

Helmholtz Graduate School for Energy- und Climate Research
[Helmholtz Interdisciplinary Doctoral Training in Energy and Climate Research]

announces 7 HITEC Doctoral Fellowships
29 November 2013

Call for applications

HITEC (Helmholtz Interdisciplinary Doctoral Training in Energy and Climate) is the graduate school for scientists and engineers who want to earn a Ph.D. in the challenging fields of energy and climate research. HITEC is a joint initiative between Forschungszentrum Jülich, the RWTH Aachen University, the Ruhr-University Bochum, the University of Cologne, the Heinrich Heine University Düsseldorf, and the University of Wuppertal. As a rule the Ph.D. certificate is awarded by one of the member universities. HITEC is committed to scientific excellence, to an interdisciplinary and international research environment, to an accepting learning environment which embraces diversity, and aims to turn the Ph.D. students into well needed experts for academia and industry.

Its faculty members, scientists and engineers, are leading experts in their fields. HITEC offers a 3-year training programme which accompanies the doctoral thesis: students can select from a variety of HITEC events, including lectures on topics or methods, hands-on training courses in the lab or professional skills training, such as scientific writing or presenting.

HITEC launches a call for applications for 7 doctoral fellowships (HITEC Fellowships). 22 projects (A) and 6 research fields (B), indicated below, are open for application. We are seeking highly qualified and motivated scientists and engineers for doctoral studies in the fields of materials science, energy conversion, renewable energies, atmospheric physics or chemistry, plasma physics, chemistry, modelling, numerical simulations, economics. The integration in international co-operations requires the ability to cooperate in an international team, thus we expect good skills in the spoken and written English language. HITEC particularly welcomes applications from women. We also welcome applications from disabled persons.

The best 12-15 applicants (one candidate per project or research field) will be invited to Germany for a week (24 March - 2 April 2014), to join the respective research group in Jülich or at the university. You will receive an email notification about the admission and invitation by the end of January 2014. The task during this one week is to jointly work on the project idea with faculty members and supervisors and to turn it into an outstanding and convincing HITEC (Ph.D.) Project. On the last day of their stay the candidates present their projects and the outline of their dissertations to the members of the HITEC Advisory Board. Of the 12-15 candidates the seven best will be selected.

► Step 1

Choose one project (see below: section A) or one research field (see below: section B) for application.

► Step 2.

Check the *Guidelines for Applicants* for details of the application (see below: C)

► Step 3

Fill out the application form: substantiate your reasons for applying to the chosen project or to the research field based on the information provided. Find out more on the websites of the institutes (Links on last page of this document..

► Step 4

Package all documents into 1 pdf-file and submit your application electronically **until 04 January 2014** to: b.koester@fz-juelich.de

A. HITEC Projects

HITEC Project # 1: Simulation of transport processes in asymmetric gas separation membranes

Gas separation membranes are considered as key components of low-emission power plants with high efficiency and novel chemical reactors. Among other types, oxygen ion conducting materials (e.g. LSCF or BSCF) are used for separating O₂ from air. For high-performance and scalable membranes an asymmetric design is inevitable consisting of a porous support with a thin and dense membrane coating. By analytical models (Binary Friction Model, modified Wagner equation) a basic understanding of the transport processes was acquired. However, no surface adsorption/desorption effects were explicitly included and the influence of the support is still not well understood. In the experiment, a thin membrane on a support may deliver a worse performance than a thicker bulk membrane. A more fundamental, numerical approach based on the Lattice Boltzmann concept shall be developed in this project, by: (1) development of a Lattice Boltzmann model and its validation and correlation with the analytical models for simple cases (cylindrical substrate pores, no surface exchange phenomena), (2) introduction of surface adsorption phenomena in the interface zones (material sinks) using isotope exchange data, (3) extension to complex pores geometries acquired by X-Ray computed tomography (μ -CT), and (4) strategies for optimizing the microstructure of the support or catalytic inter-layers. We will use the Jülich supercomputers for the computationally demanding calculations. The host institution, IEK-1, consists of a multidisciplinary team and focuses on materials development and advanced production processes with industrial relevance, whereas our partners in Twente are experts in solid state ionics (bulk diffusion and surface exchange).

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| Location of the HITEC Fellow: | Forschungszentrum Jülich , Institute of Energy and Climate Research, Materials Synthesis and Processing (IEK-1; Director [acting] Dr. Hans-Peter Buchkremer) |
| Partners of the HITEC Project: | University Twente, Inorganic Membranes, Prof. H.J.M. Bouwmeester Jülich Supercomputing Centre (JSC), SimLab "Molecular Systems", Dr. G. Sutmann |
| Specific requirements | Master in Materials Science, Physics, Computers Science, Mathematics, or Mechanical Engineering; Interest in application-oriented theory / numerical calculations |
| For project specific questions please contact | Dr. Robert Mücke, FZ Jülich, IEK-1, r.muecke@fz-juelich.de |

HITEC Project # 2: Modelling effect of oxidation induced depletion of minor alloy constituents on lifetime on Ni-base superalloy components

Ni-base superalloys possess high strength and oxidation resistance up to about 1000°C, which allow their application in the hottest sections of gas turbines and aircraft engines. Apart from the major constituents (Cr, Co, Al, Ti) minor alloying elements (below 1 wt.%) are typically added to polycrystalline Ni-base superalloys for grain boundary strengthening. Our recent studies revealed that some of these minor additions tend to enrich within the oxide scales formed on commercial superalloys with substantial effect on their oxidation behaviour during high-temperature service. The enrichment of grain boundary strengtheners within the oxide scale resulted in their depletion from the alloy, which might have an adverse effect on the material creep strength. In the proposed Ph.D. project the reaction and depletion processes of selected minor alloying additions will be investigated in specific oxidation experiments on commercial and model Ni-base alloys combined with material post-exposure characterization using advanced analytical techniques, such as SEM/EDX, TEM, SNMS, GDOES and ICP-MS available in Jülich. Based on the experiments, a model will be developed, which will allow a more precise definition of the application limits of the alloys in terms of their microstructural stability. Using the model, concepts will be worked out aiming at development of new alloys with optimized performance.

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| Location of the HITEC Fellow: | Forschungszentrum Jülich , Institute of Energy and Climate Research, Microstructure and Properties (IEK-2; Director Prof.Dr.-Ing. Lorenz Singheiser) |
| Partners of the HITEC Project: | RWTH Aachen (Foundry Institute), Outokumpu VDM (ex. Thyssen-Krupp VDM) |
| Specific requirements | Master in in Materials Science, Physics, Chemistry, or Mechanical Engineering |
| For project specific questions please contact | Dr. Dmitry Naumenko, FZ-Jülich, IEK-2, d.naumenko@fz-juelich.de |

HITEC Project # 3: Influence of inorganic trace elements and their speciation on the conversion of solid fuel particles in gasification atmosphere

Gasification of solid fuels has the advantage of producing a synthesis gas which can either be converted to valuable products (e.g. methane, liquid fuels) or used for heat and power production. Kinetic data for the conversion of fuel particles are available for a number of fuels. However, solid fuels feature not only high heterogeneity but also (high) content of inorganic species. Their release, fate and behaviour have been investigated because of their impact on slagging, fouling, and corrosion. Beyond that, they can influence the conversion rate of fuel particles, since some compounds are catalytically active or poisonous to catalysts. This aspect has not been investigated in detail so far. Therefore, the aim of the project is the quantification of the influence of amount and speciation of relevant inorganic trace elements on the conversion kinetics of solid fuel particles in gasification atmosphere. The release and speciation of inorganic trace elements in gas and condensed phase will be investigated by molecular beam mass spectrometry (MBMS), chem. analysis, XRD, SEM/EDX etc. The reaction kinetics will be quantified using a TGA/MS and a fluidised bed reactor with on-line gas analysis. The experimental work will be complemented by thermodynamic and kinetic model calculations.

