SFB 920

Multifunktionale Filter für die Metallschmelzefiltration – ein Beitrag zu Zero Defect Materials

NEWSLETTER 9 (2/2015)

DFG Deutsche Forschungsgemeinschaft

Technische Universität Bergakademie Freiberg

DEAR READERS,

The Collaborative Research Center CRC 920 “Multi-Functional Filters for Metal Melt Filtration - A Contribution towards Zero Defect Materials“ has started its second program period. During the next four years, research will be focusing on the multifiltration of inclusions and a thorough combination of modeling approaches and empirical studies. Therefore, the CRC‘s research program includes two new subprojects. One new subproject is anchored in the project area responsibe for the modeling of filter structures and filter systems. The other contributes to the project area that deals with relations between filter efficiency and materials properties.

As in previous years, several international guests are visiting the CRC. Currently, students from Poland, Irak and China are supporting the research team.

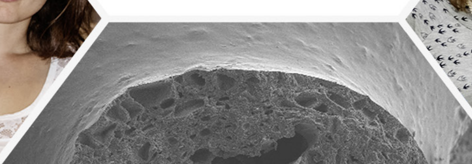
Details on these and other activities are available in our latest issue of this newsletter. Further information is provided at http://sfb920.tu-freiberg.de. We hope you‘ll enjoy the newsletter.

Yours sincerely,

Prof. Dr.-Ing. habil. Christos G. Aneziris
CRC 920 Coordinator

Prof. Dr.-Ing. habil. Horst Biermann
CRC 920 Vice Coordinator

CONTENT



MULTIFILTRATION AND MODELING AS CORE OBJECTS FOR THE SECOND PROGRAM PERIOD

Starting its second program period, the CRC 920 "Multi-Functional Filters for Metal Melt Filtration - A Contribution towards Zero Defect Materials," is focusing on new research objectives. Building on important results gained throughout the first four years, researchers will be focusing on the analysis of inclusions in metal melts as well as on intertwining modeling approaches with empirical tests.

The CRC 920 "Multi-Functional Filters for Metal Melt Filtration - A Contribution towards Zero Defect Materials" aims at a significant reduction of anorganic inclusions in metal melts by employing smart filter materials and filter systems, in order to enhance superior products and processes with groundbreaking properties and functionalities. During the second program period, researchers will focus on the **multifiltration of inclusions with different chemical properties and cristal system** as well as on hybrid functionality with both active and reactive filtrations. Current investigations will include **kinetics of the separation efficiency** as a function of the interface design, the micro and the macro structure, the atmosphere and the oxygen content of the metal melt. In addition, the CRC team aims at **reducing extremely fine inclusions ranging between 50 and 500 nm** immediately after their genesis. **Nano-functionalized filter materials**, employed in smart filter systems which permit higher filtration capacity, long-term stability and filtration efficiency, will be studied exemplarily for dead-mold casting of larger melts, bottom casting and specific continuous casting.

To this end, modern methods are used to design and test active and reactive filter materials, the filter chamber and to capture the filter efficiency of the casted component. Researchers of the CRC 920 will employ, among others, high-temperature confocal laser scanning microscopy in order to investigate in situ the agglomeration of inclusions in metal melts and their movement towards functionalized filter walls. Using 3D micro tomography and in situ compression load, adhesion of functional layers can be investigated.

Both simulation and modeling are inevitable to foster a thorough understanding of active and reactive effects of novel filter structures, their interplay with metal melt flows and, eventually, a successful implementation of these filters in metallurgic casting and mold-filling processes. Quantum-mechanical calculations, flow simulations of metal melt filtration, probabilistic agglomeration and hit models of inclusions on filter walls, thermo-dynamic modeling of materials and interfaces as well as continuum- and damage-mechanical modeling for designing filter geometries are valuable contributions to an integrated innovation chain from "functionalized filters to clean, metallic high-performance components."

