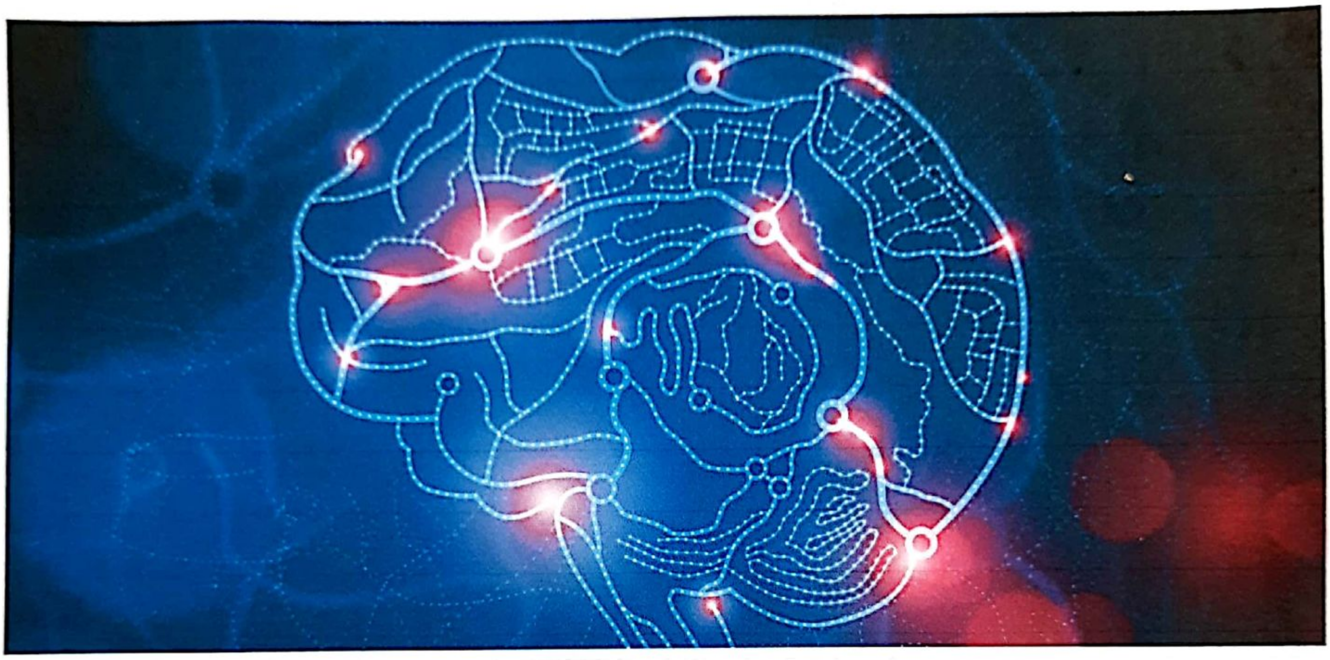
Karlsruhe Days of Optics & Photonics 2017



As every other year KSOP is hosting the two-day symposium Karlsruhe Days of Optics & Photonics (KDOP). We presented internationally renowned Optics & Photonic experts that talked about their research and work. At KDOP, participants met representatives of academia and industry.

The symposium highlighted the five research areas of KSOP (Photonic Materials & Devices, Advanced Spectroscopy, Biomedical Photonics, Optical Systems and Solar Energy) and gave our doctoral research the platform to showcase their research results in a detailed poster session.

The Karlsruhe Days of Optics & Photonics took place on **November 7 - 8, 2017**

Speakers

Tuesday, November 7

Wednesday, November 8

Speakers of the KDOP 2017

	Name	Institute	Talk
 (/school_members_lemmer_ulrich.php)	Prof. Dr. Uli Lemmer	Light Technology Institute & Institute of Microstructure Technology, Karlsruhe Institute of Technology, Germany	Welcome & Introduction
	Prof. Dr. Nader Engheta	H. Nedwill Ramsey Professor, University of Pennsylvania, Philadelphia, USA	Extreme Metastructures
 (https://www.phi.kit.edu/hunger.php)	Prof. Dr. David Hunger	Physical Institute, Karlsruhe Institute of Technology, Germany	Quantum and nano-optics with tunable microcavities
	Prof. Dr. Tobias Brixner	Institute of Physical and Theoretical Chemistry, University of Würzburg, Germany	Multidimensional Space- and Time-Resolved Spectroscopy
 (https://www.imt.kit.edu/717_142.php)	Dr. Ian Howard	Institute of Microstructure Technology, Karlsruhe Institute of Technology, Germany	Nanoscale Photophysics of Molecular Semiconductors – Spin Stories
	Dr. Moritz Helmstaedter	Max Planck Institute for Brain Research, Frankfurt, Germany	Connectomics: mapping the brain's networks
 (https://www.ibt.kit.edu/english/3560.php)	Prof. Dr. Werner Nahm	Institute of Biomedical Engineering, Karlsruhe Institute of Technology, Germany	Optical Biopsy - The Ultimate Claim for Biomedical Optics?
	Stephan Berlitz	The Future of Automotive Lighting Systems	Head of Lighting Innovations/ Functions, AUDI AG

