2025 Helmholtz – OCPC – Program

for the involvement of postdocs in bilateral collaboration projects

PART A

Title of the project:

Development of highly efficient photoelectrochemical systems for green hydrogen production

Helmholtz Centre and/or institute:

Karlsruhe Institute of Technology

Project leader:

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

Scientific Background

The growing demand for clean and renewable energy sources has intensified the need for sustainable hydrogen production technologies. Hydrogen is an excellent energy carrier due to its high energy density, zero carbon dioxide emission during use in fuel cells, combustion engines or burners, and the availability of water as a starting material in abundance in many locations. Photoelectrochemical (PEC) water splitting, which utilizes solar energy to produce hydrogen, is a promising approach for green hydrogen generation. While significant advances have been made in developing efficient photoelectrode materials (e.g., TiO_2, WO_3, α-Fe_2O_3, CdS, SnSe, and $BiVO_4$ et al.), the design and configuration of PEC devices also plays a critical role in achieving high solar-to-hydrogen (STH) efficiency for practical application and has only recently begun to attract greater interest.

At the Institute for Micro Process Engineering (IMVT) of the Karlsruhe Institute of Technology (KIT), we specialize in the design, development, and application of advanced microreactor systems for application in energy conversion and in chemical processes. Our expertise in this field lies in optimizing reactor configurations for enhanced heat, mass, and radiation transport, coupled with cutting-edge manufacturing techniques such as micro fabrication and additive manufacturing. By integrating material development with innovative reactor engineering, we aim at creating highly efficient PEC systems tailored for practical applications.

Research objectives

The overall goal of this project is to establish highly efficient photoelectrochemical systems for green hydrogen production by integrating photoreactor design and photocatalyst material development.

More specifically, the project will focus on the following research objectives:

- Reactor Design and Configuration: Developing innovative reactor designs that optimize light distribution, mass transport, and scalability for practical applications.
- Material Development: Integrating advanced photoelectrode materials with the reactor system to enhance light absorption, charge separation, and catalytic activity.
- System Efficiency: Maximizing solar-to-hydrogen efficiency by optimizing the interplay between reactor design, material properties, and operational parameters.
- Application-Oriented Solutions: Designing a PEC system that is cost-effective and scalable for broad implementation.

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

Our research unit has established deep collaborations with several research groups in China, including researchers from North China Electric Power University in Beijing, Hunan University, the University of Chinese Academy of Sciences, the Institute of Process Engineering, and the Dalian Institute of Chemical Physics. Over the past several years, we have successfully hosted two OCPC postdocs from China, further strengthening our academic exchange. Moreover, I have supervised several PhD students supported by the China Scholarship Council (CSC) program.

In November 2024, I was invited to lead my research group's participation in a Chine-European Workshop on Hydrogen-Based Fuels and Low Carbon Energy at North China Electric Power University in Beijing as well as in the Sino-German Forum on New Energies, New Materials, and Biomanufacturing, held at Westlake University in Hangzhou. During this visit, we engaged with key institutions such as Sino-PEC, Energy China, and Baima Lake Lab, establishing valuable connections for future collaborations. These partnerships provide a strong foundation for advancing joint research efforts in clean energy technologies.

Required qualification of the postdoc:

We are searching for a highly motivated postdoctoral research fellow with enthusiasm for renewable energy technologies. The ideal candidate should have:

- A PhD in Chemical Engineering, Materials Science, or a related field.
- Robust theoretical skills as well as hands-on experience in photoelectrochemistry, photocatalysis or electrocatalysis.
- Interest in advanced reactor design.
- Excellent communication skills and the ability to work in an interdisciplinary team.
- Good Skills in English, both spoken and written.