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| Location of the HITEC Fellow: | Forschungszentrum Jülich , Institute of Energy and Climate Research, Microstructure and Properties (IEK-2; Director Prof.Dr.-Ing. Lorenz Singheiser) |
| Partners of the HITEC Project: | RWTH Aachen University, Institute of Heat and Mass Transfer (WSA), Director: Univ.-Professor Dr.-Ing. Reinhold Kneer |
| Specific requirements | Master in Chemistry, Physics or Chemical Engineering |
| For project specific questions please contact | Dr. Michael Müller, FZ Jülich, IEK-2, mic.mueller@fz-juelich.de |

HITEC Project # 4: Fuel retention in Wf/W composite materials for fusion applications

Tungsten is the foremost candidate for use as a plasma-facing component (PFC) or armor material in future fusion devices. It exhibits low sputtering behavior paired with a high melting point. Tungsten is an intrinsically brittle material and is not necessarily suited as a structural material, thus limiting its use. As additional embrittlement occurs under operation conditions due to thermal impact and neutron irradiation, it is crucial to ductilize tungsten e.g. by external toughening due to fiber reinforcement. It has been demonstrated recently that by applying extrinsic toughening mechanisms, known from ceramics (SiCf/SiC) the material properties can be improved. The basic mechanism relies on the composite character of a W matrix interweaved by coated W fibers to allow for a mechanical material toughening. At Forschungszentrum Jülich a long-standing tradition in plasma-materials exists. While work on the mechanical properties of W_f/W and production enhancement is ongoing we propose an activity related to the application W under plasma-exposed conditions. Fuel (H, D, T) retention in PFMs is of great concern for the viability and safe application for fusion as a next generation energy technology. For composite materials the effects related to fuel diffusion, trapping and retention are unknown. The work is based on W_f/W samples being produced during this project and directly suited for plasma exposures. The candidate needs to familiarize himself with the topics of fuel retention in plasma facing materials and related diagnostic methods as well as the basic properties and production principles for W_f/W. In order to establish an understanding of the underlying retention mechanisms, W_f/W composite samples as well as samples of the separate constituents are to be exposed to hydrogen plasmas. The hydrogen isotope amount will be analyzed quantitatively. Understanding the underlying trapping and transport mechanisms in a composite material such as W_f/W will be established during this work.

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| Location of the HITEC Fellow: | Forschungszentrum Jülich , Institute of Energy and Climate Research, Plasma Physics (IEK-4, Director Prof. Dr. Christian Linsmeier and Prof. Ulrich Samm) |
| Partners of the HITEC Project: | Max-Planck-Institut für Plasmaphysik, Garching |
| Specific requirements | Master in Physics, Focus on Material Science / Plasma Physics |
| For project specific questions please contact | Dr. Jan W. Coenen, FZ Jülich, IEK-4, j.w.coenen@fz-juelich.de |

HITEC Project # 5: Tritium permeation barriers for future fusion reactors

Deuterium and tritium are used as fuel in fusion reactors. Tritium accumulation into reactor walls and permeation through the first wall materials have to be avoided in order to reduce the loss of radioactive tritium into structural materials and the cooling media. The development of adequate tritium permeation barriers (TPB) is crucial for a safe reactor operation. Thin oxide coatings, such as Al_2O_3 and Er_2O_3 , are promising candidates for TPB, due to their high thermal stability and corrosion resistivity. Their hydrogen permeation reduction factors are in the range of one to three orders of magnitude, as determined in gas-driven deuterium permeation experiments. Due to the high neutron activation of Al and Er, Y_2O_3 was tested as an enhanced TPB, since Y has a lower neutron activation. Magnetron sputter deposition of Y_2O_3 on fusion-relevant materials, such as Eurofer97 (steel), and the characterization of the layers and the substrate are the first tasks of this project. In addition to the Y_2O_3 layer deposition by magnetron sputtering, deposition by the sol-gel process has to be developed in cooperation with our partner in Japan. A comparison of the quality, the homogeneity, and in particular the quantitative determination of the hydrogen isotopes permeation reduction factor of the layers produced by the different techniques is the main task of this study. The layers will be characterized with respect to their composition, crystallographic phase, and their morphology. Therefore a variety of material characterization techniques will be applied, e.g. accelerator-based ion beam analysis (RBS, NRA), X-ray diffraction, X-ray photoelectron spectroscopy, as well as optical and electron microscopy (SEM, TEM). The complementary characterization methods will allow an extended understanding of TPB.

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| Location of the HITEC Fellow: | Forschungszentrum Jülich , Institute of Energy and Climate Research, Plasma Physics (IEK-4, Directors Prof. Dr. Christian Linsmeier and Prof. Dr. Ulrich Samm) |
| Partners of the HITEC Project: | The University of Tokyo, Department of Nuclear Engineering and Management, School of Engineering, Japan, Prof. Dr. Takumi Chikada |
| Specific requirements | Master in Physics, Chemistry or related subject, interest in Material Science and Crystallography, experience in thin film preparation and characterization |
| For project specific questions please contact | Dr. Anne Houben, FZ Jülich, IEK-4, an.houben@fz-juelich.de |

HITEC Project # 6: Self-passivating tungsten “smart” alloys for future fusion power plants

In fusion power plants, like DEMO plasma-facing materials (PFMs) must ensure reliable operation in the severe neutron and particle environment as well as the least risk in case of failures. Presently, tungsten is among the main candidate PFMs. During the loss-of-coolant-accident (LOCA), the temperature of PFMs can exceed 1000°C and last for several months due to the nuclear afterheat. Combined with air and water ingress this may lead to the formation of volatile tungsten oxides, causing the release of radioactive tungsten into the environment. The use of “smart” alloys can suppress the tungsten release. During plasma exposure smart alloys should have characteristics similar to those of bulk tungsten. In case of LOCA, a dense oxide layer of alloying elements is created at the surface, protecting the underlying tungsten from mobilization.

The proposed work is devoted to the development of smart alloys. The suppression of tungsten release will be investigated. Tungsten alloys will be produced using the magnetron facility. The elemental optimization of alloys will be studied at Forschungszentrum Jülich (FZJ) and at Max-Planck-Institut für

Plasmaphysik, Garching. Subsequently, the manufacturing of bulk samples by applying hot isostatic pressing and mechanical alloying will be made jointly with the CEIT, Spain. The work will be complemented by the tests in plasma simulators, like PSI-2 at FZJ. Deuterium retention, erosion and performance under thermal loads will be studied. Studies may be accomplished by exposures in European and international tokamaks.

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| Location of the HITEC Fellow: | Forschungszentrum Jülich , Institute of Energy and Climate Research, Plasma Physics (IEK-4, Director Prof. Dr. Christian Linsmeier and Prof. Ulrich Samm) |
| Partners of the HITEC Project: | Prof. Dr. C. Garcia-Rosales, CEIT, Spain, Freimut Koch, IPP Garching, Germany |
| Specific requirements | Master in Physics, Chemistry or related subject |
| For project specific questions please contact | Dr. Andrey Litnovsky, FZ Jülich, IEK-4, a.litnovsky@fz-juelich.de , Tel.: +49 2461 61 5142 |

HITEC Project # 7: Depth-resolved photo emission studies on the interaction of nitrogen with beryllium containing surfaces for fusion

Fusion research aims at the exploitation of the fusion reaction of deuterium and tritium for energy production. Next step on the road map is the construction of the experimental reactor ITER. Be and W are the proposed armor materials for its vacuum vessel. During operation these materials are eroded, transported and re-deposited by the plasma, thus forming “mixed materials”. Due to high temperatures and particle-irradiation from the plasma, e.g. N- or O-ions, these mixed materials are subject to chemical reactions and diffusion. Due to the complexity of the induced processes, a method is required which is capable of both qualitative and quantitative analysis of chemical species. X-ray photoelectron spectroscopy (XPS) provides chemical analysis. Since diffusive processes and ion implantation profiles play a key role in the solid-state reactions, a depth-resolved method is required. By using synchrotron radiation with variable photon energies, XPS can be extended towards a quantitative depth-resolved analysis method. N₂ is an important gas for controlling the power flow to first wall materials, while most of the first wall is going to be made of Be. The student will extensively study the interaction of N-ions with Be and Be-containing mixed materials. First step is the investigation of the interaction of N-ions with Be and BeO by XPS to identify the chemical reactions under various conditions. Further experiments will be carried out at the synchrotron facility HZB-BESSY II in Berlin. The depth-resolved XPS experiments will elucidate diffusive processes. Furthermore, the influence of different ion energies will be investigated. These studies will contribute significantly to the understanding of the processes which take place at the first wall and grant deeper insights into ion-solid interactions.

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| Location of the HITEC Fellow: | Forschungszentrum Jülich , Institute of Energy and Climate Research, Plasma Physics (IEK-4, Directors Prof. Dr. Christian Linsmeier and Prof. Ulrich Samm) |
| Partners of the HITEC Project: | Helmholtzzentrum Berlin – Berliner Elektronenspeicherring-Gesellschaft für Synchrotronstrahlung mbH (HZB-BESSY II), Berlin, Germany, Dr. Antje Vollmer |
| Specific requirements | Master or comparable degree in physics, chemistry or related subjects, interest in material science and photoelectron spectroscopy, experience with ultra-high vacuum experiments is desirable |
| For project specific questions please contact | Dr. Martin Köppen, FZ Jülich, IEK-4, m.koepen@fz-juelich.de |

HITEC Project # 8: Optical diagnostics for improved production of solar modules

The fabrication at highest device performance exhibit small process windows. To stay inside these challenging limits active process control is mandatory. This project will investigate optical diagnostics as process monitoring which have proven to be useful in the laboratory and have the potential to be extremely beneficial in an industrial setting. One example is the optical emission spectroscopy of a deposition plasma.