 (https://www.ipq.kit.edu/Staff_Randel.php)	Prof. Dr. Sebastian Randel	Institute of Photonics and Quantum Electronics, Karlsruhe Institute of Technology, Germany	Building Energy-Efficient Optical Networks for Next-Generation Cloud Services
	Prof. Dr. Wim C. Sinke	ECN Solar Energy, Petten, Netherlands & University of Amsterdam, Netherlands	Photovoltaics: science and technology for terawatt-scale deployment
 (http://www.imt.kit.edu/938_122.php)	Dr. Ulrich Wilhelm Paetzold	Institute of Microstructure Technology, Karlsruhe Institute of Technology, Germany	Perovskite-Based Tandem Solar Cells - Tailored Optics for Light Harvesting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Time	Program	Lecturer
10.00 a.m.	Welcome & Introduction	Prof. Dr. Uli Lemmer
10.15 a.m.	Photonic Materials & Devices (Research Area I) **Extreme Metastructures**	Prof. Dr. Nader Engheta
11.15 a.m.	Photonic Materials & Devices (Research Area I) **Quantum and nano-optics with tunable microcavities**	Prof. Dr. David Hunger
12.00 a.m.	**Lunch Break**	
01.15 p.m.	Advanced Spectroscopy (Research Area II) **Multidimensional Space- and Time-Resolved Spectroscopy**	Prof. Dr. Tobias Brixner
02.15 p.m.	Advanced Spectroscopy (Research Area II) **Nanoscale Photophysics of Molecular Semiconductors – Spin Stories**	Dr. Ian Howard
03.00 p.m.	**Poster Session (RAs I-III) & coffee break**	
04.15 p.m.	Biomedical Photonics (Research Area III) **Connectomics: mapping the brain's networks**	Dr. Moritz Helmstaedter
05.15 p.m.	Biomedical Photonics (Research Area III) **Optical Biopsy - The Ultimate Claim for Biomedical Optics?**	Prof. Dr. Werner Nahm
06.00 p.m.	**Buffet**	

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2017

Time	Program	Lecturer
10.00 a.m.	Welcome	Prof. Dr.-Ing. Christoph Stiller
10.15 a.m.	Optical Systems (Research Area IV) **The Future of Automotive Lighting Systems**	Stephan Berlitz
11.15 a.m.	Optical Systems (Research Area IV) **Building Energy-Efficient Optical Networks for Next-Generation Cloud Services**	Prof. Dr. Sebastian Randel
12.00 a.m.	**Lunch Break**	
01.30 p.m.	**Poster Session (RAs IV-V) & coffee break**	
03.00 p.m.	Solar Energy (Research Area V) **Photovoltaics: science and technology for terawatt-scale deployment**	Prof. Dr. Wim C. Sinke
04.00 p.m.	Solar Energy (Research Area V) **Perovskite-Based Tandem Solar Cells- Tailored Optics for Light Harvesting**	Dr. Ulrich W. Paetzold
04.45 p.m.	**KSOP PhD Publication Award &** OSKar Best Poster Award	
05.00 p.m.	**Farewell**	
05.15 p.m.	**Buffet**	

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Karlsruhe Institute of Technology

KSOP
Karlsruhe School of Optics & Photonics

Dr. Deski Beri

participated successfully in the

Ph.D. Program in Optics & Photonics

at the Karlsruhe School of Optics & Photonics (KSOP)

from February 2015 to December 2020
in Research Area 'Solar Energy'

Part of the KSOP Ph.D. Program in Optics & Photonics is a specific modular training program which includes management, technical, scientific as well as key competence modules.