Noteworthy, the CRC research program includes two new subprojects. Prof. Rüdiger Schwarze is coordinating investigations on the effectiveness and efficiency of filtration systems for continuous casting processes (subproject B06(N)). Prof. Michael Stelter and Prof. Christiane Scharf, coordinators of the new subproject C06(N), are dealing with the effectiveness of reactive filters for the filtration of aluminum melts as well as with lab-based analyses of filter efficiency.

With the beginning of the second program phase, the CRC member assembly confirmed the management board consisting of Prof. Christos G. Aneziris (coordinator), Prof. Horst Biermann (vice coordinator), Prof. Urs Peuker, Prof. Rüdiger Schwarze, Dr. Anja Weidner (postdoc representative), Dr. Rhena Wulf, Dipl.-Ing. Tilo Zienert (graduate student representative) as well as Dr. Undine Fischer (CRC manager and responsible for equalization of opportunities). Furthermore, the member assembly concordantly appointed three new members, namely, Prof. Andreas Leineweber, Prof. Tobias Fieback, and Prof. Olena Volkova. Dipl.-Ing.Tilo Zienert has been confirmed as graduate student representative. Dipl.-Ing. Anne Schmidt was elected as deputy representative of the CRC's doctoral students. ■

MORE NEWS

FIELD TRIP FOR PH.D. STUDENTS

On Oct 14, 2015, a field trip to the **Salzgitter Flachstahl GmbH in Salzgitter** offered Ph.D. students of the CRC 920 and the Priority Program 1418 the opportunity to witness the placing of a new lining in one of the blast furnaces deployed to produce pig iron. Production capacity of such a furnace is 10,000 to 14,000 tons of pig iron per day. Due to physical and chemical wear processes, refractory lining has to be renewed every 10 to 15 years, with a consumption of more than 3,500 tons of refractory material. Additionally, on this occasion maintenance and refurbishment operations can be executed, which can take up to three month.

During their visit, students could follow how the existing lining was removed from the 11 m high combustion chamber and replaced with new refractory material. Experienced engineers guided their visitors through the facility. They explained lining concepts in different temperature zones across the furnace and how these concepts respond to different loadings during the melting process. ■

Photo: Doctoral students of teh CRC 920 and the Priority Program 1418 on their field trip to the Salzgitter Flachstahl GmbH.

RESEARCH MEETS INDUSTRY

The CRC 920 was among the exhibitors that presented their innovations and solutions at the **WERKSTOFFWOCHE 2015 in Dresden**. The CRC 920 shared a booth with the second Collaborative Research Center at TU Bergakademie Freiberg, the CRC 799 "TRIP-MATRIX-Composite."

The WERKSTOFFWOCHE 2015 had been organized by the Deutsche Gesellschaft für Materialkunde e.V. (German Materials Society). The conference enclosed to the exhibition offered plenar sessions and seminars on novel materials and applications. Attendees and exhibitors used the opportunity to discuss latest research results, trends and developments in materials science and engineering. In addition, the WERKSTOFFWOCHE 2015 offered researchers and industry representatives rich opportunities to present products and services related to topics such as material groups, manufacturing processes, measure and testing procedures as well as quality and reliability strategies for materials. ■

Photo: The CRC 920 as well as the CRC 799 exhibiting on the WERKSTOFFWOCHE 2015 in Dresden.

INTERNATIONAL GUESTS

Several international students are currently joining the CRC's research teams. Already this summer, IASTE students from Iran and Ghana were visiting the CRC and supported the subprojects A01 and B03, respectively. From October 2015 to September 2016, two **Ph.D. scholars from Iraq and from Poland** will contribute to the research in subprojects B02 and S03.

