Tuesday Afternoon, December 9, 2014

Nanomaterials
Room: Hau - Session NM-TuE

Nanomaterials Characterization & Reactivity II
Moderator: Katsuyuki Fukutani, University of Tokyo, Japan

5:40pm **NM-TuE1 High Spatial/Energy Resolution Cathodoluminescence Spectroscopy: Powerful Tool for Precise Characterization of Nanostructures**, ***Dapeng Yu***, Peking University, China **INVITED**

Nanowires have been a top-five focused research topics in physics, and stimulated intensive interests world-wide. This talk composes of two major parts. In the first part, I will give a brief summary of our contributions to the world-wide nanowire research. In the main second part, I will extend to show the advantage of both high spatial and energy resolution cathodoluminescence (CL) in characterization of the fine structures of the nanomaterials. In particularly, I will demonstrate that the high special resolution of the CL at ~ 5.5 K enable us to address the significant strain modulation of the optical emission and electronic structures of semiconductor nano/micro wires[1-5]. In contrast, the high energy resolution of the CL makes it possible to "see" directly the resonant SPP modes that are confined to the metal nanocavity.

Jing G Y et al. Surface effects on elastic properties of silver nanowires: contact atomic-force microscopy[J]. Physical Review B, 2006, 73(23): 235409.

2] Han X B et al. Electronic and mechanical coupling in bent ZnO nanowires. Advanced Materials, 2009, 21(48): 4937-4941.

3] Han X B et al. Strain-Gradient Effect on Energy Bands in Bent ZnO Microwires. Advanced Materials, 2012, 24(34): 4707-4711.

4] Fu X W et al. Exciton Drift in Semiconductors under Uniform Strain Gradients: Application to Bent ZnO Microwires. ACS nano 8.4 (2014): 3412-3420.

/p>5] Fu X W et al. Tailoring Exciton Dynamics by Elastic Strain-Gradient in Semiconductors. Advanced Materials 26.16 (2014): 2572-2579.

6:20pm **NM-TuE3 Quantum Many-Body Effects in Light Emission from Molecular Exciton and Plasmon Induced by Scanning Tunneling Microscopy**, *K. Miwa*, RIKEN, Japan, ***Mamoru Sakaue***, *H. Kasai*, Osaka University, Japan

Luminescence from the systems consisting of metal nanostructures (NSs) and adsorbed molecules can be strongly influenced by quantum many-body effects which arise from the interplay between dielectric response of metal NSs and intra-molecular electronic/vibrational excitations. In light emission induced by the tunneling current of a scanning tunneling microscope (STM) from molecule-covered metal surfaces, interface plasmons localized near the tip-substrate gap region play important roles in electronic excitations and radiative decays of the molecule. Recent experimental results have also suggested that the dynamics of molecules (e.g., luminescence and energy absorption) have an influence on the luminescence-spectral profiles of interface plasmons [1]. Since the dynamics of molecules and interface plasmons have influence on each other, quantum many-body effects resulting from interplay between these dynamics are expected to occur. To unveil these effects from a microscopic point of view, there is a need to investigate the dynamics of the molecule and interface plasmons within the framework of quantum many-body theory. In this study, we develop the effective model of the system and investigate the effects of coupling between molecular exciton and interface plasmon (exciton-plasmon coupling) on the luminescence properties using the nonequilibrium Green's function method [2-5]. It is found that in addition to the dynamics of the molecule, the dynamics of interface plasmons plays an essential role in determining the luminescence spectral profiles of interface plasmons. Prominent peak and dip structure observed in recent experiments are interpreted by the developed theory. The details of exciton-plasmon coupling on the luminescence properties will be discussed.

References

[1] N. L. Schneider and R. Berndt, Phys. Rev. B 86 (2012) 035445.

[2] K. Miwa, M. Sakaue, and H. Kasai, J. Phys. Soc. Jpn. 82 (2013) 063745.

[3] K. Miwa, M. Sakaue, and H. Kasai, J. Phys. Soc. Jpn. 82 (2013) 124707.

[4] K. Miwa, M. Sakaue, and H. Kasai, Nano. Res. Lett. 8 (2013) 204.

[5] K. Miwa, M. Sakaue, B. Gumhalter and H. Kasai, J. Phys.: Condens. Matter 26 (2014) 222001.