Dr. Deski Beri participated in the following modules:

Scientific Modules:	Karlsruhe Days of Optics & Photonics (KDOP) 2017 | November 7, 2017
	KSOP - QMat Summer School 2020 | September 3 - 4, 2020
Key Competence Modules:	Scientific Writing and Presentation | May 10 - 17, 2016

Karlsruhe, August 2021

Prof. Dr. Uli Lemmer, KSOP Coordinator

Dr.-Ing. Judith Elsner, KSOP Managing Director

The Graduate School 'Karlsruhe School of Optics & Photonics' (KSOP) was founded within the scope of the German Excellence Initiative. Physicists, chemists, biologists, mechanical and electrical engineers contribute in a multidisciplinary approach to the educational concept covering the five Research Areas: Photonic Materials & Devices, Quantum Optics & Spectroscopy, Biomedical Photonics, Optical Systems, and Solar Energy. KSOP Ph.D. students are embedded in an excellent research environment in the Karlsruhe Institute of Technology (KIT) which bundles the research and education strengths of the former Universität Karlsruhe (TH) and the Forschungszentrum Karlsruhe together with strong partners such as the Research Centre for Information Technologies in Karlsruhe (FZI) and the Stuttgart-based Centre for Solar Energy and Hydrogen Research (ZSW).

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Karlsruhe Institute of Technology

KSOP Karlsruhe School of Optics & Photonics

Synthesis of good stability and high plqy silicon nanocrystal using microwave-assisted hydrosilylation reaction

Deski Beri, Dmitry Busko, Andrey Mazilkin, Bryce S. Richards and Andrey Turshatov

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Research Area 5:
Solar Energy

Motivation and Goal

- ❑ Silicon nanocrystals (nc-Si) have potential applications in optoelectronics, nanophotonics for energy conversion, photodynamic therapy, etc.
- ❑ Stable at the environmental condition and having high PLQY is a great challenge in nc-Si synthesis.
- ❑ Tuning PL emission can be done by using different kinds of electronegative ligand graft with the core of nc-Si
- ❑ Microwave-assisted hydrosilylation reaction can be used for production of different ligands functionalized nc-Si and giving high PLQY value
- ❑ Working selective with significant enhancement in ligand-Si bonding make this typical reaction is suitable to produce high PLQY stability silicon nanocrystal

Result and Discussion

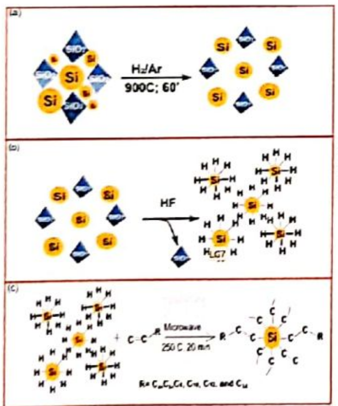

Fig 1. A brief synthesis of silicon nanocrystals from a. disproportionation reaction SiO to form nc-Si and matrix SiO_2, b. chemical etching, and c. hydrosilylation reaction using microwave reactor

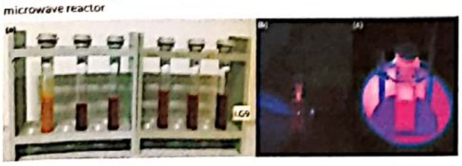

Fig 2. (a). Product of silicon nanocrystals with different aliphatic alkyl group as ligands, (b) illuminated by 405 nm laser pointer, and (c) illuminated by 375 nm LED.

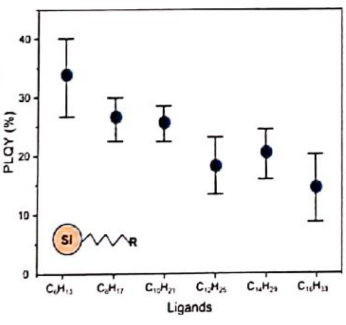

Fig 3. PLQY value vs aliphatic hydrocarbon ligands, (inset) schematics representation of ligands with different hydrocarbon chain attach to nc-Si

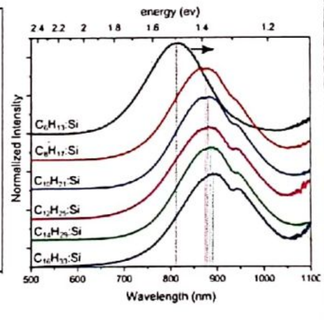

Fig 4. Emission spectra of aliphatic hydrocarbon ligands, arrow direction represents the red shift emission peaks due to carbons atom increased

