectroscopy and 2D surface mapping of devices consisting of 10 –20 nanotubes is performed in the visible, and a strong correlation between the nanotube's second optical transition (S22) and the photocurrent is found. Subsequently, the SWCNTs are non-covalently modified with three different fluorescent dye molecules with off-resonant absorption maxima at 532, 565, and 610 nm. Energy transfer from the dyes onto the SWCNTs allows for the optical properties of the nanotube to be tailored and holds promise for the development of photo-detectors and for applications in photovoltaics and biosensing

Summary

Primary authors: Mr ALAM, Asiful (Karlsruhe Institute of Technology); Mrs DEHM, Simone (Karlsruhe Institute of Technology); Dr HENNRICH, Frank (Karlsruhe Institute of Technology); Dr YURIY, Zakharko (Universitaet Heidelberg); Dr GRAF, Arko (Universitaet Heidelberg); Dr PFOHL, Moritz (Karlsruhe Institute of Technology); Mr HOSSAIN, Ihteaz (Karlsruhe Institute of Technology); Prof. KAPPES, Manfred (Karlsruhe Institute of Technology); Prof. ZAUMSEIL, Jana (Universitaet Heidelberg); Prof. KRUPKE, Ralph (Technische Universitaet Heidelberg); Dr FLAVEL, Benjamin (Karlsruhe Institute of Technology)

Presenter: Dr FLAVEL, Benjamin (Karlsruhe Institute of Technology)

Session Classification: Poster Session

Contribution ID: **10** Type: **Invited Talk**

Optics and Photonics of Aligned Carbon Nanotube Films

Monday, July 9, 2018 9:00 AM (30 minutes)

Summary

Primary author: Prof. KONO, Junichiro (Rice University)

Presenter: Prof. KONO, Junichiro (Rice University)

Contribution ID: **11** Type: **Invited Talk**

Exciton-Polaritons, Plexcitons and Trion-Polaritons in Single-Walled Carbon Nanotube Thin Films and Devices

Tuesday, July 10, 2018 10:40 AM (30 minutes)

Summary

Primary author: Prof. ZAUMSEIL, Jana (Heidelberg University)

Presenter: Prof. ZAUMSEIL, Jana (Heidelberg University)

Contribution ID: **12** Type: **Poster**

High-Speed and integrated graphene blackbody emitters

Monday, July 9, 2018 5:15 PM (15 minutes)

Summary

Primary author: FUKAZAWA, Yusuke

Co-authors: MIYOSHI, Yusuke; AMASAKA, Yuya; RECKMANN, Robin; YOKOI, Tomoya; ISHIDA, Kazuki; KAWAHARA, Kenji; Prof. AGO, Hiroki; Prof. MAKI, Hideyuki

Presenter: FUKAZAWA, Yusuke

Session Classification: Poster Session

Contribution ID: **13** Type: **Contributed Talk**

H₂-evolving SWCNT Photocatalysts for Effective Use of Solar Energy

Wednesday, July 11, 2018 11:30 AM (20 minutes)

Summary

Primary authors: TAKAGUCHI, Yutaka (Okayama University); Mr IZAWA, Takumi (Okayama University); Mr MIYAMOTO, Daiki (Okayama University); Dr TAJIMA, Tomoyuki (Okayama University); Dr MIYAKE, Hideaki (Okayama University)

Presenter: TAKAGUCHI, Yutaka (Okayama University)

Contribution ID: **14** Type: **Poster**

Photon antibunching in single-walled carbon nanotubes at telecommunication wavelengths and room temperature

Monday, July 9, 2018 5:30 PM (15 minutes)

Summary

Primary author: KAWABE, Rintaro (Hideyuki Maki Group in Keio University (Department of Applied Physics and Physico-Informatics,Faculty of Science and Technology)

Co-authors: Prof. MAKI, Hideyuki; Prof. ISHI-HAYASE, Junko; Mr TAKAKI, Hiroshi; Mr ENDO, Takumi

Presenter: KAWABE, Rintaro (Hideyuki Maki Group in Keio University (Department of Applied Physics and Physico-Informatics,Faculty of Science and Technology)

Session Classification: Poster Session

Contribution ID: **15** Type: **Contributed Talk**

Theory of a carbon-nanotube polarization switch

Tuesday, July 10, 2018 11:40 AM (20 minutes)

Summary

Primary authors: SASAKI, Ken-ichi (NTT Basic Research Laboratories); Prof. TOKURA, Yasuhiro (Faculty of Pure and Applied Sciences, University of Tsukuba)

Presenter: SASAKI, Ken-ichi (NTT Basic Research Laboratories)

Contribution ID: **16** Type: **Poster**

Cavity-control of bright and dark interlayer excitons in van der Waals heterostructures

Monday, July 9, 2018 5:45 PM (15 minutes)

Monolayer transition metal dichalcogenides integrated in optical microcavities host exciton-polaritons as a hallmark of the strong light-matter coupling regime [1]. Analogous concepts for hybrid light-matter systems employing spatially indirect excitons with a permanent electric dipole moment in heterobilayer crystals promise realizations of exciton-polariton gases and condensates with immanent dipolar interactions. Here, we identify optical signatures of spatially indirect momentum-bright and momentum-dark interlayer excitons in vertical $MoSe_2$-WSe_2 heterostructures and implement cavity-control of both exciton manifolds. To this end we employ a tunable open-access cavity with one curved fiber-based mirror [2] and one planar mirror with extended $MoSe_2$-WSe_2 heterobilayer flakes on top. The configuration of controlled intermirror spacing and lateral scanning capabilities is used to explore the light-matter coupling of excitons as a function of the cavity length at representative positions of heterobilayers selected by two-dimensional cavity imaging. Our experiments quantify the strength of interlayer excitons and demonstrate Purcell enhancement in cavity-modified photonic environments [3].

[1] X. Liu, T. Galfsky, Z. Sun, F. Xia, E.-c. Lin, Y.-H. Lee, S. Kena-Cohen, and V. M. Menon, Nature Photonics 9, 30 (2015).
[2] D. Hunger, T. Steinmetz, Y. Colombe, C. Deutsch, T. W. Hänsch, and J. Reichel, New J. Phys. 12,065038 (2010).
[3] M. Förg, L. Colombier, R. Patel, J. Lindlau, A. D. Mohite, H. Yamaguchi, D. Hunger, and A. Högele, arXiv:1710.00990 (2017).

Summary

Primary author: Mr FÖRG, Michael (Ludwig-Maximilians-Universität Munich)

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Presenter: Mr FÖRG, Michael (Ludwig-Maximilians-Universität Munich)

Session Classification: Poster Session

Contribution ID: **17** Type: **Contributed Talk**

Controlling the optical fingerprint of transition metal dichalcogenides via molecules, strain and disorder

Wednesday, July 11, 2018 10:00 AM (20 minutes)

Summary

Primary authors: FEIERABEND, Maja (Chalmers); Prof. MALIC, Ermin (Chalmers)

Presenter: FEIERABEND, Maja (Chalmers)

Contribution ID: **18** Type: **Contributed Talk**

Direct Determination of Chemically Induced Doping Concentrations in (6,5)- Single-Wall Carbon Nanotubes by EPR

Thursday, July 12, 2018 10:00 AM (20 minutes)