In cooperation with the Technical University of Eindhoven (TU/e) the Ph.D. candidate at the IEK5 will evaluate and apply different optical diagnostic methods for active process control during solar module production. The TU/e specializes in plasma and plasma-surface interaction diagnostics, and the IEK5 will provide expertise in the field of thin-film silicon solar cells and has close contact with various industrial partners.

The Ph.D. project will be divided into the following work packages:

1. The available optical diagnostic methods will be analyzed and categorized for their application in an industrial production line.
2. These methods will be evaluated to find the most suitable for mass production, i.e. the method which will result in the most significant improvement in reproducible device performance and production costs. This task will be performed in close collaboration with the IEK5 industry partners.
3. The selected diagnostic tool/s will then be implemented in the Jülich solar module pilot production line.
4. Finally, the benefit of the implemented automated active process control setup will be analyzed by applying e.g. production cost models.

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| Location of the HITEC Fellow: | Forschungszentrum Jülich , Institute of Energy and Climate Research, Photovoltaics (IEK5; Director Prof. Dr. Uwe Rau) |
| Partners of the HITEC Project: | Dept. of Applied Physics, Eindhoven University of Technology (Plasma & Materials Processing Group) |
| Specific requirements | Master in Electrical Engineering, Materials Science or Physics |
| For project specific questions please contact | Dr. Matthias Meier, FZ Jülich, IEK5, ma.meier@fz-juelich.de Dr. Stefan Haas, FZ Jülich, IEK5, st.haas@fz-juelich.de |

HITEC Project # 9: Prompt gamma signature of actinid

Reducing the long-term hazards of nuclear waste demands innovative strategies and development of new technologies for partitioning and characterization of long lived fission products and actinides. Accurate knowledge of the nuclear data of the relevant isotopes is a prerequisite for predictions and simulation studies. Particularly for actinides these data are ambiguous or only known with large uncertainties.

In a previous Ph.D. thesis ground has been paved for the preparation of pure actinide samples for PGAA (prompt gamma Activation Analysis) investigations. Thermal neutron capture cross sections for ^{237}Np , ^{241}Am , or ^{242}Pu could be determined with low uncertainty under cold neutron irradiation. In continuation of the ongoing work we expect to expand our knowledge of the prompt gamma Activation Analysis (PGAA) signature by incorporation of more radionuclides, imbedding the actinides in various matrices (cement, glass, monazite...), and study the behaviour under cold, thermal and fast neutron irradiation. This Ph.D. project is embedded in a larger framework TANDEM (TransActinide Nuclear Data Evaluation and Measurement) where Jülich, München, Budapest and Berkeley are cooperation partners. The application of such data for analytical purposes is in the core interest of the Institute and will be pursued in view of a possible re-characterization of legacy waste from the ASSE research repository and also for retrospective analysis of residues from the returned waste packages from LaHague, France and Sellafield, UK of reprocessed German nuclear fuel.

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| Location of the HITEC Fellow: | Forschungszentrum Jülich , Institute of Energy and Climate Research, Nuclear Waste Management and Reactor Safety (IEK-6; Director Prof. Dirk Bosbach). |
| Partners of the HITEC Project: | FRM II, Garching; BNC Budapest; LBNL, Berkeley, USA |
| Specific requirements | MSc or Diploma in Nuclear Physics, experimental experience in neutron activation and gamma spectroscopy |
| For project specific questions please contact | Dr. Matthias Rossbach, IEK-6, phone: +49 2461 61 3114 m.rossbach@fz-juelich.de |

HITEC Project # 10: Measurements of OCS in the TTL with the airborne Mid-Infrared Cavity enhanced Absorption spectrometer and investigation of its contribution to the stratospheric sulfate aerosol loading (AMICA–OCS)

Stratospheric aerosol has a significant impact on the Earth's climate system, both by scattering part of the incoming solar radiation back to space and by providing surfaces for heterogeneous reactions that influence the chemistry of the stratosphere. The largest fraction of stratospheric aerosol is made up of sulfate, a major source of which is the flux of carbonyl sulfide (OCS) from the troposphere to the stratosphere. However, models do not agree on the exact size of this flux. In particular the role of an enhanced flux from biomass burning emissions in the main tropical transport regions has not been quantified. One reason is the lack of high resolution OCS observations in the upper troposphere and lower stratosphere (UTLS).

In the proposed HITEC project, OCS measurements in the UTLS region with an unprecedented precision, accuracy and time resolution shall be carried out, and also simultaneous measurements of CO and CO₂ to identify biomass burning sources. With these new observations, our understanding of the transport and chemical processes affecting the OCS flux to the stratosphere will be substantially improved.

The tasks that shall be carried out by the Ph.D. student within AMICA–OCS include:

- laboratory tests of a new Airborne Mid-Infrared Cavity enhanced Absorption spectrometer (AMICA)
- assembly and use of a calibration system for OCS, CO and CO₂
- integration of AMICA on the Geophysica aircraft and operation during a test campaign and a tropical field experiment (both planned for 2015)
- scientific interpretation of the measurement data, in particular with respect to the role of biomass burning for OCS in the stratosphere.

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| Location of the HITEC Fellow: | Forschungszentrum Jülich , Institute of Energy and Climate Research, Stratosphere (IEK-7; Director Prof. Dr. Martin Riese) |
| Partners of the HITEC Project: | University of Wuppertal, Physical Chemistry, Prof. Dr. Thorsten Benter |
| Specific requirements | Master (or equivalent) in Atmospheric Science, Meteorology, or a related discipline; experience in atmospheric trace gas measurements; basic knowledge of electronics and computer programming (e.g. Python, MATLAB, C) are desirable |
| For project specific questions please contact | Dr. Marc von Hobe, Forschungszentrum Jülich, IEK-7, m.von.hobe@fz-juelich.de |

HITEC Project # 11: Airborne imaging and 3-D tomography of gravity-waves

At IEK-7, we have developed the GLORIA air-borne infrared imaging limb sounder in close cooperation with the Karlsruhe Institut für Technologie (KIT) and the Bergische Universität Wuppertal (University of Wuppertal). GLORIA measures 3D atmospheric temperature and trace gas volume mixing ratios.

In the winter 2015/2016, GLORIA will be deployed in the GW-LCYCLE campaign based in Kiruna (northern Sweden) that targets the generation and propagation of atmospheric gravity waves. Gravity waves are waves in atmospheric temperature, winds and density. They present a major uncertainty in medium-scale weather forecast and climate prediction. The aim of this project is to generate, for the first time, a spatially highly resolved 3-D reconstruction of gravity waves from atmospheric temperature fields.

The thesis work comprises the preparation of the measurements and participation in the campaign as well as inference and interpretation of 3D temperature distributions: In preparation of the campaign, calibration measurements will be evaluated and instrument errors estimated. The error characterization is used to find an optimal set of parameters for the 3D reconstruction of temperatures from radiances. The Ph.D. candidate will participate in the operation of GLORIA in Kiruna (Sweden). A special focus lies on the 3D tomographic reconstruction of the temperature field from the measured radiances. The reconstructed gravity wave temperature structures will be compared to model forecasts for improving model accuracy. Scientific interpretation of gravity waves will be embedded in national and international collaborations, e.g. in the SPARC (Stratospheric Processes and their Role in Climate) gravity wave initiative.

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| Location of the HITEC Fellow: | Forschungszentrum Jülich , Institute of Energy and Climate Research, Stratosphere (IEK-7; Director Prof. Dr. Martin Riese) |
| Partners of the HITEC Project: | University of Wuppertal, Physikalisch Technische Bundesanstalt, SPARC GW initiative (Stratospheric Processes and their Role in Climate) |

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| Specific requirements | Master in Atmospheric Physics, Geophysics, Physics, Meteorology or Mathematics; programming experience |
| For project specific questions please contact | Dr. Jörn Ungermann, FZ Jülich, IEK-7, j.ungermann@fz-juelich.de |

HITEC Project # 12: Glaciation processes in mixed-phase clouds

The IPCC report 2013 states that clouds continue to contribute to the largest uncertainty to estimates of the Earth's changing energy budget. Particularly, mixed-phase clouds (consisting of both liquid drops and ice crystals) are poorly understood. The evolution of the cloud ice fraction is -amongst other parameters- controlled by the relative humidity (RH). The RH effect on the mixed-phase clouds microphysical and radiative properties ('relative humidity glaciation effect') is up to now unknown, but especially important since it will also propagate to the development of precipitation. In the frame of this project, the 'relative humidity glaciation effect' should be studied during two airborne field campaigns in 2014. The task is to quantify the degree of glaciation of mixed-phase clouds caused by this effect. To this end, the applicant has to

- operate a cloud particle spectrometer side by side with hygrometers during the airborne field campaigns and to
- develop data evaluation algorithms to determine the glaciation degree.