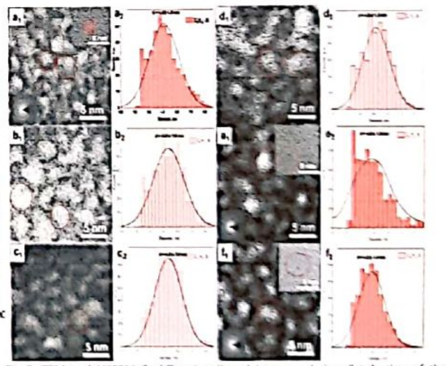

Fig 5. TEM and HRTEM & diffraction (inset) image and size distribution of the (a_1&a_2) C_6H_{13}:Si, (b_1&b_2)C_8H_{17}:Si, (c_1&c_2)$C_{10}H_{21}$:Si, (d_1&d_2)$C_{12}H_{25}$:Si,(e_1&e_2)$C_{14}H_{29}$:Si, and (f_1 & f_2) $C_{16}H_{33}$:Si

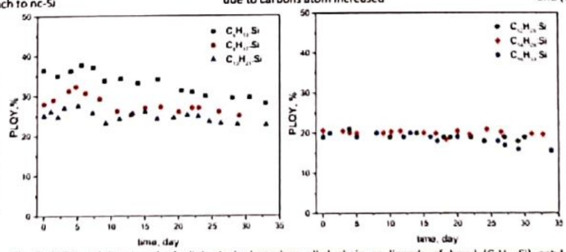

Fig 6. PLQY stability trend of aliphatic hydrocarbon alkyl chain as ligands of hexyl (C_6H_{13}:Si) octyl (C_8H_{17}:Si) decyl ($C_{10}H_{21}$:Si), dodecyl ($C_{12}H_{25}$:Si), tetradecyl ($C_{14}H_{29}$:Si), and hexadecyl ($C_{16}H_{33}$:Si)

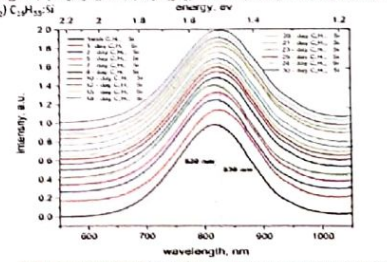

Fig 7. One month PL stability of C_6H_{13}: Si under ambient conditions, shows the environmental stability of the nc-Si

Conclusions

- ❑ Using MW hydrosilylation reaction we successful to synthesis nc-Si with 40% PLQY from precursor silicon rich oxide
- ❑ Nc-Si produced by wet chemical method and MW hydrosilylation shows very good luminescent stability under ambient and environmental condition
- ❑ At similar Si core size, PLQY drops gradually by decreasing electronegativity of the ligands
- ❑ It is possible to use MW hydrosilylation to work with different kinds of ligand in the future

References

1. Ozin, G. et.al. (2015),*Small* **11,** 335–340, **2.** Korgel, B. et.al. (2015), *Langmuir* 150608134833001

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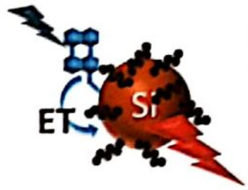
Synthesis of spectral conversion materials

Synthesis of Dye Functionalized Silicon Nanocrystals via Microwave Assisted Hydrosilylation

Motivation

- Silicon nanocrystals (SiNc) has a limited light absorption in the visible range that restricts many potential applications of this material. One way to enhance the absorption is by using organic dyes as a light harvesting antenna.
- In this project, three different organic dyes which absorb blue and green light are used to study the mechanism of energy transfer from organic molecules to the semiconductor material (SiNc).



Synthetic Method

- Scheme

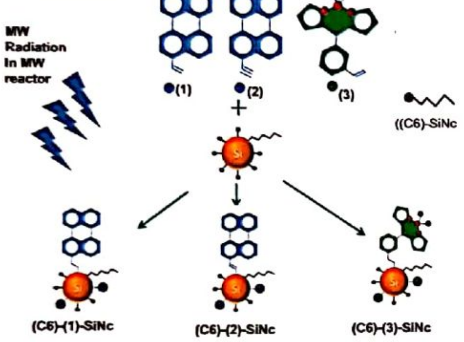


Fig. 1. Schematic representation of the synthetic procedure of dye functionalized silicon nanocrystals via microwave assisted hydrosilylation (1)=3-ethenylperylene; (2)=3-ethynylperylene; (3)=ethylene-m-phenyl BODIPY

Characterization

- Dynamic Light Scattering

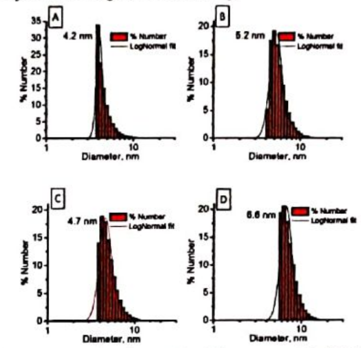


Fig. 2. Particle size of dye functionalized silicon nanocrystals, A. (C6)-SiNc as control, B. (C6)-(1)-SiNc, C. (C6)-(2)-SiNc and D. (C6)-(3)-SiNc