Control over doping of semiconducting Single-Wall Carbon Nanotubes (SWNTs) by (electro-) chemical methods and intrinsic impurities are considered to be crucial for future applications of SWNTs in carbon-based electronics and photonics. Previous indirect all-optical techniques hypothesize charge carrier localization in semiconducting (6,5)-SWNTs following redox chemical AuCl3 doping, which is indicated by spectral and dynamical changes of the S1 exciton band [1].
Here, we present direct quantitative investigations of chemical impurities by means of electron paramagnetic resonance (EPR). For the as-produced (6,5)-SWNT samples we detected very low signal intensities stemming from two separate radical-like, isolated spin contributions that we assign to defects or residual impurities and which may be associated with what is sometimes referred to as intrinsic p-doping. Their concentration indicates exceptional nanotube quality with only few paramagnetic species per µm nanotube. Upon addition of the doping agent (AuCl3)2 we observe a linear increase of the EPR signal intensity which we ascribe to localized p-type impurities on the nanotube. However, at higher doping concentrations, the observed signal saturates, before decreasing again and finally vanishing at the highest AuCl3 concentrations. This seemingly puzzling result can be understood in terms of the formation of EPR silent, diamagnetic bi-radicals which start to appear at moderate doping concentrations. We model this behaviour with a stochastic formation of impurity sites in a 1D lattice, yielding good agreement with experimental data. In conclusion, we can confirm charge carrier confinement at low impurity concentrations in SWNTs with potentially far reaching implications for future device applications.

Summary

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Presenter: Dr SPERLICH, Andreas (Julius Maximilian University of Würzburg, Germany)

Contribution ID: **19** Type: **Poster**

Post modification approach for photoluminescence modulation of locally functionalized single-walled carbon nanotubes

Wednesday, July 11, 2018 5:45 PM (15 minutes)

Summary

Primary authors: Mr SHIGA, Tamehito (Kyushu University); Prof. FUJIGAYA, Tsuyohiko (Kyushu University); Prof. NAKASHIMA, Naotoshi (Kyushu University); Dr SHIRAKI, Tomohiro (Kyushu Univeristy)

Presenter: Mr SHIGA, Tamehito (Kyushu University)

Session Classification: Poster Session

Contribution ID: **20** Type: **Poster**

Evaluation of substituent effects on the potential levels of locally-functionalized single-walled carbon nanotubes using in situ photoluminescence spectroelectrochemistry

Monday, July 9, 2018 6:00 PM (15 minutes)

Summary

Primary authors: Mr SHIRAISHI, Tomonari (Kyushu University); Prof. NAKASHIMA, Naotoshi (Kyushu University); Dr SHIRAKI, Tomohiro (Kyushu University)

Presenter: Mr SHIRAISHI, Tomonari (Kyushu University)

Session Classification: Poster Session

Contribution ID: **21** Type: **Poster**

Spectral tuning of optical coupling between air-mode nanobeam cavities and individual carbon nanotubes

Wednesday, July 11, 2018 5:00 PM (15 minutes)

We design high quality factor air-mode nanobeam cavities by finite-difference time-domain simulations, and utilize the cavities to enhance the emission of air-suspended carbon nanotubes 1. The cavities are fabricated from silicon-on-insulator wafers, and nanotubes are synthesized over the cavities by chemical vapor deposition. Photoluminescence spectroscopy is performed on the devices, where we observe optical coupling when the nanotube emission energy is close to the cavity resonance. Taking advantage of laser-heating-induced blueshifts of the nanotube emission, we can reduce the detunings 2. We derive and numerically calculate the generalized expression for the spectral overlap, and good correlation to the enhancement factors is obtained.

Work supported by JSPS (KAKEIHI JP16H05962, JP16K13613), and MEXT (Photon Frontier Network Program, Nanotechnology Platform). H.M. is supported by RIKEN Junior Research Associate Program, and T.U. is supported by ALPS and JSPS Research Fellowship.

1 R. Miura, S. Imamura, R. Ohta, A. Ishii, X. Liu, T. Shimada, S. Iwamoto, Y. Arakawa, and Y. K. Kato, Nature Commun. 5, 5580 (2014).
2 H. Machiya, T. Uda, A. Ishii, and Y. K. Kato, Appl. Phys. Lett. 112, 021101 (2018).

Summary

Primary author: MACHIYA, Hidenori (Nanoscale Quantum Photonics Laboratory, RIKEN)

Co-authors: KATO, Yuichiro (Nanoscale Quantum Photonics Laboratory); ISHII, Akihiro (Nanoscale Quantum Photonics Laboratory, RIKEN); UDA, Takushi (Nanoscale Quantum Photonics Laboratory, RIKEN)

Presenter: MACHIYA, Hidenori (Nanoscale Quantum Photonics Laboratory, RIKEN)

Session Classification: Poster Session

Contribution ID: **22** Type: **Poster**

Optical properties of core-shell systems based on carbon nanotubes

Monday, July 9, 2018 6:15 PM (15 minutes)

Summary

Primary author: ORCIN-CHAIX, Lucile

Presenter: ORCIN-CHAIX, Lucile

Session Classification: Poster Session

Contribution ID: **23** Type: **Poster**

Probing the optical dipole transition and vibrational coherences in individual (5,4) carbon nanotubes by femtosecond pulse shaping

Wednesday, July 11, 2018 6:45 PM (15 minutes)

Summary

Primary author: Dr CIESIELSKI, Richard (Ludwig-Maximilians-Universität München)

Co-authors: Prof. HARTSCHUH, Achim (Ludwig-Maximilians-Universität München); Mr GIEGOLD, Veit (Ludwig-Maximilians-Universität München)

Presenter: Dr CIESIELSKI, Richard (Ludwig-Maximilians-Universität München)

Session Classification: Poster Session

Contribution ID: **24** Type: **Poster**

Optical Properties of Oxidized Single-Wall Carbon Nanotubes

Monday, July 9, 2018 6:45 PM (15 minutes)

Summary

Primary author: OHFUCHI, Mari (Fujitsu Labs.)

Presenter: OHFUCHI, Mari (Fujitsu Labs.)

Session Classification: Poster Session

Contribution ID: **25** Type: **Contributed Talk**

Nonperturbing, conjugation-preserving covalent functionalization of single-walled carbon nanotubes

Monday, July 9, 2018 11:40 AM (20 minutes)

The most common outcome of covalent treatments of carbon nanotubes is the conversion of sp2 carbon atoms into their sp3 hybridization state. Even mild approaches interrupt the conjugation of the carbon network with detrimental effects on their optoelectronic properties. Cycloaddition reactions establish covalent bonds through pi-electrons to bridge targeted functionalities onto the tubes. The carbon atoms below the bridge are converted into the sp3 state (closed configuration, Fig. 1a) or, if the C-C bond below the bridge is released, keep their sp2 character (open configuration, Fig. 1b) and preserve the overall conjugation of the extended network. We have recently demonstrated that the outcome of a triazine-based [2+1] cycloaddition reaction results in the open configuration (Fig. 1c) and preserves the intrinsic properties of the tubes, even at high degrees of functionalization (4%) 1. Here we will highlight some of the benefits of this approach, such as the preservation of their radiative emission (Fig. 1d) or the fine-tuning of the position of their Fermi levels.
We will moreover discuss how the functionalized tubes can be exploited as starting platform for advanced materials. We show how the attachment of molecular systems makes them integrating part and in electronic communication with the conjugated network of the tubes, yielding new ways to non-perturbatively tailor, control, and alter the optical response of the tubes for novel applications. The conjugation of the molecular switch spyropiran-merocyanine, for example, enables controlled on-off switching of the tubes'emission to be exploited for nanotubes-based super-resolution microscopy.