The measurements and data analysis of the effects responsible for mixed-phase cloud glaciation will help to improve the understanding of the fundamental details of the microphysical processes of mixed-phase clouds.

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| Location of the HITEC Fellow: | Forschungszentrum Jülich , Institute of Energy and Climate Research, Stratosphere (IEK-7; Director Prof. Dr. Martin Riese) |
| Partners of the HITEC Project: | University of Wuppertal, Institute for Atmospheric Physics, Prof. Dr. Ralf Koppmann |
| Specific requirements | Master in Meteorology or Physics, experience in cloud physics desirable |
| For project specific questions please contact | Dr. Martina Krämer, FZ Jülich, IEK-7, m.krämer@fz-juelich.de |

HITEC Project # 13: Development of a small satellite for climate research (DiSSECT)

In the last years, miniaturization of scientific payloads usher a new era from large scale, multi-instrumented satellite missions towards small and cost-effective satellites. The smallest units (CubeSats) have a volume of one liter and are highly standardized. CubeSats are involved in several educational programs by Space Agencies and Universities world-wide. Monolithic spatial heterodyne spectrometers (SHS) and piezo-actuated Fabry-Perot interferometers (PFPI) are two spectrometer designs, that can be highly miniaturized to fit to the resources provided by CubeSats. Combined with detector arrays, they allow for the observation of atmospheric emission spectra (to derive temperature data) and dynamical wave structures at the same time. Temperatures and waves in the middle atmosphere are highly relevant in the context of global change and climate modeling. Recently, coupling processes initiated by waves attach increasing importance for the climate system and stress the importance of middle atmosphere observations. This Ph.D. thesis will deal with the specification and prototype-analysis of a SHS instrument for the observation of temperatures in the middle atmosphere and waves as derived from O₂ A-band emissions. A model will be developed to simulate SHS measurements and to analyze existing measurements.

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| Location of the HITEC Fellow: | University of Wuppertal , Physics Department (Prof. Dr. Ralf Koppmann) and Research Center Jülich (Dr. M. Kaufmann) |
| Partners of the HITEC Project: | Forschungszentrum Jülich, Institute of Energy and Climate Research, IEK-7; Max-Planck-Institute for Meteorology, Hamburg |
| Specific requirements | Master in Physics or a related subject |
| For project specific questions please contact | Dr. Martin Kaufmann, FZ Jülich, IEK-7, m.kaufmann@fz-juelich.de; Prof. Dr. Ralf Koppmann, University of Wuppertal, koppmann@uni-wuppertal.de |

HITEC Project # 14: Aircraft measurements and modelling of chemical tracers to quantify transport and mixing in the UTLS

The upper troposphere and lower stratosphere (UTLS) is a key region in the climate system. However, the processes influencing chemical composition of the UTLS (photochemistry, microphysics, and transport) are complex, and their interplay and possible future changes are not well understood. The distributions of the most important radiative species in the UTLS, water vapor and ozone, and of other greenhouse gases are very sensitive to transport and mixing across the tropopause. Recent observations and climate simulations indicate that the transport patterns may be changing due to increasing greenhouse gas levels. The aim of this project is to investigate patterns and time scales of transport and mixing in the UTLS by a combination of new high-resolution in situ measurements and chemistry-transport modeling of a suite of chemical tracers with a wide range of lifetimes (few days to many years). The measurements will be performed with a novel airborne four-channel gas chromatograph developed at the University of Wuppertal which will be deployed on the research aircraft HALO during several field experiments starting in 2016. Prior to the UTLS observations, the initial task will be the optimization of the instrument regarding the precise and fast (1-2 min) detection of a suite of suitable hydro- and halocarbon tracer species. The distributions of the target tracers in the UTLS will be simulated by the Lagrangian chemistry-transport model CLaMS developed in Jülich in order to aid the interpretation of the observations. The synergistic use of highly resolved measurements and CLaMS simulations of chemical tracers constitutes a unique tool to improve current understanding of transport processes, pathways, and time scales in the UTLS. This will in turn contribute to improved predictions of future UTLS composition, and thus climate change.

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| Location of the HITEC Fellow: | University of Wuppertal , Department of Physics, Atmospheric Physics Group (Prof. Dr. C. Michael Volk) |
| Partners of the HITEC Project: | Forschungszentrum Jülich, Institute of Energy and Climate Research, Stratosphere (IEK-7, Director Prof. Dr. Martin Riese) |
| Specific requirements | Master (or equivalent) in Atmospheric Science, Meteorology, Physics or Chemistry |
| For project specific questions please contact | Prof. Dr. C Michael Volk, Department of Physics, University of Wuppertal, M.Volk@uni-wuppertal.de ; Dr. Bärbel Vogel, Forschungszentrum Jülich, IEK-7, b.vogel@fz-juelich.de |

HITEC Project # 15: Atmospheric oxidation of organic molecular markers: a stable carbon isotopes perspective

Biomass burning releases huge amounts of trace gases and particulate matter (PM) into the atmosphere, impacting on air quality and climate. A major chemical component of biomass burning aerosol is levoglucosan, originated from thermal breakdown of cellulose during combustion. In the last few decades, levoglucosan used to be seen as an excellent tracer to apportion primary smoke contribution to the ambient PM. Recent studies have shown a substantial decrease of the levoglucosan concentration in wood smoke particles when exposed to gas-phase OH. Similar processes may apply to other common marker compounds in aerosol, thus corrupting source apportionment of ambient aerosol. Investigations on the chemical degradation of typical marker compounds in laboratory experiments under conditions simulating atmospheric aerosol are therefore necessary to develop an improved process understanding. Here isotope effects provide fingerprints of chemical processes, which might be otherwise difficult to quantify.

The goal of this project is to investigate the degradation of commonly used organic marker molecules by carrying out laboratory experiments under conditions that simulate atmospheric aerosol. To this end the successful candidate will plan and conduct aerosol oxidation experiments, apply isotope mass spectrometry to determine the kinetic isotope effect (KIE) of atmospherically relevant reactions and interpret results with the help of chemical models. He/she will employ laboratory findings to interpret ambient isotopic measurements.

The results of this project will contribute to forward the process understanding in tropospheric chemistry. This and emission source apportionment are essential for the development of scenarios to improve air quality. The parameterizations developed from the project will be implemented into the modeling of isotope global distributions in the troposphere. The use of stable isotopes for process understanding within the atmospheric research is a highly innovative field.

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| Location of the HITEC Fellow: | Forschungszentrum Jülich , Institute of Energy and Climate Research, Troposphere (IEK-8; Directors Prof. Astrid Kiendler-Scharr, Prof. Andreas Wahner) |
| Partners of the HITEC Project: | University Wuppertal, Faculty of Mathematics and Natural Sciences, Prof. Ralf Koppmann |
| Specific requirements | MSc degree (or equivalent) in chemistry, physics, or atmospheric science with an overall grade of at least “good”; very good experimental skills; experience in physical chemistry and/or isotope mass spectrometry are helpful |
| For project specific questions please contact | Dr. Iulia Gensch, FZ Jülich, IEK-8, i.gensch@fz-juelich.de |

HITEC Project # 16: Oxygenated organic volatile compounds from real plant emissions: formation and partitioning

Aerosols are the least understood component of the atmosphere. They play an important role for the radiative balance of the Earth atmosphere and climate. To be climate relevant, aerosol particles need to grow larger than certain sizes of about of 50-100 nm. The atmospheric oxidation of reactive volatile organic compounds (VOC) provides condensable material that grows the particles to the required sizes. Most of such reactive VOC are emitted by the vegetation. Their oxidation products (OVOC) are subject to different pathways in the atmosphere, which makes them very interesting but difficult to catch. OVOC can either be further oxidized in the gas phase or they can condense onto the particulate phase. Once residing in the particulate phase OVOC are withdrawn from simple gas-phase oxidation. However, some reactions also take place in the particulate phase.

The goal of your project is to understand formation pathways of medium and highly oxidized OVOC and their partitioning into the particulate phase. The source of the reactive VOC will be real plants, and the plant emissions are oxidized in controlled experiments in our simulation chambers (SAPHIRPlus). The doctoral candidate will apply state of the art high resolution mass spectrometry with chemical ionization (CIMS) to gas-phase and particulate-phase. Partitioning coefficients of a series of biogenic organic compounds will be achieved, which are useful for models. The doctoral candidate will apply different CIMS schemes in order to address the range of medium to highly oxidized OVOC.