- Fourier Transform Infrared Spectroscopy

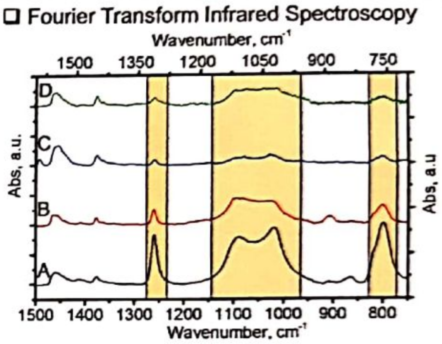


Fig. 3. ATR-FTIR spectra of representative freestandind dye functionalized SiNc, a. (C6)-SiNc as control, b. (C6)-(1)-SiNc, c. (C6)-(2)-SiNc and d. (C6)-(3)-SiNc

Result

- PL Absorption and Emission

The measurement of absorption and emission spectra have been performed to proof functionalization of SiNc with the dyes. The enhancement of absorption in the blue and green region for dye functionalized SiNc indicate dyes function as a light absorber, meanwhile, the emission remains at the peak emission maximum

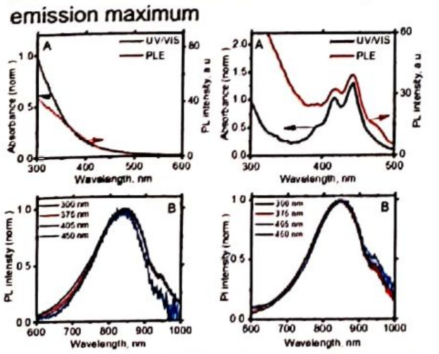


Fig. 4. (left) free standing (C6)-SiNc A. The absorbance and PL excitation and B. PL emission, (right) free standing (C6)-(1)-SiNc A. The absorbance and PL excitation and B. PL emission

- PL Quantum Yields (PLQY)

The PLQY of dye functionalized SiNc can be used to study surface passivation and reactivity of a molecule during the reaction. In addition, it can also be used to show the nature of energy transfer from dye to silicon.

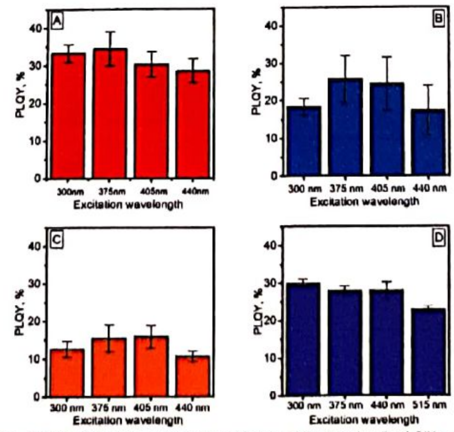


Fig. 5. Photoluminescent quantum yields (PLQY) of dye functionalized SiNc, A. (C6)-SiNc as control, B. (C6)-(1)-SiNc, C. (C6)-(2)-SiNc and D. (C6)-(3)-SiNc

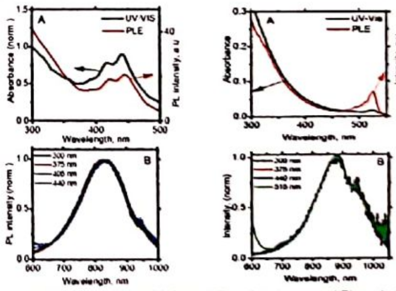


Fig. 6. (left) free standing (C6)-(2)-SiNc A. The absorbance and PL excitation and B. PL emission, (right) free standing (C6)-(3)-SiNc A. The absorbance and PL excitation and B. PL emission

Conclusions

- Hydrosilylation reaction in the microwave reactor has been successful to produce dye functionalized SiNc
- After functionalization with dyes, the light absorption in the visible range enhanced as a good indication of a light harvesting antenna
- PLQY under different excitation wavelength for all dye functionalized SiNc preserved constant relative to the control except for triple perylene

Key references

- D. Beri, D. Busko, A. Mazilkin, I. A. Howard, B. S. Richards, A. Turshatov, *Rsc Adv* **2018**, *8*, 9979-9984.

Acknowledgement and partners

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