1 A. Setaro, *et al.*, Nat. Comm. **8**, 14281 (2017).

Summary

Primary authors: Dr SETARO, Antonio (Freie Universität Berlin); Mrs MAREEN GLAESKE; Prof. ADELI, Mohsen; Prof. HAAG, Rainer; Prof. REICH, Stephanie

Presenter: Dr SETARO, Antonio (Freie Universität Berlin)

Contribution ID: **28** Type: **Poster**

Kinetics of diazonium functionalization of carbon nanotubes

Monday, July 9, 2018 6:30 PM (15 minutes)

Summary

Primary author: Ms MÜLLER, Kerstin (Julius Maximilian University Würzburg, Germany)

Co-authors: Mr FUHL, Lucas (Julius Maximilian University Würzburg, Germany); Dr SCHÖPPLER, Friedrich (Julius Maximilian University Würzburg, Germany); Prof. HERTEL, Tobias (Julius Maximilian University Würzburg, Germany)

Presenter: Ms MÜLLER, Kerstin (Julius Maximilian University Würzburg, Germany)

Session Classification: Poster Session

Contribution ID: **29** Type: **Invited Talk**

Killer defects in semiconducting SWNTs

Wednesday, July 11, 2018 2:00 PM (30 minutes)

The doping of semiconductors is key for providing electronic and photonic devices with their desired functionality. This comes with the realization, that the failure to successfully dope certain classes of materials "is an important bottleneck for the technological utilization of these materials" in electronic or photonic devices, as succinctly expressed by Zunger 1. This concern also pertains to the doping of semiconducting single-wall carbon nanotubes (s-SWNTs) where our ability to provide stable and measured concentrations of surplus carriers remains a major challenge.
Current approaches to doping of s-SWNTs are mostly designed around redox chemistry or covalent modification with electron pulling or pushing side-chain functionalities while the use of substitutional impurities has hardly been explored for the purpose of electronic enhancement. Despite the importance of doping for device technologies, however, it appears that our ability to quantify the concentration of impurity site concentrations or their effectiveness in providing surplus free carriers is still rather limited.
To address these shortcomings we have performed spectroscopic investigations of redox-and electrochemically doped (6,5) s-SWNT samples using fluorescence and absorption spectroscopy 2. Spectroscopically, there appears to be no noticeable difference between these two approaches. In both cases, exciton bands are found to broaden, become asymmetric and shift to higher energies when the electrochemical potential is shifted toward valence or conduction band edges. These observations are consistent with confinement of excitons by a stochastic distribution of impurities, suggesting that doping is in-homogeneous rather than homogeneous. Moreover, our analysis suggests that the interaction of minority carriers with external counterions can provide deep traps in the band gap which act as 'killer defects', capturing free charge carriers and effectively preventing the desired homogenous doping.
We also discuss how the analysis of exciton absorption bands can be applied to quantify impurity level concentrations. In the context of optical spectroscopy this allows to define and clearly distinguish between intrinsic-, weak-, moderate- and heavy-doping regimes. The onset of degenerate s-SWNT doping is determined to be at about ± 0.1 e/nm.
The observed generation of deep charge traps by adsorbed counterions can largely be attributed to weak dielectric screening of Coulomb interactions by SWNTs or their environment, a common characteristic of low-dimensional systems. We take this as evidence for serious fundamental challenges which may have far reaching and possibly broader implications for the successful fabrication of functional semiconductor devices from nanoscale materials.

1. A. Zunger, Appl. Phys. Lett 83, 57-59 (2003).
2. K. Eckstein, H. Hartleb, M.M. Achsnich, F. Schöppler, T. Hertel, ACS Nano 11, 10401 (2017).

Summary

Primary authors: Prof. HERTEL, Tobias (Institute of Physical and Theoretical Chemistry); Mr ECKSTEIN, Klaus (Institute of Physical and Theoretical Chemistry); Ms ACHSNICH, Melanie (Institute of Physical and Theoretical Chemistry); Dr SCHÖPPLER, Friedrich (Institute of Physical and Theoretical Chemistry)

Presenter: Prof. HERTEL, Tobias (Institute of Physical and Theoretical Chemistry)

Contribution ID: **30** Type: **Poster**

Effect of functionalization and subsequent thermal treatment on photoluminescence properties of single-walled carbon nanotubes

Monday, July 9, 2018 6:45 PM (15 minutes)

Summary

Primary author: Dr MAEDA, Yutaka (Department of Chemistry, Tokyo Gakugei University)

Co-authors: Mr TAKEHANA, Yuya (Department of Chemistry, Tokyo Gakugei University); Mr MINAMI, Shun; Ms NISHINO, Akane; Mr KONNO, Yui; Dr YAMADA, Michio; Dr DANG, Jing S.; Prof. NAGASE, Shigeru; Mr AOTA, Shun; MIYAUCHI, Yuhei; MATSUDA, Kazunari (Kyoto University); Dr IIZUMI, Yoko; Dr OKAZAKI, Toshiya; Dr WANG, Wei W.

Presenter: Dr MAEDA, Yutaka (Department of Chemistry, Tokyo Gakugei University)

Session Classification: Poster Session

Contribution ID: **33** Type: **Invited Talk**

Excitons in Coupled Nanotube Photovoltaic Thin Films

Tuesday, July 10, 2018 11:10 AM (30 minutes)

We have previously reported on the efficient harvesting of excitons from photoexcited, semiconducting nanotube thin films. The films are interfaced with C60 fullerenes to form a type-II heterojunction with band offsets that exceed the exciton binding energy. Excitons photogenerated near the heterointerface are dissociated into separable electrons (which transfer to C60) and holes (which remain on the nanotubes) with quantum efficiency ≈ 90%. This behavior has promise for creating nanotube photoabsorber-based photovoltaic solar cells and photodetectors. However, the efficiency by which excitons can be dissociated remains high only when the nanotube films are thin (5 nm in thickness). The efficiency rapidly decreases as the nanotube film thickness increases, due to poor inter-nanotube exciton migration.

Here, we present on recent work designed to understand and improve exciton migration in coupled nanotube films via theory 1 and experiments [2-4]. We have calculated exciton transfer rates due to Coulomb coupling between nanotubes of varying orientations considering both first- and second-order (phonon-assisted) processes. Second-order dark-to-bright inter-nanotube transfer is as fast as both first and second order bright-to-bright transfer. This important result shows that dark excitonic states are able to efficiently and directly transfer between nanotubes in films.1 We have tested the hypothesis that poor inter-nanotube exciton migration in films can be attributed to quenching by defects via experiments in which (i) diazonium defects are intentionally added to nanotubes at known concentrations 2 and in which (ii) nanotubes are prepared via three different processes of decreasing harshness: extended ultrasonication, brief ultrasonication, and shear force mixing [3]. Inter-nanotube exciton transfer is then characterized via photoluminescence-, transient absorption-, and device photocurrent spectroscopies. Our results show that poor out-of-plane exciton diffusion depth can be attributed in large part due to losses that arise from the trapping and quenching of excitons by defects induced during processing. Other photovoltaic parameters including fill-factor and open-circuit voltage also improve with decreasing processing harshness.

1 A.H. Davoody, M.S. Arnold, I. Knezevic et al., J. Phys. Chem. C, 121, 13084–13091 (2017).
2 J. Wang, J.T. Flach, M.T. Zanni, M.S. Arnold et al., J. Phys. Chem. C, 4, 8310-8318 (2017).
[3] M.J. Shea, J.T. Flach, M.T. Zanni, M.S. Arnold et al., In Revision (2018).