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| Location of the HITEC Fellow: | Forschungszentrum Jülich , Institute of Energy and Climate Research, Troposphere (IEK-8; Directors Prof. Dr. A. Wahner, Prof. Dr. A. Kiendler-Scharr) |
| Partners of the HITEC Project: | Rhenish Institute of Environmental Research at the University of Cologne (RIU, Director Prof. Dr. Andreas Wahner) |
| Specific requirements | Master in Chemistry, Physics or Atmospheric Science. Desirable are experiences in mass spectrometry and programming (MatLab). |
| For project specific questions please contact | Dr. Thomas Mentel, FZ Jülich, IEK-8, t.mentel@fz-juelich.de |

HITEC Project # 17: Climate effects of tropopause region aerosol: Process-oriented studies using combined in-situ observations and the chemistry- climate model ECHAM-HAMMOZ

The largest uncertainties in our current knowledge on climate change are associated with the complex feedback mechanisms of aerosols in the upper troposphere and lower stratosphere (UTLS). This project aims at an improved understanding of aerosol sources, sinks and transformation processes, their impact on the global radiation budget (direct climate effect), and their interaction with cloud formation and cloud properties (indirect climate effect). Specific tasks are

- the analysis of recent routine observations of aerosols on a global scale from instrumented passenger aircraft and dedicated field studies;
- the investigation of correlation of aerosol observations with numerical model results for identifying potential model errors and shortcomings of the observation data;
- the development of suitable statistical methods to employ these data for the evaluation of coupled chemistry-climate models.

The proposed work offers the potential for making substantial contributions to understanding the role of the UTLS aerosol in the global climate system and provides an opportunity to engage in a research collaboration with the TROPOS and DLR institutes.

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| Location of the HITEC Fellow: | Forschungszentrum Jülich , Institute of Energy and Climate Research, Troposphere (IEK-8; Directors Prof. Dr. A. Wahner, Prof. Dr. A. Kiendler-Scharr) |
| Partners of the HITEC Project: | Meteorological Institute, Bonn University (A. Bott), Institute for Tropospheric Research, Leipzig (M. Hermann), Institute of Atmospheric Physics, DLR (A. Minikin) |
| Specific requirements | Master in Physics, Meteorology, or Physical Chemistry; In-depth knowledge of atmospheric chemistry and physics; excellent programming skills (FORTRAN, Python) |
| For project specific questions please contact | Dr. Andreas Petzold (a.petzold@fz-juelich.de) |

HITEC Project # 18: Stochastic short range forecasts for wind and solar energy prediction

Objectives: Variabilities of wind, and the even higher variability of cloud modulated solar insolation is a by far unresolved challenge for intra-day forecasts, which form the information basis of dynamic power grid management or trading activities at energy stock exchanges. Modelling predictive skills and uncertainty margins are one of the future key techniques, to provide the required knowledge foundation. The aspired simulations also include insolation forecasts influenced by aerosols, simulated Chemistry-Transport-Models (CTMs) for photovoltaic and concentrating solar power plants.

As a novel approach in atmospheric chemistry modelling, the proposed work aims at developing stochastic modelling, which quantify the uncertainties of results.

Working steps:

1. Implementation: Due to its computational intensity, the proposed approach will resort to JUQUEEN as one of Europe's most powerful platform. The overall approach is conducted in the realm of stochastic modelling on, which generalizes deterministic differential equations to a stochastic formulation, as far as internal model parameters are concerned.
2. Error estimation: For chemistry transport modelling, major sources of uncertainties occur by external parameters, as the meteorological parameter input, as well as internal parameters like anthropogenic emission rates, deposition and sedimentation velocities.
3. Ensemble generation: The novel approach proposed here is based on the identification of the leading instability state perturbations. These will be applied for ensemble modelling based on the Karhunen-Loeve expansion (Principal Component Analysis) technique.
4. Evaluation: The a posteriori validation of the results will be performed by Talagrand diagrams (and spanning trees as multidimensional extensions). An existing data mining system will be applied to analyse the error characteristics.

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| Location of the HITEC Fellow: | Rhenish Institute of Environmental Research at the University of Cologne (RIU, Director Prof. Dr. Andreas Wahner) or Research Centre Jülich |
| Partners of the HITEC Project: | FhI for Wind Energy and Energy Systems (IWES, Kassel) |
| Specific requirements | Master in Physics, Meteorology, or Geophysics or Applied Mathematics. Proficiency in programming. Some experience in numerical treatment of partial differential equations and or Stochastics. |
| For project specific questions please contact | PD Dr. Hendrik Elbern, FZ Jülich, IEK-8, h.elbern@fz-juelich.de |

HITEC Project # 19: Multi-Elemental speciation analysis in fine dust by online sequential extraction as novel approach for identification of dust sources

Fine dust is ubiquitously present in the atmosphere with influence on climate and also on human health. Surface mining of coal is potentially a significant source of fine dust and therefore there is substantial interest in the identification of the major sources of fine dust near mining sites. Determination of the (trace)

elemental profile in combination with multivariate data analysis has the potential to support assignment of dust sources. In addition, characterisation of the binding forms (i.e. the species) of elements in fine dust further improves the selectivity of this classification approach. A novel online sequential extraction (OSE) technique using inductively coupled plasma mass spectrometry for elemental detection has the potential to fractionate elemental contents according to their binding forms and to overcome draw backs of classical off-line sequential extraction schemes for small sample amounts. Application of this new approach in combination with measurement of total element contents can support the identification of dust sources and model calculations on dust dispersion. The main work packages for the Ph.D. student will be the development and optimisation of the OSE approach using real dust samples and also reference materials with similar matrix for method validation. Subsequently the new method will be applied to dust samples from the vicinity of mining areas and samples from potential dust sources. Multivariate chemometric methods will be employed for data analysis.

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| Location of the HITEC Fellow: | Forschungszentrum Jülich , Central Institute for Engineering, Electronics and Analytics (ZEA-3, Director Dr. Stefan Küppers) |
| Partners of the HITEC Project: | Department of Mining, Surface Mining and Drilling, RWTH Aachen University (Prof. Dr. Christian Niemann-Delius, Dr. Alexander Hennig) |
| Specific requirements | Master in Analytical Chemistry or Environmental Sciences. Experience in elemental analysis and/or atmospheric particle sampling and characterisation is advantageous. |
| For project specific questions please contact | Dr. Volker Nischwitz, FZ Jülich, ZEA-3; v.nischwitz@fz-juelich.de |

HITEC Project # 20: Experimental investigation and numerical modelling of dust removal from firewood stoves by electrostatic precipitators

Woody biomass is becoming an increasingly important part of the global response to the challenges of energy security and greenhouse gas emissions. Woody biomass can be utilized thermally resulting in the emission of gaseous pollutants as well as dust. For the dust removal electrostatic precipitators are applied which efficiently remove fine particulate matter by electrostatic forces. In recent years efforts have been made to extend the use of electrostatic precipitators to small scale firewood stoves and furnaces.

Scientifically the phenomena underlying the dust removal especially in small scale electrostatic precipitators are not well understood. Parameters like the intensity and shape of the electric field and their interaction with the gas flow as well as details of the deposition process are difficult to investigate solely through experimental investigations. Modern simulation technologies resolving the particle fluid interaction in combination with a representation of the electrostatic forces like the Discrete Element Method (DEM) combined with Computational Fluid Dynamics (CFD) allow gaining detailed insight. So far only few investigations with DEM/CFD approaches involving electrostatic forces have been reported in literature.

A contribution to the improved understanding of the detailed mechanisms relevant to electrostatic precipitators and their simulation is intended through this HITEC Project. Combined numerical and experimental investigations are planned to resolve details behind the fundamental processes within electrostatic precipitators like deposition behavior, layer formation and electric field/particle interaction. For this purpose an existing DEM/CFD framework needs to be extended for the inclusion of electrostatic forces to model for the interaction of particles, gas flow, electrostatic field and dust layer formation. Obtained numerical results are validated against experiments performed at the University Wuppertal involving e.g. deposition and dust layer analysis as well as flow field measurements.

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| Location of the HITEC Fellow: | Ruhr-University Bochum , Institute of Energy Technology, Department of Mechanical Engineering, Chair of Energy Plant Technology (LEAT, Director: Prof. Dr.-Ing. V. Scherer) |
| Partners of the HITEC Project: | Prof. Dr.-Ing. habil. Eberhard Schmidt, Institute for Safety Engineering / Environmental Protection, University of Wuppertal |
| Specific requirements | Master in Energy Technology, Chemical or Mechanical Engineering; Experiences in Fluid Mechanics, CFD and particle based methods (DEM) as well as knowledge about electrostatic precipitators are of advantage |
| For project specific questions please contact | Dr.-Ing. Harald Kruggel-Emden, Ruhr-University Bochum; kruggel-emden@leat.rub.de |

HITEC Project # 21: Selection of biomasses for biogas production regarding to the nutrient composition

Numerous biomasses are available for biogas production, such as energy crops, agricultural wastes or manure. The selection of biomass mainly depends on availability and production, transport and storage costs as well as on existing laws. However, for the microorganisms of the anaerobic degradation process a balanced nutrient supply is essential. The objective of this project is to select plant biomasses with regard to the nutrient composition needed for a stable process and high biogas quality and production rates without the addition of external additives. Therefore, two “catalogues” have to be prepared using literature and experiences of the cooperation partners. The first comprises the nutrient requirements of the microorganisms, where important nutrients have to be listed with optimum values as well as lower and upper limits. In the second a variety of plant biomasses has to be evaluated which can be used as sustainable feedstocks for biogas production, with particular emphasis on the chemical composition. Therefore, additional analysis of (especially new, e.g. perennial) plant biomasses will be necessary. Using the information of both catalogues, plant biomasses and promising plant biomass mixtures will be selected and tested experimentally in biochemical methane potential tests (BMP tests) to evaluate this method for specific biomass selection.

