Mesoscopic Materials Research Laboratory Seminar

Supported by "Kobe University Strategic International Collaborative Research Grant (Type B Fostering Joint Research)"

Date: October 18, 2022, 14:00-15:00
Room: 2E-303 (Meeting Room of Dept. of Electrical and Electronic Engineering)
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Prof. Ilya Sychugov

KTH Royal Institute of Technology, Dept. of Applied Physics

Transparent Nanocomposites: from Solar Windows to Transparent Wood

Modifications at nanoscale can bring new functionalities to well-established materials, such as glass and wood. First, fundamental photophysical properties of Si quantum dots (QDs) were investigated on a single-particle level to understand their potential for light conversion[1, 2]. We found that Si QDs possess high quantum efficiency and a large Stokes shift, suitable for the role of nano-phosphors in building-integrated photovoltaics[3, 4]. As a proof-of-concept we fabricated 20x20 cm^2 prototypes, where QD-doped polymer layer is sandwiched between glass plates. Such solar windows feature high transparency (>80%), low haze (<3%), high color rendering index (~ 88) and, at the same time, deliver up to 0.6 W of electrical peak power under one sun[5].

Another example of functional transparency achieved by modifications at nanoscale is transparent wood[6]. We demonstrated that by selectively removing color-containing compound (lignin) from wood fibers, and by filling the lumens with refractive-index-matching polymer, controlling transparency and haze[7]. Moreover, adding specific nanoparticles to the cell wall of such a nanocomposite can provide luminescent, photochromic and flame-retardant functions[8-10].

These new transparent nanocomposite may broaden the pool of sustainable materials for modern zero- and positive-energy buildings, where traditional glazing and load-bearing properties can be enhanced with, respectively, photovoltaic and optical functions.

1. Luo, J. W., et al., Absence of Red-shift in the Direct Band Gap of Silicon Nanocrystals with Reduced Size. *Nat. Nanotechnol.* **2017,** *12*, 930-932.
2. Zhou, J., et al., Wafer-scale fabrication of isolated luminescent silicon quantum dots using standard CMOS technology. *Nanotechnology* **2020,** *31*, 505204.
3. Sychugov, I., Analytical Description of a Luminescent Solar Concentrator. *Optica* **2019,** *6*, 1046-1049.
4. Zhou, J., et al., Low-Cost Synthesis of Silicon Quantum Dots with Near-unity Internal Quantum Efficiency. *J. Phys. Chem. Lett.* **2021,** *12*, 8909−8916.
5. Huang, J., et al., Large-area Transparent "Quantum Dots Glass" for Building Integrated Photovoltaics. *ACS Photonics* **2022,** *9*, 2499-2509.
6. Höglund, M., et al., Transparent wood biocomposites by fast UV-curing for reduced light-scattering through wood/thiol-ene interface design. *ACS Appl. Mater. Interfaces* **2020,** *12*, 46914.
7. Chen, H., et al., Photon Walk in Transparent Wood: Scattering and Absorption in Hierarchically Structured Materials. *Adv. Opt. Mater.* **2022,** *10*, 2102732.
8. Li, Y., et al., Luminescent Transparent Wood. *Adv. Opt. Mater.* **2017,** *5* (1), 1600834.
9. Samanta, A., et al., Reversible dual-stimuli responsive chromic transparent wood bio-composites for smart window applications. *ACS Appl. Mater. Interfaces* **2021,** *13*, 3270-3277.
10. Samanta, A., et al., Charge regulated diffusion of silica nanoparticles into wood for flame retardant transparent wood. *Adv. Sustain. Syst.* **2022,** *6*, 2100354.

Program

14:00-15:00

Ilya Sychugov, KTH Royal Institute of Technology, Department of Applied Physics

"Transparent Nanocomposites: from Solar Windows to Transparent Wood"

15:00-15:15

Hiroshi Sugimoto, Kobe University, Graduate School of Engineering

"Optical Functionalities of Colloidal Mie Resonant Silicon Nanoparticles"

15:15-15:30

Hiroaki Hasebe, Kobe University, Graduate School of Engineering

"Toroidal Dipole Resonance of Silicon Nanodisk Array for Photochemical Applications"

15:30-15:45

Keisuke Moriasa, Kobe University, Graduate School of Engineering

"Narrowband Absorption Enhancement in Silicon Nanodisk Array for NIR Photodetection"