Summary

Primary authors: Mr WANG, Jialiang; Dr SHEA, Matthew; Dr DAVOODY, Amirhossein; Dr KARIMI, Farhad; Ms FLACH, Jessica; Dr MCDONOUGH, Thomas; Prof. ZANNI, Martin; Prof. KNEZEVIC, Irena; Prof. ARNOLD, Michael

Presenter: Prof. ARNOLD, Michael

Contribution ID: **34** Type: **Invited Talk**

Luttinger liquid in carbon nanotubes

Tuesday, July 10, 2018 9:00 AM (30 minutes)

Single Walled carbon nanotubes provide the ideal platform to explore Luttinger liquid physics due to the strong one-dimensional quantum confinement. I will discuss out combined electrical and optical studies to correlate the unusual electron tunneling and plasmon excitations of a Luttinger liquid. I will also show that distinctly different plasmon behavior in electrically gated metallic and semiconducting carbon nanotubes, which are described by the linear Luttinger liquid and nonlinear Luttinger liquid, respectively.

Summary

Primary author: Prof. WANG, Feng (University of California, Berkeley)

Presenter: Prof. WANG, Feng (University of California, Berkeley)

Contribution ID: **35** Type: **Poster**

Dielectric properties of vertically aligned carbon nanotubes in the mid-IR and THz spectral range

Wednesday, July 11, 2018 6:45 PM (15 minutes)

Summary

Primary author: Prof. ROSKOS, Hartmut (Physics Institute, Goethe-University)

Co-authors: Dr THOMSON, Mark (Physics Institute, Goethe-University); Dr ZOUAGHI, Wissem (Physics Institute, Goethe-University); Dr RYCHETSKY, Ivan (Institute of Physics, Academy of Sciences); Prof. KUZEL, Petr (Institute of Physics, Academy of Sciences)

Presenter: Prof. ROSKOS, Hartmut (Physics Institute, Goethe-University)

Session Classification: Poster Session

Contribution ID: **36** Type: **Invited Talk**

Mid- and high-temperature exciton photophysics of carbon nanotubes and their applications

Monday, July 9, 2018 9:30 AM (30 minutes)

Summary

Primary author: MIYAUCHI, Yuhei

Presenter: MIYAUCHI, Yuhei

Contribution ID: **37** Type: **Invited Talk**

Photo-induced interactions between SWCNTs and oxygen

Thursday, July 12, 2018 9:00 AM (30 minutes)

Summary

Primary author: WEISMAN, R. Bruce (Rice University)

Presenter: WEISMAN, R. Bruce (Rice University)

Contribution ID: **38** Type: **Invited Talk**

PL quantum yield of SWCNTs: photon reabsorption effect

Thursday, July 12, 2018 11:10 AM (30 minutes)

Summary

Primary author: Dr KATAURA, Hiromichi (NMRI, AIST)

Co-authors: Dr WEI, Xioajun (NMRI, AIST); Ms TSUZUKI, Mayumi (NMRI, AIST); Dr WANG, Guowei (NMRI, AIST); Dr YOMIGIDA, Yohei (NMRI, AIST); Dr HIRANO, Atsushi (NMRI, AIST); Dr TANAKA, Takeshi (NMRI, AIST)

Presenter: Dr KATAURA, Hiromichi (NMRI, AIST)

Contribution ID: **39** Type: **Invited Talk**

Nanoscale Imaging in, of & with Luminescent Single Walled Carbon Nanotubes

Wednesday, July 11, 2018 2:30 PM (30 minutes)

Summary

Primary author: COGNET, Laurent (University of Bordeaux)

Presenter: COGNET, Laurent (University of Bordeaux)

Contribution ID: **40** Type: **Invited Talk**

DNA-wrapped carbon nanotubes for sorting and multiplex optical sensing

Summary

Primary author: ZHENG, Ming

Presenter: ZHENG, Ming

Contribution ID: **41** Type: **Invited Talk**

Carbon Nanotube Optical Bandgap Modulation for Cancer Research and Diagnosis

Wednesday, July 11, 2018 10:40 AM (30 minutes)

The measurement of biomarkers, drugs, and metabolites in live cells and organisms would allow for improvements in disease detection, drug development, and biomedical research. Single-walled carbon nanotubes have suitable optical properties for application as sensors for use in live cells and in vivo, including narrow, near-infrared emission bands with sensitivity to the local environment. To develop them into sensors for bioanalytes, we devised new methods to probe single-walled carbon nanotube optical properties, including near-infrared hyperspectral imaging and live-tissue excitation/emission spectroscopy. We also identified a new mechanism of carbon nanotube photoluminescence environmental responsivity, whereby electrostatic charges mediate spectral red-shifting. We believe that this effect is consistent with previous findings of carbon nanotube solvatochromic behavior. We found that this mechanism facilitates the measurement of multiple classes of bioanaltytes, such as nucleic acids, drugs, and proteins, enabling the development of in vivo implantable sensors for the study and detection of cancer.

Summary

Primary author: Prof. HELLER, Daniel (Memorial Sloan Kettering Cancer Center)

Presenter: Prof. HELLER, Daniel (Memorial Sloan Kettering Cancer Center)

Contribution ID: **42** Type: **Invited Talk**

Spectroscopy of localized excitons in cryogenic carbon nanotubes

Monday, July 9, 2018 4:10 PM (30 minutes)

Summary

Primary author: HOEGELE, Alexander (LMU Munich)

Presenter: HOEGELE, Alexander (LMU Munich)

Contribution ID: **43** Type: **Contributed Talk**

Probing exciton-exciton annihilation in hBN with cathodoluminescence experiments

Monday, July 9, 2018 3:00 PM (20 minutes)

Summary

Primary author: PLAUD, Alexandre (ONERA-CNRS / UVSQ-CNRS)

Co-authors: SCHUÉ, Léonard; LOISEAU, Annick (ONERA-CNRS); BARJON, Julien (UVSQ-CNRS)

Presenter: PLAUD, Alexandre (ONERA-CNRS / UVSQ-CNRS)

Contribution ID: **44** Type: **Invited Talk**

Trions at a Trapping Defect

Monday, July 9, 2018 10:40 AM (30 minutes)

Summary

Primary author: Prof. WANG, YuHuang (University of Maryland)

Presenter: Prof. WANG, YuHuang (University of Maryland)

Contribution ID: **45** Type: **Poster**

Molecular screening effects on trion binding energies and electronic band gaps in air-suspended carbon nanotubes

Wednesday, July 11, 2018 6:00 PM (15 minutes)

Summary

Primary author: Dr TANAKA, Shunsuke (Quantum Optoelectronics Research Team, RIKEN Center for Advanced Photonics)

Co-authors: UDA, Takushi (Nanoscale Quantum Photonics Laboratory, RIKEN); KATO, Yuichiro (Nanoscale Quantum Photonics Laboratory)

Presenter: Dr TANAKA, Shunsuke (Quantum Optoelectronics Research Team, RIKEN Center for Advanced Photonics)

Session Classification: Poster Session

Contribution ID: **46** Type: **Poster**

Modulation-Doped Multiple Quantum Wells of Aligned Single-Wall Carbon Nanotubes

Monday, July 9, 2018 6:45 PM (15 minutes)

Summary

Primary author: Ms KOMATSU, Natsumi (Rice University)

Co-author: KONO, Junichiro (Rice University)

Presenter: Ms KOMATSU, Natsumi (Rice University)

Session Classification: Poster Session

Contribution ID: **47** Type: **Poster**

Narrow-band thermal exciton radiation in individual suspended single-walled carbon nanotubes