6:40pm **NM-TuE4 Imaging Three-Dimensional Surface Objects with Submolecular Resolution by Atomic Force Microscopy**, ***Tomoko Shimizu***, *C. Moreno, O. Stetsovych, O. Custance*, NIMS, Japan

Submolecular imaging using atomic force microscopy (AFM) has recently been established as a stunning technique to reveal the chemical structure of unknown molecules, to characterize intramolecular charge distributions, and bond ordering, as well as to study chemical transformations and intermolecular interactions. So far, most of these feats were achieved on planar molecular systems because high-resolution imaging of three-dimensional (3D) surface structures with AFM remains challenging. Here we present a method for high-resolution imaging of non-planar molecules and 3D surface systems using silicon cantilever based AFM. We demonstrate this method by resolving the step-edges of the (101) anatase surface at the atomic scale, by simultaneously visualizing the structure of a pentacene molecule together with the atomic positions of the substrate, and by resolving the contour and tip-surface force field on a C_{60} molecule with intramolecular resolution. The method holds substantial promise for the study of 3D surface structures such as nanotubes, clusters, nanoparticles, polymers, and biomolecules using AFM with unprecedented resolution.

7:00pm **NM-TuE5 Spatial Mapping of Exciton Lifetimes in Single Zno Nanowires**, ***Frank Güell***, Universitat de Barcelona, *J.S. Reparaz*, Institut Catala de Nanotecnologia, *G. Callsen*, Technische Universität Berlin, *M.R. Wagner*, Institut Catala de Nanotecnologia, *A. Hoffmann*, Technische Universität Berlin, *J.R. Morante*, Institut de Recerca en Energia de Catalunya

The quest for novel semiconductor materials with improved optoelectronic performance has triggered intense research activities to exploit the great diversity of effects offered by low dimensional systems. In this work, we demonstrate that the recombination dynamics of excitons in ZnO nanowires can be well understood within the concept of optical nanocavities. We investigate the spatial distribution of the lifetimes of the near-band-edge and bound-exciton emissions in single ZnO nanowires with different dimensions by means of temperature dependent and time-resolved spectroscopy. We demonstrate that the lifetime of the excitons is systematically reduced by 30% at the tips of the nanowires with respect to their maximum value at the center, which originates from the combined effect of the cavity-like properties of these nanostructures with the Purcell effect. In addition, show that the model of Rashba and Gurgenishvili is valid even at the nanoscale, i.e. the lifetime of the bound excitons is proportional to the localization energy (Eloc) to the power of 3/2. This result provides a means to understand the spatial dependence of the lifetimes of the near-band-edge emission (NBE), which is not intuitive due to their spatially extended nature. Finally, the temperature dependence of the photoluminescence and lifetimes of the excitons in single nanowires is also briefly discussed in comparison to bulk ZnO samples.

7:40pm **NM-TuE7 What is New in Thin Film and Interfaces Characterization**, ***Miguel Jose Yacaman***, University of Texas San Antonio, USA **INVITED**

Electron Microscopy methods to characterize Thin films and interfaces have advanced very substantially during the last decade.In particular two methods are some of the most significant : Aberration corrected TEM-STEM images and Precession Electron Diffraction.In this paper we describe this methods and apply them to the characterization of gold thin films. It is possible to obtain atomic images of the interfaces using STEM-HAADF which yield realiable information about the atomic positions .When we combine this with single grain diffraction we can obtain a very complete description of the grain structure.

We present the case of polycrystalline Gold thin films grown at different temperatures.We discuss the distribution of most likely boundaries present and its frecuency as a function of the temperature .In addition by using STEM-HAADF it is possible to obtain the surface topography evolution as function of the temperature.

8:40pm **NM-TuE10 Double Dressing for Efficient Manipulation of the Optically Active Frequency Bands in Nanostructured Artificial Atoms**, ***Hanz Ramírez***, Grupo de Física Teórica y Computacional, Escuela de Física, Universidad Pedagógica y Tecnológica de Colombia, Tunja, Boyacá, Colombia

In this work, a model to study the coupling between a semiconductor qubit and two time-dependent electric fields is developed. By using it in the resonantly monochromatic double dressing regime, control of the local density of optical states is theoretically and numerically demonstrated for a strongly confined exciton.

As a main result, tailored manipulation of the optical density of states in semiconductor quantum dots is proved. It is shown that by coupling a nanostructured qubit simultaneously to two distinguishable lasers whose frequencies match the exciton transition, a discrete eigenstate turns into an energy subband in a process closely analogous to band formation in solid state physics.

Such strong changes in the local density of optical states, controllable through the ratio between the driving laser intensities, open new possibilities for on-demand photon emission from artificial atoms.

The presented results are in remarkable qualitative and quantitative agreement with experimental measurements.

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