2025 Helmholtz – OCPC – Program

for the involvement of postdocs in bilateral collaboration projects

PART A

Title of the project:

Heterogeneous core-shell nanocrystals for biomedical applications

Helmholtz Centre and/or institute:

Karlsruhe Institute of Technology (KIT), Institute for Microstructure Technology (IMT)

Project leader:

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Program Coordinator (Email, telephone)

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Description of the project (max. 1 page)**:**

The objective of the project is to identify, synthesize, and characterize novel heterogeneous rare earth (RE)-based core-shell nanocrystals (NCs). Our group has recently synthesized the first generation of high-quality (narrow size and shape distributions) heterogeneous RE-based core-shell NCs by combining ternary (core domain) and binary (shell domain) fluorides (**Figure 1**, Nature Commun. 2023, 14, 4462).

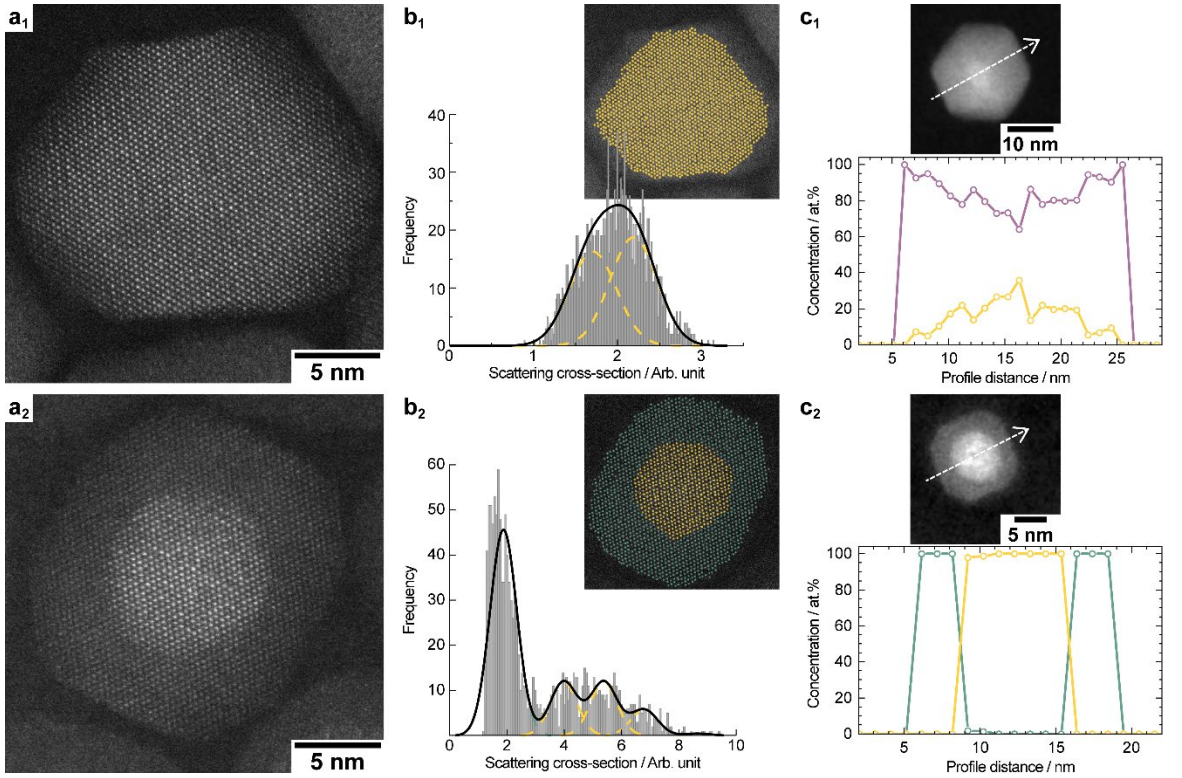

Figure 1. *Typical homogeneous (top row) and heterogeneous (bottom row) RE-based materials combinations for downshifting.*

Dramatic (positive) impact on the photoluminescence (downshifting) quantum yield has been observed compared to the homogeneous RE-based core-shell counterparts. Because heterogeneous RE-based core-shell NCs offer new possibilities to control and improve their optical characteristics, proper combinations must be identified. Therefore, based on the crystal structure and lattice mismatch, several combinations (ternary and/or binary sulfide-sulfide, fluoride-sulfide, fluoride-oxide, and fluoride-sulfide) for the core and shell domains have already been identified. None of them has been reported in the literature. The main objective is to test all identified heterogeneous combinations for downshifting (emission at ca. 1550 nm and 1850 nm with excitation at either 800 nm or 980 nm). The latter will be fully characterized by x-ray powder diffraction (Whole Powder Pattern Modelling) and high-resolution scanning transmission electron microscopy (EDX chemical maps combined to atom counting analyses). These advanced structural characterization techniques have been successfully applied for fluoride-fluoride heterogeneous core-shell NCs. All heterogeneous systems that will lead to the formation of high-quality NCs will be selected for small animal imaging. At the end of je project, the most promising imaging probes for biomedical applications should be identified and their performances compared to current standards (indocyanine green, quantum dots, and homogeneous RE-based core-shell NCs) will be available.

Description of existing or sought Chinese collaboration partner institute (max. half page)**:**

This project is open to all Chinese universities and institutions. We look forward to collaborating with Chinese partners with experience in nanocrystals synthesis and in vivo imaging. There is currently no existing or sought Chinese collaboration partner institute assigned to this project.

Required qualification of the postdoc:

- PhD in Materials Chemistry or Chemistry. The main topic of the PhD must be focused on inorganic nanocrystals.
- Experience: 1) Hands-on experience with the synthesis of inorganic nanoparticles (lanthanide-based ternary fluorides or noble metals); 2) Hands-on experience with surface functionalization of inorganic nanoparticles; 3) Hands-on experience with x-ray powder diffraction. 4) Very good knowledge of photoluminescence spectroscopy. Experience in measuring optical properties (emission spectrum, lifetime, quantum yield) will be considered as an advantage.
- Additional skills: 1) Talented at the bench: performing research activities independently (i.e. with minimal supervision) under the guidance of a principal investigator; 2) Writing scientific articles as a first author; 3) Organized and self-motivated.
- Language requirement: Very good English skills (speaking and writing).