Wednesday, July 11, 2018 6:15 PM (15 minutes)

Summary

Primary authors: Dr NISHIHARA, Taishi (Nagoya University); Mr TAKAKURA, Akira (Nagoya University); Dr MIYAUCHI, Yuhei (Nagoya Universtiy); Prof. ITAMI, Kenichiro (Nagoya University)

Presenter: Dr NISHIHARA, Taishi (Nagoya University)

Session Classification: Poster Session

Contribution ID: **48** Type: **Invited Talk**

Environmental Effects on Photoluminescence Properties of Carbon Nanotube sp3 Defects

Thursday, July 12, 2018 9:30 AM (30 minutes)

Summary

Primary author: DOORN, Stephen

Presenter: DOORN, Stephen

Contribution ID: **49** Type: **Invited Talk**

Transition metal dichalcogenide nanotubes

Wednesday, July 11, 2018 9:00 AM (30 minutes)

Due to their favorable and rich electronic and optical properties, group-VI-B transition-metal dichalcogenides (TMDs) have attracted considerable interest. They have earned their position in the materials portfolio of the spintronics and valleytronics communities. The electrical performance of TMDs will be enhanced by rolling up the two-dimensional (2D) sheets to form quasi-one-dimensional (1D) tubular structures. Actually, the TMD nanotubes were first synthesized back in 1992 1, but only recently device related researches have been conducted 2.In this presentation, we discuss transport and optoelectronic properties ranging from field effect transistor (FET) operation to solar cell actions in tungsten disulfide multiwalled nanotubes (WS2-NT).
We first fabricated electric double layer transistor (EDLT) of an individual WS2-NT and found an ambipolar operation, in sharp contrast to the solid gated FET devices which exhibits only n-type conduction. Furthermore, we found that gating with KClO4/polyethylene glycol electrolyte, induce superconductivity at Tc = 5.8 K. This is the first superconductivity in the individual nanotube structure. Importantly, this superconductivity of gated WS2 exhibited peculiar transport properties arising only from tublar and chiral structure [3].
Using the EDLT devices, we were able to fabricate a p-n junction in an individual WS2-NT, and found that this p-n junction shows current-driven light emission, and photovoltaic actions. Both of these actions are linearly polarized along the NT axis, and more importantly, the external quantum efficiency for the photovoltaic effect reaches a value as high as 4.8%, exceeding by far that of 2D TMDs and even approaching the internal quantum efficiency of the 2D TMDs [4].

1 R. Tenne et al., Nature 360, 444 (1992).
2 R. Levi et al., Nano Lett. 13, 3736 (2013).
[3] F. Qin et al., Nat. Comm. 8, 14465 (2017).
[4] Y. J. Zhang et al., 2D Materials, in press.

Summary

Primary author: IWASA, Yoshi (The University of Tokyo & RIKEN)

Presenter: IWASA, Yoshi (The University of Tokyo & RIKEN)

Contribution ID: **50** Type: **Invited Talk**

Single SWNT spectroscopy for nano-metrology

Tuesday, July 10, 2018 9:30 AM (30 minutes)

Summary

Primary authors: Prof. HOMMA, Yoshikazu (Department of Physics, Tokyo University of Science); Prof. CHIASHI, Shohei (Department of Mechanical Engineering, The University of Tokyo)

Presenter: Prof. HOMMA, Yoshikazu (Department of Physics, Tokyo University of Science)

Contribution ID: **51** Type: **Contributed Talk**

Antenna-Controlled Antibunching in the Photoluminescence of Single Carbon Nanotubes

Wednesday, July 11, 2018 3:00 PM (20 minutes)

Summary

Primary author: Prof. HARTSCHUH, Achim (LMU Munich)

Co-authors: Mr SCHÄFER, Frank (LMU Munich); Mr BIEWALD, Alexander (LMU Munich); Mr COCA-LOPEZ, Nicolas (LMU Munich)

Presenter: Prof. HARTSCHUH, Achim (LMU Munich)

Contribution ID: **52** Type: **Invited Talk**

Bright and tunable single-photon emission with a carbon nanotube embedded in a fiber micro-cavity.

Monday, July 9, 2018 3:40 PM (30 minutes)

Summary

Primary authors: JEANTET, Adrien (ENS, Paris); CLAUDE, Théo (ENS, Paris); CHASSAGNEUX, Yannick (ENS, Paris); Prof. LAURET, Jean-Sébastien (ENS, Saclay); Prof. REICHEL, Jakob (ENS, Paris); VOISIN, Christophe (Ecole Normale Supérieure, Paris)

Presenter: VOISIN, Christophe (Ecole Normale Supérieure, Paris)

Contribution ID: **53** Type: **Contributed Talk**

Room-temperature single photon emission from carbon nanotubes

Monday, July 9, 2018 4:40 PM (20 minutes)

Single-walled carbon nanotubes are a promising material as quantum light sources at room temperature and as nanoscale light sources for integrated photonic circuits on silicon. Here we discuss the use of carbon nanotubes as room-temperature single photon emitters from two different approaches. The first is where efficient exciton-exciton annihilation process 1 is used to reduce the number of mobile excitons. We investigate photon statistics in as-grown individual air-suspended carbon nanotubes and perform theoretical analysis to show that diffusion-driven annihilation of mobile excitons can produce high-purity single photons 2. In the second approach where exciton trapping sites are created to localize excitons [3], we demonstrate integration of carbon nanotube dopant states to silicon photonic crystal microcavities [4]. The coupling of the dopant emission to the microcavity results in an increase of photoluminescence by a factor of ~100, corresponding to a single-photon emission rate of 1.7 x 10^7 Hz which is the highest reported for room-temperature operation of nanotube single photon sources. Our results show that both diffusive (1D) and localized (0D) excitons in carbon nanotubes can produce high quality single photons at room temperature, opening up a pathway to quantum light sources with additional functionality and flexibility.

Work supported by JSPS (KAKENHI JP16H05962, JP16K13613, JP17H07359) and MEXT (Photon Frontier Network Program, Nanotechnology Platform). A.I. acknowledges support from MERIT, and H.M. is supported by RIKEN Junior Research Associate Program. We thank Advanced Manufacturing Support Team at RIKEN for their assistance in machining. This work was conducted in part at the Center for Integrated Nanotechnologies, a US Department of Energy, Office of Science user facility and supported in part by Los Alamos National Laboratory Directed Research and Development funds.

Summary

Primary author: Dr ISHII, Akihiro (RIKEN)

Co-authors: Dr UDA, Takushi (Nanoscale Quantum Photonics Laboratory, RIKEN); Dr HE, Xiaowei (Center for Integrated Nanotechnologies, Materials Physics and Applications Division, Los Alamos National Laboratory); Dr NICOLAI F., Hartmann (Center for Integrated Nanotechnologies, Materials Physics and Applications Division, Los Alamos National Laboratory); MACHIYA, Hidenori (Nanoscale Quantum Photonics Laboratory, RIKEN); Dr HTOON, Han (Center for Integrated Nanotechnologies, Materials Physics and Applications Division, Los Alamos National Laboratory); Dr DOORN, Stephen; KATO, Yuichiro (Nanoscale Quantum Photonics Laboratory)

Presenter: Dr ISHII, Akihiro (RIKEN)

Contribution ID: **54** Type: **Poster**

Enhanced Raman scattering of graphene using double resonance in silicon photonic crystal nanocavities

Monday, July 9, 2018 6:45 PM (15 minutes)

Summary

Primary author: Dr GOMULYA, Widianta (Nanoscale Quantum Photonics Laboratory, RIKEN)

