2016 Jülich – OCPC – Programme
for the involvement of postdocs in bilateral collaboration projects

PART A

Title of the project: Catalytic Membrane Reactors for Chemicals Production at Intermediate Temperature (CaMRIT)

Jülich's institute: Institute of Energy and Climate Research 1- Materials Synthesis and Processing

Project leader: Dr. Stefan Baumann

Web-address: http://www.fz-juelich.de/iek/iek-1/EN/Home/home_node.html;jsessionid=41740DF4AD1D3A26E64B1EFF5C2C10A8

Description of the project (max. 1 page)[1]**:** *see overleaf*

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

We seek cooperation with institutes working on

- Ceramics technology in energy applications
- Catalysis and/or catalytic membrane reactors
- Synthesis of fine chemicals, synthetic fuels etc.
- Heat/Power to Chemicals/Fuels (Q2X)

Potential partner institutes

- CAS: Dalian Institute of Chemical Physics (Prof. Xinhe Bao, Prof. Xiaoguang Guo)
- CAS: Qingdao Institute of Bioenergy and Bioprocess Technology (Prof. Heqing Jiang)
- South China University of Technology, Guangzhou, School of Materials Science and Engineering (Prof. Pinggen Rao)
- South China University of Technology, Guangzhou, School of Chemistrya and Chemical Engineering (Prof. Haihui Wang)
- CAS: Guangzhou Institute of Advanced Technology (Prof. Fangwei Guo)

Required qualification of the post-doc:

- PhD in Materials Science, Physics, Chemistry or any relative field in ceramic ion conductors and/or catalysis
- Experience with materials synthesis and processing, oxygen ion conductors, functional characterization, membrane reactors

[1] Please add overleaf

- Additional skills in layer deposition, gas analytics, nano-materials

PART B

Documents to be provided by the post-doc:

- Detailed description of the interest in joining the project (motivation letter)
- Curriculum vitae, copies of degrees
- List of publications
- 2 letters of recommendation

PART C

Additional requirements to be fulfilled by the post-doc:

- Max. age of 33 years
- PhD degree not older than 5 years
- Very good command of the English language
- Strong ability to work independently and in a team
- High motivation and hands-on mentality

Description of the project:

Oxygen transport membranes (OTM) enable the separation of pure oxygen from air in an energy efficient way. Oxygen is taken up from air and transported in ionic form through the crystal lattice, which at the same time is electronic conductive, so that the electrons of the ions are instantaneously transported back through the membrane itself after the oxygen is released again. Therefore, no electrical circuit or power is necessary. The process is not consuming any energy if the system is kept at high temperature (typically ≥ 700°C) and an oxygen partial pressure gradient, i.e. the driving force for the diffusion process, is sustained.

The separated oxygen can be used for any purpose. Particularly advantageous, in membrane reactors the oxygen can directly be provided to numerous catalytic reactions to form fine chemicals or fuels. This concept is very efficient particularly if the heat necessary to sustain the required temperature can be provided by the process itself. This enables a novel technology contributing to a sustainable future in energy and chemical industries, i.e. Heat to X (H2X), which is a special type of Power to X without the need of electricity.

The Institute of Energy and Climate Research, IEK-1 Materials Synthesis and Processing of the Forschungszentrum Jülich has a long experience in the development of OTMs with advanced microstructure to achieve outstanding permeation rates for the sole generation of pure oxygen. Such membranes are already tested for different applications e.g. conversion of methane into synthesis gas or higher hydrocarbons as well as conversion of ammonia selectively into nitrogen monoxide. However, the specific requirements in membrane reactor conditions need specific materials development, which is often not sufficiently addressed.

Therefore, this project aims in the development of materials with distinct properties for selected catalytic reactions. A special focus will be laid on partial oxidation reactions working at intermediate temperatures at or below 500°C. The challenge is to achieve certain long term permeability of the membrane material at such low temperatures and in corrosive atmospheres. Sufficient oxygen fluxes shall be realized by microstructural optimization of the membrane components, i.e. thin membrane layers on porous supports with low polarization resistance. In addition, catalytic surface layers have to be applied for both oxygen reduction on the air side and the targeted chemical reaction on the product side. In this case materials known from literature shall be used if applicable. Possible interface reactions have to be investigated, which might hinder oxygen transport.

Ceramic powders will be synthesized by e.g. solid state reactions, Pechini process, or Sol-Gel synthesis and characterized by ICP-OES and XRD. In addition, functional properties such as electrical conductivity and oxygen permeability as well as relevant properties for the further processing to membrane components such as thermal/chemical expansion and sintering activity will be determined. Promising materials will be processed to supported membrane layers by means of tape casting including advanced techniques such as phase inversion casting or (magnetic) freeze casting accompanied by microstructural investigation by SEM and XCT as well as its influence on the overall oxygen permeation. Surface activation will be realized by screen printing and/or infiltration of standard catalysts. Finally, the oxygen flux in application relevant conditions will be determined identifying rate limiting processes in order to further optimize the components iteratively. Stability issues will be addressed by annealing in application-oriented conditions as well as permeation tests under an air/CO gradient. For this purpose specific test equipment has to be modified or built up.