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| Location of the HITEC Fellow: | Ruhr-University Bochum , Chair of Thermodynamics (Prof. Dr.-Ing. Roland Span) |
| Partners of the HITEC Project: | , Forschungszentrum Jülich, Institute of Bio and Geo Sciences, Plant Sciences, IBG-2 (Dr. Nicolai D. Jablonowski) |
| Specific requirements | Master in Environmental, Agricultural, Process or Mechanical engineering, or in biology or similar |
| For project specific questions please contact | Dr.-Ing. Mandy Gerber, m.gerber@thermo.rub.de |

HITEC Project # 22: Ultra-long-lived investment projects: the value of R&D expenditures in alternative carbon technologies

The scope of the proposed Ph.D. thesis is to investigate the value of subsidizing parallel research & development (R&D) activities on alternative long-lived technologies with a special focus on their long-term impact. Such parallel R&D is currently ongoing, e.g., in the field of carbon capture methods such as pre-, post- and oxy-fuel combustion technology. With the long-term impact (e.g. the reduction in CO₂ abatement cost and the development of a clean coal technology which may serve as a cost-efficient and secure source of electricity), those expenditures or subsidies can be designated as ultra-long-lived investment ([ULLI](#)) projects, generally characterized by lifetimes which exceed the planning horizon of the investor. Thus, long-term future consequences either for the investor himself or for any other stakeholder are usually neglected in the decision-making process. Such ULLI projects are typically infrastructure investments with very long lifecycles, as they are often found in the energy sector (power plants, grids, nuclear waste deposit sights, CO₂ reservoirs etc.).

With the focus on carbon capture and storage technologies, this research project bridges the gap between the research area “Energy, Mobility & Environment” (EME) hosted by the RWTH School of Business and Economics and the new collaborative research center “CRC/Transregio Oxyflame – Development of Methods and Models to Describe the Reaction of Solid Fuels in an Oxy-fuel Atmosphere” funded by the German Research Foundation (DFG; SFB/Transregio 129).

Questions which shall guide the Ph.D. student in the early stage of research are:

- What classical models for the evaluation of R&D projects exist (e.g. [real options analysis](#))?
- How to discount the future value of new technologies and their potential? What is special about ULLI projects compared to shorter-term R&D projects?
- Developing a real options model for the investigation of alternative and competing R&D projects.
- What are strengths and weaknesses of the three different carbon capture and storage technologies investigated?
- What is the benefit of simultaneously subsidizing R&D of multiple technologies?

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| Location of the HITEC Fellow: | Institute of Future Energy Consumer Needs and Behavior (FCN), E.ON Energy Research Center, RWTH Aachen University (Prof. Dr. Reinhard Madlener), www.eonerc.rwth-aachen.de/fcn |
| Partners of the HITEC Project: | Institute for Heat and Mass Transfer, RWTH Aachen University, (Prof. Dr. Reinhold Kneer) |

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| Specific requirements | This Ph.D. position requires an academic master/diploma degree. For more specific information please visit the website of the School of Business and Economics . A sound background in economics is a prerequisite, knowledge in energy or environmental economics is desirable. |
| For project specific questions please contact | Prof. Dr. Reinhard Madlener, RMadlener@eonerc.rwth-aachen.de Wilko Rohlf, rohlf@wsa.rwth-aachen.de |

B. HITEC Research fields (selected, open for Application)

23 Research Field: **Materials Synthesis and Processing**

The section 'Materials Synthesis and Processing' (IEK-1) of the Institute of Energy and Climate Research at Forschungszentrum Jülich develops and investigates modern materials and component production processes in advanced energy converters, new high-performance energy storage of the future and conducts research on other interesting materials-related topics. The focus is on both powder-based shaping and coatings methods, as well as on gas-phase-based thin-film technologies. Research and development work centres on new materials and production processes for structural components and coatings. The main research areas are currently solid oxide fuel cells (SOFCs), solid state batteries, barrier coatings for power plant engineering (in particular, thermal barrier coatings), and gas separation membranes for low emission power plants. Rapid transfer of the scientific results and developed technologies to industry is an important pillar of our work.

In the SOFC field, the IEK-1 developed cells with sol-gel thin films that delivered, together with high-performance cathodes the powders also manufactured in Jülich, the highest performance of any SOFC so far world-wide (1.6A/cm² at 0.7V at 600°C, >4A/cm² at 800°C). They are in particular useful for low and intermediate temperature applications. Using these cells, the best performing stack was build-up in Jülich. Furthermore, the development of wet-sprayed and thermal-sprayed Cr-barrier coatings on metal interconnects allowed the development of the longest so far operated planar stack (>50.000h) and the stack with the lowest degradation containing metallic interconnects (~0.1%/1000h). Based on SOFC technology, rechargeable batteries are developed with a metal-metal oxide storage. Research is pursued on solid-state batteries with Li or Na as charge carriers that allow a high volumetric power density by employing thin-film coatings (PVD, sol-gel) and a higher intrinsic safety than traditional polymer Li batteries.

Thermal spraying allows to coat thermal barrier coatings for modern gas turbines in power plants or in aero-engines increasing the efficiency and/or the life-time. New materials like pyrochlores (Gd₂Zr₂O₇) that exhibit a higher temperature capability with very low sintering activity are used to enhance the coatings further. The introduction of suspension plasma spraying (SPS) and plasma spray physical vapour deposition (PS-PVD) allowed to produce new microstructures which cannot be abricated with traditional plasma spraying, e.g. a strain tolerant columnar structure. New benchmarks for the durability of the coatings could be set with the new materials and new manufacturing processes. They are measured in house with thermal cycling rigs allowing accelerated life-time assessment.

In the gas separation membrane field, IEK-1 focuses on asymmetric dense proton and oxygen ion conducting and micro-porous membranes. Ceramic as well as metal substrates serve as mechanical supports. The gas-tightness of the membrane coatings is much more critical than for fuel cells. That's why special effort is laid on the manufacturing of defect-free coatings and an appropriate characterisation of the supports. The coatings techniques comprise screen printing, wet powder spraying, sol-gel dip coating, spin coating, PVD, and PS-PVD.

A modelling group supports the experimental work using various simulation techniques on the macro and meso scale (FEM, CFD, Monte Carlo, Lattice Boltzmann [upcoming], etc.). It both helps understanding the theory and allows investigating parameters inaccessible in experimental work.

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| Location of the HITEC Fellow: | Forschungszentrum Jülich , Institute of Energy and Climate Research, Materials Synthesis and Processing (IEK-1; Director (acting) Dr. Hans-Peter Buchkremer) |
| For specific questions please contact | Dr. Robert Mücke, r.muecke@fz-juelich.de |
| Link | http://www.fz-juelich.de/iek/iek-1/EN/ |

24 Research Field: Microstructure and Properties of Materials

The research activities at IEK-2 are concentrated on properties of materials and coatings under service relevant conditions in gas and steam power plants, for solid oxide fuel cells, plasma facing components of future fusion devices and selected properties of solid state electrochemical storage devices. The scientific competences of IEK-2 are focused on:

- Thermodynamic properties of high temperature materials and coatings using ab-initio and Calphad based methods. Specific experimental methods are Knudsen- Effusion-Mass Spectroscopy (KEMS) as well as High Pressure Mass Spectroscopy (HPMS) to study solid gas phase reactions at high temperatures.
- Investigation of physical, thermal and mechanical properties of metallic and ceramic high temperature materials including metallic corrosion resistant coatings and thermal barrier coatings using a cluster of creep, fatigue, thermal fatigue and thermo-mechanical fatigue machines in combination with in-situ measurement of crack initiation as well as propagation. Development of damage models and life prediction models for coated and uncoated components.
- High heat flux thermal shock testing of candidate materials for plasma wall interaction and investigation of damage evolution of high temperature materials.
- Cluster of microstructural analytical facilities from atomic resolution (analytical transmission electron microscopy - TEM) up to specific component relevant analysis using optical microscopy, scanning electron microscopy (SEM) and x-ray diffraction (XRD).
- High-temperature corrosion behaviour of uncoated and coated materials under controlled atmospheres and deposits. Development of new metallic construction materials and coating systems with high durability in isothermal and cyclic service conditions in a wide temperature range of environments, containing e.g. oxygen, water vapour, hydrogen, carbon dioxide and/or sulphur dioxide. Adoption of analytical methods specifically for corrosion research e.g. Sputtered Neutrals Mass Spectrometry (SNMS), Laser Raman-Spectroscopy (LRS) and Glow Discharge Optical Emission Spectroscopy (GD-OES). Modelling of degradation and prediction of oxidation limited lifetime of components due depletion / interdiffusion processes in high-temperature materials and coating systems.