Co-authors: MACHIYA, Hidenori (Nanoscale Quantum Photonics Laboratory, RIKEN); KASHIWA, Kotaro (4 Department of Mechanical Engineering, The University of Tokyo); Dr INOUE, Taiki (The University of Tokyo); Prof. CHIASHI, Shohei (Department of Mechanical Engineering, The University of Tokyo); MARUYAMA, Shigeo (The University of Tokyo); KATO, Yuichiro (Nanoscale Quantum Photonics Laboratory)

Presenter: Dr GOMULYA, Widianta (Nanoscale Quantum Photonics Laboratory, RIKEN)

Session Classification: Poster Session

Contribution ID: **55** Type: **Poster**

Reflectance of Carbon Nanotube Forest metamaterials

Wednesday, July 11, 2018 6:30 PM (15 minutes)

CNT forest of high emissivity, nearly ideal "black-body absorber1", is attracting researchers as a candidate material for the future application of high-sensitive sensor, thermal energy storage device2, and so on. Recently, metamaterials, electro-magnetic circuit to the incident EM-wave, opened a method to design desired optical properties. We recently reported CNT forest metamaterial in infrared and visible region in order to increase optical and thermal absorbance utilizing FIB nanofabrication [3, 4].
In this paper, metamaterials composed by 1D anisotropic refractive index material of CNT Forests, and the effect of nano-sized patterning on the optical and thermal properties are discussed. Figure 1 shows calculated UV-Vis-IR spectra of vertical- and parallel-aligned metal-nanorod CNT forests to the Electric field (Ez) of incident EM wave, showing good correspondence to the experimental results[5] shown in Fig. 1(d-g). Components of perpendicularly aligned CNTs, which were parallel to the Ez of EM wave, increased reflectance in longer wave length region. Alignment of CNTs had an important role to improve absorption on the metamaterial patterns. Patterning shape effect of CNT forest metamaterials[3-5] will be also discussed in detail.
This work was supported by JSPS KAKENHI Grant Number JP 17K06205, and JP 24560050.

1 K. Mizuno et al., PNAS **106**(15), 6044-6047 (2008)
2 H. Furuta, JSPS KAKENHI Grant Number JP 17K06205.
[3] A. Pander, et al., Nano-Micro Lett. 9:44 (2017).
[4] H. Miyaji, et al., Dia. Rel. Mat. **83**, 196-203 (2018)
[5] A. Pander, K. Ishimoto, H. Furuta, A. Hatta, Proc. of NT15 conference (29.06.2015, Tokyo), p288, (submitted to Vacuum).

Fig.1 (a-c) Calculated Transmittance, reflectance and absorbance spectra by meep FDTD program for the metal-nanorod CNT forests. Ez of EM wave was perpendicular to (a) x-axis and (b) y-axis of CNT alignment, and (c) parallel to z-axis of CNT alignment. (d, e) Highly vertically aligned CNT forests exhibiting low reflectance in 10-degree specular reflectance [5]. (f, g) Low-degree aligned (wavy) CNT forests showing higher reflectance in longer wavelength [5].

Summary

Primary authors: FURUTA, Hiroshi (School of Systems Engineering, Kochi University of Technology); Dr PANDER, Adam (Kochi University of Technology); Mr MIYAJI, Hiroki (Kochi University of Technology); Mr SHIMADA, Shingo (Kochi University of Technology); Dr TAKANO, Keisuke (Center for Energy and Environmental Science, Shinshu University); Prof. HATTA, Akimitsu (Kochi University of Technology); Prof. NAKAJIMA, Makoto (Institute of Laser Engineering, Osaka University)

Presenter: FURUTA, Hiroshi (School of Systems Engineering, Kochi University of Technology)

Session Classification: Poster Session

Contribution ID: **56** Type: **Poster**

Tracing individual growth process of single-walled carbon nanotubes by digitally coding isotope labels

Monday, July 9, 2018 6:45 PM (15 minutes)

Summary

Primary authors: Dr OTSUKA, Keigo (The University of Tokyo); Mr YAMAMOTO, Shun (The University of Tokyo); Dr INOUE, Taiki (The University of Tokyo); Dr XIANG, Rong (The University of Tokyo); Prof. CHIASHI, Shohei (The University of Tokyo); Prof. MARUYAMA, Shigeo (The University of Tokyo)

Presenter: Dr OTSUKA, Keigo (The University of Tokyo)

Session Classification: Poster Session

Contribution ID: **57** Type: **Invited Talk**

Electroluminescence from carbon nanotubes

Monday, July 9, 2018 2:00 PM (30 minutes)

Electrically generated light emission from carbon nanotubes is of great interest for the development of nanoscale on-chip electro-optical transducers and single-photon sources [1,2], operating in the telecom band and at GHz frequency [3]. To further advance device performance, reproducibility and reliability we need to better understand and control the mechanism of light generation, tailor the interface between the nanotube and environment and to locally modify nanotube properties with nanoscale precision. In my presentation I will report on our current efforts in this direction and present latest results.

Summary

Primary author: Prof. KRUPKE, Ralph (Karlsruhe Institute of Technology and Technische Universitat Darmstadt)

Presenter: Prof. KRUPKE, Ralph (Karlsruhe Institute of Technology and Technische Universitat Darmstadt)

Contribution ID: **58** Type: **Contributed Talk**

Synthesis and properties of single-walled carbon nanotubes co-axially wrapped with mono- and few-layer BN nanotubes

Wednesday, July 11, 2018 4:40 PM (20 minutes)

Summary

Primary authors: Dr XIANG, Rong (The University of Tokyo); Dr INOUE, Taiki (The University of Tokkyo); Mr ZHENG, Yongjia (The University of Tokyo); Ms LIU, Ming (The University of Tokyo); Prof. CHIASHI, Shohei (The University of Tokyo); Prof. MARUYAMA, Shigeo (The University of Tokyo)

Presenter: Prof. MARUYAMA, Shigeo (The University of Tokyo)

Contribution ID: **59** Type: **Poster**

Photoluminescence from Single-walled Carbon Nanotubes on hexagonal Boron Nitride Substrates

Wednesday, July 11, 2018 6:45 PM (15 minutes)

Photoluminescence (PL) spectroscopy is one of the important analysis techniques for the optical properties of single-walled carbon nanotubes (SWNTs). However, PL spectra are measured only from surfactant-wrapped SWNTs 1, suspended SWNTs 2, and vertically-aligned SWNTs [3]. For optical and opto-electronic applications of SWNTs, SWNTs which lie on substrates and emit PL signal are needed. In this study, SWNTs were directly synthesized on hexagonal boron nitride (h-BN) substrates and PL spectroscopy was performed. h-BN is a suitable substrate for SWNTs because it has large band gap and its surface is atomically flat [4]. By using mechanical exfoliation technique, multilayered h-BN was obtained on silicon substrates. Iron metal particles and ethanol were used as the catalyst and carbon source of SWNT growth, respectively. Figure 1 shows (A) PL spectrum and (B) PL map obtained from SWNTs on h-BN. Relatively sharp PL emission was measured. It is known that the optical transition energy (Eii) of SWNTs depends on the surrounding conditions. The E11 and E22 of SWNTs on h-BN were almost the same as those of surfactant-wrapped SWNTs, and PL map, as shown in Fig. 1(B), exhibited that the chirality was (9,5).
1 S. M. Bachilo, et al., Science 298, 2361 (2002).
2 J. Lefebvre, et al., Phys. Rev. Lett. 90, 217401 (2003).
[3] O. Kiowski, et al., Phys. Rev. B 75, 075421 (2007).
[4] N. A Lanzillo, N. Kharche and S. K. Nayak, Sci. Rep. 4, 3609 (2014).
[5] S. Chiashi, S. Watanabe, T. Hanashima, Y. Homma, Nano Lett. 8, 3097 (2008).

