I²CNER Webinar

International Institute for Carbon-Neutral Energy Research (WPI-I²CNER)
Kyushu University

Title **Recent developments in ceramic membranes for gas separation and membrane reactors**


Speaker Prof. Wilhelm A. Meulenberg
Institute of Energy and Climate Research, Materials Synthesis and Processing (IEK-1) Forschungszentrum Jülich GmbH, Germany
Inorganic Membranes, Department of Chemical Engineering, University of Twente, Enschede, The Netherlands


Time& Date 16:00 PM(JST), Wednesday, July 31st, 2024

## Abstract


Ceramic membranes are used to separate gases from gas mixtures or to produce chemicals (e.g., syngas, commodity chemicals, or synthetic energy carriers) in situ within membrane reactors (Deibert et al., 2017). These membrane reactors are modular and can theoretically be utilized wherever unexploited heat or power is readily available, making them highly efficient and flexible.

There are two different types of ceramic gas separation membranes: porous membranes and dense membranes. In microporous membranes, the process of molecular separation is based on the principles of size exclusion and/or competitive adsorption effects. Ceramic membranes are more expensive to produce than polymer membranes and are therefore used in applications where polymer membranes cannot perform due to the operating conditions (high temperature and/or transmembrane pressure, aggressive environment). Potential applications of microporous ceramic membranes include the purification and treatment of wastewater and organic solvents as well as the dehydration of alcohols. While ceramic membranes with pore sizes above 1 nm are commercially available and already utilized in a variety of sectors, gas separation membranes with a pore size of ca. 0.5 nm and lower are still in the research and development stage. In contrast to microporous membranes, material separation in dense ion-conducting ceramic membranes is based on diffusion processes. These involve the movement of ions through the crystal lattice. Electron transport may also take place in the lattice. The diffusion process is thermally activated, requiring operating temperatures of several hundred degrees Celsius. Since there is almost no limit to the selectivity of the separation mechanism, these membranes are equally suited to producing high-purity gases and chemicals in reactors (Meulenberg et al., 2019a, 2019b).

The lecture will provide an overview of selected potential fields of application for ceramic porous and dense membranes and, in addition, highlight some new development directions regarding material selection and thin-film concepts as well as their manufacturing technologies.

In the case of porous membranes, both the classic amorphous oxide ceramic membranes (silica-based) and graphene-based or bio-inspired carbon membranes will be presented. Furthermore, zeolite and metal-organic framework membranes (MOFs) will be briefly presented.

In the case of dense membranes, the current developments of mixed-conducting oxygen transport membranes and hydrogen-conducting proton-conducting membranes will be presented. This includes the single-phase membranes and dual phase membrane systems.


## About the Speaker

Prof. Dr. Wilhelm A. Meulenberg is head of the department Gas Separation Membranes at the Institute of Energy and Climate Research IEK-1 at Forschungszentrum Jülich GmbH, Germany.

He graduated 1994 in two different studies - Metallurgy and Materials Technology and Mineralogy at the RWTH Aachen University, Germany. There he also obtained his Ph.D. in 1999. Topic of his Ph.D. was the manufacturing characterization of ceramic shell moulds for investment casting at the Institute of Gesteinshüttenkunde of RWTH Aachen University, Germany.

Since then, he has been working at Forschungszentrum Jülich GmbH in various areas of materials development and component manufacturing for high temperature fuel cells and ceramic gas separation membranes.

From 1999 to 2001, he worked in the development of high temperature fuel cells at the Institute of Materials and Processing for Energy Applications IWV-1. From 2001 to 2003, he was personal scientific assistant to the Executive Board at Forschungszentrum Jülich GmbH.

In 2003, he started to build up the field of inorganic gas separations at the Institute of Energy and Climate Research IEK-1, where currently he is the head of the department. Recent research is focussed on the field of mixed ionic electronic conductors for gas separation and membrane reactors for the production of synthetic fuels and chemicals in membrane reactors. In addition, he works in the field of porous membranes for separation of hydrogen and $CO_2$ from different gas mixtures. His Google Schoolar h-index in 2024 is 38 ($i_{10}$=96) with more than 6070 citations.

In parallel, he had a position from 2010 - 2019 at the University of Queensland, Australia - an Adjunct Associate Professorship. Since 2016 until today, Wilhelm A. Meulenberg is Full Professor at the University of Twente, Netherlands for ionic conductors.

Registration https://zoom.us/webinar/register/WN_-enKYNFQR4KOidS-Id6GLQ


Host Prof. Kwati Leonard
Contact Research Support and Public Relations
TEL: +81 92 802-6935
Email: iq-kenkyu@jimu.kyushu-u.ac.jp