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| Location of the HITEC Fellow: | Forschungszentrum Jülich , Institute of Energy and Climate Research, Microstructure and Properties of Materials (IEK-2; Director: Prof.Lorenz Singheiser) |
| For specific questions please contact | Dr.-Ing. Dmitry Naumenko, d.naumenko@fz-juelich.de |
| Link | http://www.fz-juelich.de/iek/iek-2/EN/Home/home_node.html |

25 Research Field: Heat and Mass Transfer

At the Institute of Heat and Mass Transfer (WSA), RWTH Aachen University, research is conducted in various fields, such as oxy-fuel combustion, falling liquid films, natural convection heat transfer, impinging jets, and spray injection for internal combustion engines. All research fields are closely related to energy, either by direct improvements of energy systems, by investigating fundamental governing mechanisms of heat transfer or by improving models to design and develop energy systems. In the field of spray modeling for instance, a collision algorithm for anisotropic disperse flows has been developed based on ellipsoidal parcel representations.

The research topic in the framework of the HITEC Graduate School program should govern the investigation of basic heat transfer phenomena in the field of falling liquid films, Rayleigh-Bénard convection, or impinging jets (see literature [1-5] for details). All three phenomena are characterized by the presence of instabilities (i.e. Rayleigh-Taylor, Plateau-Rayleigh or Kelvin-Helmholz) which have substantial influence on the flow field and thus on heat transfer. In order to investigate those phenomena, numerical and experimental techniques have been established at the WSA. The numerical techniques include direct numerical simulations of multi-phase flows as well as integrated boundary layer models. Experimentally, basic thickness measurements using confocal-chromatic imaging techniques, temperature measurements using IR-thermography, and velocity measurements using Laser-Doppler-Velocimetry have been applied in the past.

A new measurement technique, which is currently under development at WSA, is the application of Light-Field-Photography for the visualization of three-dimensional velocity and temperature fields. Light-Field-Photography allows determining the exact three-dimensional position of particles within a control volume by separating the light using a micro-lens array located in front of the camera chip (for more details see

[6]). Combining the methods of particle image velocimetry for the measurement of the velocity with liquid crystal thermography, both fields can be measured simultaneously. Both methods are well-established at WSA.

The Ph.D. candidate is invited to apply the proposed experimental and numerical techniques in order to continue the investigation of the above mentioned heat transfer phenomena or to initiate the investigation of other flow phenomena primary characterized by the presence of instabilities.

[1] Dietze, G.: **Flow Separation in Falling Liquid Films**, Dissertation RWTH Aachen (2010), online: http://www.fast.u-psud.fr/~dietze/Ph.D._Dietze.pdf

[2]Haustein, H.; Tebrügge, G.; Rohlfs, W., Kneer, R.: **Local heat transfer coefficient measurement through a visibly-transparent heater under jet-impingement cooling**, Intern. J. of Heat and Mass Transfer, Volume 55 (2012), Issues 23–24, Pages 6410-6424

[3] Rohlfs, W., Dietze, G.F., Haustein, H.D., Kneer, R.: **Experimental investigation of 3-dimensional wavy liquid films under the coupled influence of thermo-capillary and electrostatic forces**, The European Physical J. Special Topics, Volume 219 (2013), Pages 111-119

[4] Rohlfs, W., Haustein, H., Garbrecht, O., Kneer, R.: **Insights into the local heat transfer of a submerged impinging jet: Influence of local flow acceleration and vortex-wall interaction**, Intern. Journal of Heat and Mass Transfer, Volume 55 (2012), Issues 25–26, Pages 7728-7736

[5] Rohlfs, W.; Dietze, G. F.; Haustein, H. D.; Tselodub, O., Kneer, R.: **Experimental investigation of 3-dimensional wavy liquid films under the influence of electrostatic forces**, Experiments in Fluids, 2012, DOI: 10.1007/s00348-012-1342-0

[6] Ng, R. (2006). **Digital Light Field Photography**. Ph.D. thesis, Stanford University.

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| Location of the HITEC Fellow: | RWTH Aachen University, Institute of Heat and Mass Transfer (WSA), Director: Univ.-Professor Dr.-Ing. Reinhold Kneer |
| For specific questions please contact | Wilko Rohlfs, rohlfs@wsa.rwth-aachen.de |
| Link | www.wsa.rwth-aachen.de |

26 Research Field: Energetic conversion of particulate fossil fuels and biomass

The main focus of research is the energetic conversion of particulate fossil fuels and biomass and their related industrial applications. Numerous experimental and theoretical investigations of energy processes and plants are being performed. Two main areas are addressed:

Physical Modeling: The urge for optimization of process technologies and the statutory regulation of pollutant emissions have tremendously enhanced the operational requirements for modern furnaces and energy technology processes. The application of physical modeling of burners, furnaces and energy technology processes introduces an opportunity to systematically and at the same time highly cost effectively examine the influence of their operating parameters.

Mathematical Modeling / Numerical Simulation: This research area focuses on the numerical simulation of turbulent reactive fluid and particle flows involving heat and mass transfer by means of mathematical modeling. The Mathematical Modeling of the physical and chemical processes is an important tool in order to gain a better understanding of the complex interacting processes. This is of special interest applying fundamental research results to the case of technical devices such as fluidized beds, incinerators and rotary drums.

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| Location of the HITEC Fellow: | Bochum University, Institute of Energy Technology, Director: Prof. V. Scherer; Emmy Noether group on Fluidized Systems in Energy Technology, Dr. Harald Kruggel-Emden |
| For specific questions please contact | Dr. Harald Kruggel-Emden, kruggel-emden@leat.ruhr-uni-bochum.de |
| Link | http://www.leat.rub.de/ |

27 Research Field: Thin-film Photovoltaics

The Institute of Energy and Climate Research (IEK-5) – Photovoltaics belongs to the world leading research institutions in the range of thin-film photovoltaics. The IEK-5 investigates the scientific basis and the technology for efficient and cost-effective solar modules made from silicon thin-films and related materials. We cover the entire spectrum from research and development of the materials science to process- and device design and, finally, to demonstration of industrially relevant production methods.

The institute is subdivided in two departments. In the department of **Materials and Solar Cells** (http://www.fz-juelich.de/iek/iek-5/DE/Forschung/Abteilung%20MS/Ab_MS_node.html) technology approaches of thin-film silicon solar cells and solar modules are investigated. Fundamental research on the growth of thin-films and the process development for the industrial application are the basis of the department. Thereby nanotechnology-based processes are getting more and more in the focus of the today's activities. With the combination of fundamental scientific research and industrial relevant development advanced and novel solar device concepts are realized.

In the department of **Analytics and Simulations** (http://www.fz-juelich.de/iek/iek-5/DE/Forschung/Abteilung%20AS/Ab_AS_node.html) various characterization methods are evolved and applied to study for example the material quality of solar cell absorber materials or the light scattering characteristic of textured interfaces, which are essential for the light management in the solar cell device. Furthermore, mathematical models are created to simulate charge carrier and light trapping processes in photovoltaic elements. The industrial linking results through characterization methods for solar modules like our large area flasher system or our log-in thermography setup.

Our institute employs about 110 scientists, engineers, technicians and administration secretaries. We educate about 30 Ph.D. and master students from different countries in various disciplines like physics, engineering, material science and chemistry. Thus, we are a highly multidisciplinary, multicultural team which profits from the spirit and ideas of our members.

Our ideology is the German “Energiewende” wherein we play a significant role by developing and establishing promising photovoltaic devices and concepts. By the combination of fundamental scientific and highly industrial relevant research we are gathering knowledge for the deep understanding of physical processes in our devices such that we can improve the nowadays and the future solar cell. The close contact to our industrial partners, which we strengthen in our public funded projects, keeps us up to date about the state of the art technological approaches and the political decisions.

For our Ph.D. applicants we offer projects in many different research areas and disciplines, which result from the multiplicity of our institute.

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| Location of the HITEC Fellow: | Forschungszentrum Jülich , Institute of Energy and Climate Research, Photovoltaics (IEK-5; Director: Prof.Uwe Rau) |
| For specific questions please contact | Dr. Matthias Meier, ma.meier@fz-juelich.de |
| Link | http://www.fz-juelich.de/iek/iek-5/EN/Home/home_node.html |

#28 Research Field: Atmospheric Research – Tropopause Region

IEK-7 studies chemical, microphysical and dynamic processes in the atmosphere and the role they play in climate change. The institute focuses on the tropopause region (5 to 15 km), because here changes in greenhouse gases, aerosols and clouds have a particularly strong effect on the radiative forcing of the atmosphere.