Summary

Primary authors: CHIASHI, Shohei (The University of Tokyo); Ms YOTSUMOTO, Satoshi (The University of Tokyo); Mr OGAMOTO, Tatsuro (The University of Tokyo); Mr ARAI, Hayato (The University of Tokyo); Mr UEDA, Naomasa (The University of Tokyo); Dr INOUE, Taiki (The University of Tokyo); Dr XIANG, Rong (The University of Tokyo); MARUYAMA, Shigeo (The University of Tokyo)

Presenter: CHIASHI, Shohei (The University of Tokyo)

Session Classification: Poster Session

Contribution ID: **60** Type: **Poster**

Monolayer WSe2-MoS2 Lateral Heterojunction Light-Emitting Diodes

Monday, July 9, 2018 6:45 PM (15 minutes)

Summary

Primary authors: Dr PU, Jiang (Nagoya University); Dr LI, Ming-Yang (Academia Sinica); Mr HUANG, Jing-Kai (KAUST); Prof. MIYAUCHI, Yuhei (Kyoto University); Prof. MATSUDA, Kazunari (Kyoto University); Prof. LI, Lain-Jong (KAUST); Prof. TAKENOBU, Taishi (Nagoya University)

Presenter: Dr PU, Jiang (Nagoya University)

Session Classification: Poster Session

Contribution ID: **62** Type: **Contributed Talk**

Tunable Interlayer Excitons in Folded & Twisted Graphene

Monday, July 9, 2018 10:00 AM (20 minutes)

Summary

Primary author: Prof. GRAHAM, Matt (Oregon State University, Physics)

Presenter: Prof. GRAHAM, Matt (Oregon State University, Physics)

Contribution ID: **63** Type: **Invited Talk**

Long-lived Charge Separation Across Interfaces with Semiconducting Single-walled Carbon Nanotubes

Thursday, July 12, 2018 10:40 AM (30 minutes)

Semiconducting single-walled carbon nanotubes (s-SWCNTs) are attractive absorbers for use in solar energy harvesting schemes because of their strong and energetically tunable optical absorption, and high charge carrier mobilities due to the delocalized nature of the π-electron system. Beyond their technological potential, s-SWCNTs offer attractive properties for fundamental studies of charge generation in strongly confined nanoscale systems and photoinduced electron transfer (PET) processes. For example, strong quantum confinement and low dielectric screening impart single-walled carbon nanotubes with exciton-binding energies substantially exceeding kBT at room temperature. Additionally, the energetically narrow and distinct spectroscopic signatures for excitons and charges within s-SWCNT thin films enables the unambiguous temporal tracking of fundamental photophysical processes occuring at important photoactive heterojunctions designed for charge separation.

In this presentation, I will discuss recent studies that probe the generation and recombination of long-lived charges in samples consisting of heterojunctions between s-SWCNTs and various electron acceptors, both organic and inorganic. I will focus on the roles of important interfacial properties that can influence the kinetics and efficiency of the interfacial PET process and recombination of the resulting separated charges. These properties include the energetic energetic driving force for exciton dissociation, the amount of residual wrapping polymer on the highly enriched s-SWCNTs, the local dielectric enrivonrment, the presence or absence of an electric field, and geometrical factors of the interface that can be modified via structural properties of the acceptors. Better fundamental understanding of these model interfaces can inform the design of more efficient solar energy harvesting systems, photodetectors, and other opto-electronic devices.

Summary

Primary authors: Dr BLACKBURN, Jeffrey (National Renewable Energy Laboratory); Dr KANG, Hyun Suk (NREL); Dr ARIAS, Dylan (NREL); Dr JOHNSON, Justin (NREL); Dr FERGUSON, Andrew (NREL)

Presenter: Dr BLACKBURN, Jeffrey (National Renewable Energy Laboratory)

Contribution ID: **64** Type: **Invited Talk**

Optical properties of dyes confined into carbon and boron nitride nanotubes

Wednesday, July 11, 2018 3:40 PM (30 minutes)

The inner cavity of nanotubes has been used as a template for the encapsulation of elongated dyes molecules, such as polythiophenes (6T). The 1D confinement of the nanotube wall drives the stacking of the molecules and induces original aggregation effects in their optical properties [1,2]. When confined inside a carbon nanotube, the organics dyes exhibit for instance a surprisingly strong Raman signal clear of its luminescence emission due to an efficiently quenching effect from the nanotube [3]. Here we show that boron nitride nanotubes (Eg~5 eV) having inner diameters between 1 nm to 5 nm provide similar 1D confinement effects with the difference that they preserve the luminescence of the dyes. The resulting 1D nanohybrids (dye@BNNT) shows in photoluminescence imaging experiments strong and tunable luminescence emissions depending on the dyes used. Experiments on individual dyes@BNNT demonstrate that the BNNT protect the dyes against oxidation and reduce significantly the dyes photobleaching under continuous photoexcitation. Preliminary results on Daphnia Pulex colored with dyes@BNNT suggest that these dye@BNNT nanoprobes have reduced toxicity for multimodal imaging based on Raman and luminescence and that they can be adapted to work in the NIR I window to study biological materials.

(1) E. Gaufrès et al Nature Photon. (2014)
(2) S. Cambré et al Nature Nano (2015)
(3) E. Gaufrès et al ACS Nano (2016)

Summary

Primary authors: Dr GAUFRES, Etienne (CNRS); Ms ALLARD, Charlotte (University of Montreeal); Dr RAFFAELA , Nascimento (University of Montreal); Dr FOSSARD, Frederic (CNRS); Dr SCHUÉ, Léaonrad (University of Montreal - CNRS); Dr LOISEAU, Annick; Prof. MARTEL, Richard (University of Montreal)

Presenter: Dr GAUFRES, Etienne (CNRS)

Contribution ID: **65** Type: **Poster**

Resonance Raman Signature of Intertube Excitons in Compositionally-Defined Carbon Nanotube Bundles

Wednesday, July 11, 2018 6:45 PM (15 minutes)

Electronic interactions in low-dimensional nanomaterial heterostructures can lead to novel optical responses arising from exciton delocalization over the constituent materials. Similar phenomena have been suggested to arise between closely interacting semiconducting carbon nanotubes of identical structure. Such behavior in carbon nanotubes has potential to generate new exciton physics, impact exciton transport mechanisms in nanotube networks, and place nanotubes as one-dimensional models for such behaviors in systems of higher dimensionality. Here we use resonance Raman spectroscopy to probe intertube interactions in (6,5) chirality-enriched bundles. Raman excitation profiles for the radial breathing mode and G-mode display a previously unobserved sharp resonance feature. We show the feature is evidence for creation of intertube excitons and is identified as a Fano resonance arising from the interaction between intratube and intertube excitons.1 The universality of the model suggests that similar Raman excitation profile features may be observed for interlayer exciton resonances in 2D multilayered systems.
1 J. R. Simpson, O. Roslyak, J. G. Duque, E. H. Hároz, J. J. Crochet, H. Telg, A. Piryatinski, A. R. Hight Walker, and S. K. Doorn , Nature Comm. 9, 637 (2018).
2 J. Cannon, et al., J. Phys. Chem. B, 116, 9812 (2012).

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Summary

Primary authors: Dr SIMPSON, Jeffrey R. (Towson University and National Institute of Standards & Technology); Dr ROSLYAK, Oleksiy (Fordham University); Dr DUQUE, Juan G. (Los Alamos National Lab); Dr HAROZ, Erik H. (Los Alamos National Lab); Dr CROCHET, Jared J. (Los Alamos National Lab); Dr TELG, Hagen (Los Alamos National Lab); Dr PIRYATINSKI, Andrei (Los Alamos National Lab); Dr HIGHT WALKER, Angela R. (National Institute of Standards & Technology); Dr DOORN, Stephen K. (Los Alamos National Lab)

Presenter: Dr SIMPSON, Jeffrey R. (Towson University and National Institute of Standards & Technology)

Session Classification: Poster Session

Contribution ID: **66** Type: **Invited Talk**

Electrochemically doped light-emitting devices of transition metal dichalcogenide monolayers

Monday, July 9, 2018 2:30 PM (30 minutes)

Summary

Primary author: Prof. TAKENOBU, Taishi (Nagoya University)

Presenter: Prof. TAKENOBU, Taishi (Nagoya University)

Contribution ID: **67** Type: **Poster**

Achieving 20% Efficiency Perovskite Solar Cells with High Stability by using Semiconducting Single-walled Carbon Nanotube Grain Bridges

Wednesday, July 11, 2018 6:45 PM (15 minutes)

Since liquid-junction perovskite solar cells (PSCs), the development of organo-lead halide perovskite photovoltaics research has gained momentum with the achievement of the solid-state PSCs in 2012. High absorption coefficient, long-range diffusion length and high defect tolerance of PSCs enable remarkable certified power conversion efficiencies (PCEs) over 20%. Although PSCs are proven to be promising next-generation solar devices, further breakthroughs in terms of efficiency and stability are necessary to supersede conventional silicon solar cells. With regard to the performance and stability of PSCs, perovskite grain boundaries play a significant role. Structural disorders at these boundaries induce shallow trap states and non-radiative recombination of localised charge carriers which serve as limitations to PSC performance. At the same time, these areas are also responsible for the perovskite degradation, as the reaction with moisture in air has been found to initiate from the grain boundaries. Therefore, technologies aiming at passivating the perovskite grains are highly desired.

Over the last two decades, carbon nanotubes (CNTs) with an exceptional charge carrier property with outstanding chemical and mechanical stability have generated a lot of excitement among researchers for their device applicability. Especially, single-walled carbon nanotubes (SWNTs) with a certain chirality possess a wide range of direct bandgap of up to 2 eV, qualifying for a light-harvesting medium with strong absorption and high carrier mobility. Semiconducting SWNTs (s-SWNTs) are highly conductive along the tube axis and therefore can function effectively as a charge-transporter between perovskite grains. While there have been a few reports on phenyl-C61-butyric acid methyl ester (PCBM) as a charge-transporter at the grain boundaries of perovskite films, fullerenes have inherently low carrier mobility and low stability compared to SWNTs. It has also been demonstrated that hydrophobic and air-stable SWNTs can protect the perovskite layer successfully from the oxygen and moisture.

Here, we fabricated PSCs in a configuration of glass/ITO/SnO2/CH3NH3PbI3/spiro-MeOTAD/Au in which the perovskite grains are passivated and connected by s-SWNTs. s-SWNTs here are functioning as a charge-transporter, light-harvester, and protector from the moisture in air. By incorporating a small amount of s-SWNTs in deionised water, 18.0% efficiency of the reference PSCs increased to 20% with reduced hysteresis. due to the increased perovskite grain size arising from favourable vapour pressure of the solvent. Upon addition of s-SWNTs, the PCE further increased beyond 20% with improved hysteresis and air/light stability. Ultimately, s-SWNTs added PSCs showed superior stability over the reference devices.

Summary

Primary authors: Dr JEON, Il (The University of Tokyo); Mr SEO, Seungju (The University of Tokyo); Prof. MARUYAMA, Shigeo (The University of Tokyo)

Co-authors: Prof. KATAURA, Hiromichi (AIST); Dr TANAKA, Takeshi (AIST); Prof. MATSUO,

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Presenter: Dr JEON, Il (The University of Tokyo)

Session Classification: Poster Session

Contribution ID: **68** Type: **Poster**

Effects of Chirality and Defect Introduction on the Intermediate Frequency Mode

Wednesday, July 11, 2018 6:45 PM (15 minutes)

An intermediate frequency mode (IFM) of single-walled carbon nanotubes (SWCNTs) has intriguing properties. The IFM originates from a phonon branch that has acoustic nature in graphene, and has non-zero momentum. Phonons with these properties are usually not analyzable with photons. However, the IFM of SWCNTs was successfully observed in prior reports [1, 2]. Remarkable features of the IFM may provide new insights into Raman spectroscopy of SWCNTs. Although the effects of chirality and defect density on the peak position was well explained in these reports, what determines the IFM intensity is not clear. We will show our recent analysis of the IFM intensity with focusing on the effects of chirality and defect density.
Intensities of the IFM, the D-mode, and the G-mode are shown in Figure 1a as functions of a duration time of defects introduction into an air-suspended SWCNT. Defects were introduced by using photoinduced bleaching in air [3]. The G-mode intensity decreased as results of the defect introduction. On the other hand, the IFM intensity increased along with the D-mode intensity. Furthermore, fluctuations of the IFM intensity was clearly following that of the D-mode intensity, which implies that the IFM originates from K-momentum phonons similar to the D-mode. From the results shown in Figure 1a, we suggest the intensity ratio IIFM/ID as a good representation to understand the physics underlying K-momentum phonons. Figure 1b shows effects of chirality on the IIFM/ID, as well as IRBM/IG, obtained from 5 kinds of SWCNTs; (12,1), (11,3), (10,5), (9,7), and (9,8). Although the chiral angle dependence of the IIFM/ID is less significant than the IRBM/IG, the ratios decrease with an increase of the chiral angle.

1 T. Inaba, et al., J. Phys. Chem. C submitted
2 A. Vierck, et al., Carbon 117, 360 (2017)
[3] T. Inaba, and Y. Homma, Appl. Phys. Let. 107, 071907 (2015)

Summary

Primary authors: Dr INABA, Takumi (Tokyo University of Science); Mr TANAKA, Yuuichirou (Tokyo University of Science); Prof. HOMMA, Yoshikazu (Tokyo University of Science)

Presenter: Dr INABA, Takumi (Tokyo University of Science)

Session Classification: Poster Session

Contribution ID: **69** Type: **Poster**

Long-lived direct and indirect interlayer excitons in van der Waals heterostructures

Wednesday, July 11, 2018 6:45 PM (15 minutes)

Summary

Primary author: WURSTBAUER, Ursula

Presenter: WURSTBAUER, Ursula

Session Classification: Poster Session

Contribution ID: **70** Type: **Contributed Talk**

Probing the optical dipole transition and vibrational coherences in individual (5,4) carbon nanotubes by femtosecond pulse shaping

Wednesday, July 11, 2018 11:10 AM (20 minutes)

Summary

Primary author: Dr CIESIELSKI, Richard (Ludwig-Maximilians-Universität München)

Co-authors: Prof. HARTSCHUH, Achim (Ludwig-Maximilians-Universität München); Mr GIEGOLD, Veit (Ludwig-Maximilians-Universität München)

Presenter: Dr CIESIELSKI, Richard (Ludwig-Maximilians-Universität München)