In order to increase the prognostic value of chemistry-climate models (on the timescale of decades), IEK-7 conducts research on small-scale processes globally (waves, clouds, exchange processes), as a lack of understanding of these processes currently limit the prognostic capability of global and regional climate and weather models. For these studies, novel measuring equipment for research aircraft and research balloons will be developed and deployed in international measuring campaigns in the Arctic, in the mid-latitudes, or in the tropics (e.g. on the new German research aircraft HALO or high-flying Russian aircraft M55-Geophysica). Future aircraft campaigns will focus on the climate impact of transport of water vapor and pollutants by the Asian Monsoon to the upper troposphere and stratosphere and of air mass exchange between the tropics and higher latitudes. IEK-7 uses global satellite data (e.g. TIMED) to investigate the global circulation and underlying wave dynamics and contributes to the development of new ESA satellite missions (e.g. Earth Explorer Missions). All measured data are interpreted in combination with computer simulations of the Earth's atmosphere (e.g. with the Chemical Lagrangian

Model of the Stratosphere CLaMS developed at IEK-7). In the future, studies on the impact of the energy industry (e.g. emission of greenhouse gases) on the composition of the upper troposphere and stratosphere will be intensified in order to create synergies with energy research.

At IEK-7 scientists work in the field of atmospheric modeling with the chemistry transport model CLaMS, development and application of aircraft instrumentation, and development and application of algorithms for inverse modeling of atmospheric radiation (remote-sensing).

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| Location of the HITEC Fellow: | Forschungszentrum Jülich , Institute of Energy and Climate Research, Stratosphere (IEK-7; Director Prof. Dr. Martin Riese) |
| For specific questions please contact | Dr. Bärbel Vogel, b.vogel@fz-juelich.de |
| Link | http://www.fz-juelich.de/iek/iek-7/EN/Home/home_node.html |

C. Guideline for Applicants

Please follow these guidelines for your application!

These guidelines should help you as you think about applying to the Helmholtz Interdisciplinary Doctoral Training in Energy and Climate (HITEC). We are pleased that you are considering HITEC, and offer you encouragement along with some words of advice.

HITEC presents exceptional opportunities offering students the academic and intellectual resources of one research centre and five universities. Working towards a Ph.D. you will develop the capacity for independent research by working closely with a scholar, or a small group of scholars, whose work can serve as a model. It is a transition period at the end of which you will have become a colleague to your professors. Such a position is earned by commitment to the difficult, but fulfilling, craft of independent research through which you demonstrate the ability to make an original contribution to knowledge. Towards this goal HITEC provides an inspiring and accepting learning environment. Meeting this challenge requires personal sacrifice - of time, of leisure, of immediate rewards. But the achievement is well worth the cost in terms of intellectual satisfaction and the opportunity to expand the boundaries of knowledge. Before resolving to set out on the path to a doctoral degree, do reflect on the commitment that will be required. If you think you have this commitment - sufficient to sustain you through three years of intense and concentrated work and study - we welcome your application.

► General requirements

- You need to apply for one of the 22 projects or one of the 6 research fields outlined in the 'Call for Applications'. If your background meets the specific requirements of several projects, you can apply to more than one project. In this case you have to fill out a separate application form for each project. **If you do not refer to one or several of the projects/research fields your application will not be considered!**
- Candidates are expected to have a Master, a German "Diplom" or an equivalent degree, when they start their Ph.D. project. The specifics of the degree and the experience required are indicated for each of the projects listed in the 'Call for applications'.
- It is not mandatory that you have completed your degree by the time you submit your application. However, the expected date of your final exam should not be later than July/August 2014.
- The integration in international co-operations requires the ability to cooperate in an international team, thus we expect good skills in the spoken and written English language.

► Documents required for application: **Please package all documents into 1 pdf-file**

1. Application form: *Curriculum Vitae*

Your CV should be between one and two pages long and list your personal data; the dates of your education and personal academic history; awards; publications; and contributions or other significant achievements.

- Personal data: Name (surname, given name); date of birth; place of birth; male/female; citizenship; country of permanent residence, native language; family status; e-mail address; mailing address, where you may be contacted; telephone;
- Educational data: - Secondary school education; from – to (month/year); type of final exam (original name); awarded on (date); results
 - Higher education; from – to; at (institution); subject
 Academic year at time of application; major; minor; currently affiliated with (institution)
 - Degrees held: day/month/year; exact degree title; subject; degree results
 - Degrees expected before taking up a possible fellowship, expected date of final examination
- Research: Briefly outline your major research projects, completed or ongoing
- Academic honours, awards, fellowships
- Publications (if applicable)

2. Application Form: Personal and Research Statement

The statement (1-2 pages) should describe your academic and career plans as well as your motivation for the application and your scientific interests **in regard to the HITEC project chosen**. When writing your personal statement, make sure to answer the following questions:

- what are your scientific interests in regard to the project?
- why do you think you will be successful in working on the project?
- why do you think is HITEC the right choice for you?
- why do you want to come to Germany, to Jülich or to the universities of Aachen, Bochum, Cologne, Düsseldorf, Wuppertal?

3. Letters of Recommendation

Two letters of recommendation from faculty members or others well acquainted with your academic work are required. Please indicate the two reviewers with names and complete contact data in the application form.

Letters of recommendation should be submitted electronically or via postal services directly by the professors. Letters that have been submitted by the applicants themselves will not be accepted. Please be aware that **the deadline for your referees to submit their letters of recommendation is the same as the application deadline. Therefore, you need to make sure that they have enough time to submit their letters before the closing of the call.**

4. Transcripts

One official transcript from every college or university you have attended should be submitted. To prevent delays, you should arrange with your registrar to provide transcripts as soon as possible or submit preliminary transcripts with as many grades as possible.

5. Proof of Proficiency in English

If your native language is neither English nor German, you must submit a proof of your English language proficiency. This is not required if you have attended a school, university or college where English is the language of instruction. Indicate results of the followings tests, alternatively:

- Test of English as a Foreign Language (TOEFL); reading, listening, speaking, writing; please also indicate year of test.
 - Internet-Based Test (TOEFL iBT):
 - TOEFL Computer-Based Test (CBT):
 - TOEFL Paper-Based Test (PBT):
- Certificate of Proficiency in English (CPE) or Certificate in Advanced English (CAE); please indicate year of test
- International English Language Testing System - Academic Test (IELTS); please indicate year of test

► Evaluation procedure and decision

The best 12 – 15 applicants (one candidate per project) will be invited to Germany for a week, to join the respective research group in Jülich or at one of the universities. The task during this one week is to jointly work on the project idea with faculty members and supervisors and to turn it into an outstanding and convincing HITEC (Ph.D.) Project. On the last day of the stay the candidates present their projects and the outline of their dissertations to the members of the HITEC Advisory Board. The seven best candidates will be offered a HITEC fellowship.

All costs (travel and accommodation) for the week in Germany will be covered by HITEC. You will receive an email notification about the admission and invitation by the end of January. We ask you to abstain from e-mail or phone enquiries after submitting your application. Please be assured that we will inform you as soon as the decisions will have been taken. The one week stay in Germany will be scheduled from 24 March until 2 April 2014. The earliest start of the HITEC Fellows is 1 June; later starts are possible and will be discussed between the HITEC Fellows and their supervisors.

► HITEC Fellows

HITEC Fellows will be employed as Ph.D. students. As a rule, the funding period for Ph.D. students is **three years**. The graduate school HITEC provides an inspiring scientific environment and a supportive supervision concept allowing HITEC Fellows to complete their thesis within the given time.

► Information about

- the Institute of Energy and Climate Research at Forschungszentrum Jülich: http://www.fz-juelich.de/portal/EN/AboutUs/organizational_structure/Institutes/InstituteEnergyClimate/_node.html
- RWTH Aachen University, Institute of Heat and Mass Transfer: <http://www.wsa.rwth-aachen.de/?L=2>
- Bochum University, Department of Energy Plant Technology: <http://www.lead.ruhr-uni-bochum.de/index.php?do=start.html&lang=englisch>
- Bochum University, Institute of Thermodynamics: <http://www.thermo.rub.de/en.html>
- Wuppertal University, Atmospheric Physics <http://www.atmos.physik.uni-wuppertal.de/en/home/atmospheric-physics.html>
- HITEC: www.fz-juelich.de/hitec/EN/_node.html

► Contact

- HITEC Office: Dr. Bärbel Köster, Managing Director
- E-Mail: b.koester@fz-juelich.de

Submit your complete application electronically until 04 January 2014 to b.koester@fz-juelich.de