Furthermore, until February 2016 the CRC 920 hosts a **doctoral student from Wuhan University of Science and Technology**. He will be involved with e-module measurements for porous refractory materials. His research is funded by a scholarship from the Wuhan University. The research visit is embedded in the international cooperation between TU Bergakademie Freiberg and Wuhan University. ■

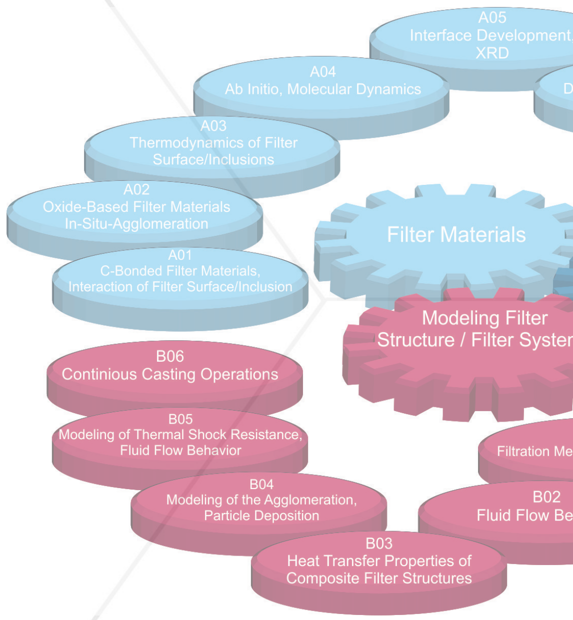
Photo: Junfeng Chen (middle) from Wuhan/China, with Anne Schmidt (left) und Claudia Voigt (right).

WORKING GROUPS' REPORT

Research teams in the CRC 920 are connected in four working groups, thus ensuring targeted activities, close collaborations between subprojects, and intensive exchanges between all researchers involved. Young scientists are taking responsibility for coordinating these working groups - a measure the CRC has taken to support young scientists already in early career stages to promote their capabilities to work independently as well as in teams and to strengthen their management skills.

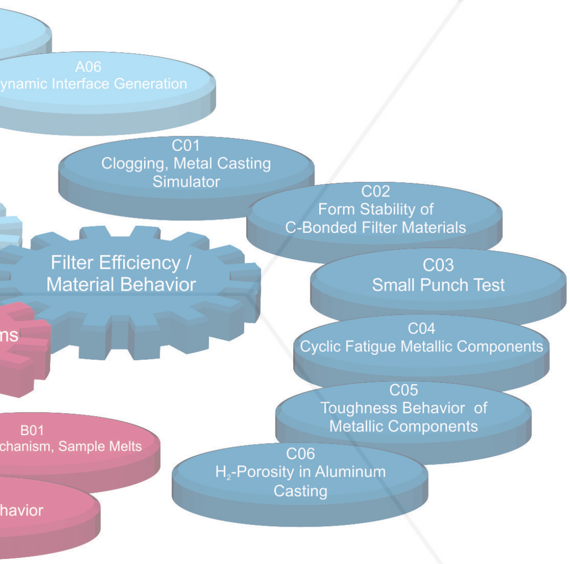
Working Group 1: "Metal melt/inclusions, active/reactive filter materials, boundary surface design" (Coordination: Dipl.-Ing. Claudia Voigt)

- Finger test experiments in steel casting simulator on prismatic samples of carbon bonded Al_2O_3 filters with graded structure (A01),
- Application of electrophoresis for the coating of aluminum foams (A02),
- Investigations of aluminum and AlSi7Mg-alloy under vacuum by means of differential thermal analysis (A03),
- Calculations of heat capacity for stable structures in the system Al_5Fe_2 and providing the equations for calculating the surface energy considering broken atomic bonds (A04),
- Investigations of AlSi7Mg melt in contact with SiO_2, mullite and metastable Al_2O_3 by SPS-melting (A06),
- Studies on the influence of the design of the casting system on the filtration process (S03),
- Systematic studies on the maximum resolution of filter structures using a computer tomograph (S01),
- Determining the conditions for manipulating nanoparticles during high temperature tests in the atomic force microscope (B01),
- Investigations on crack initiating non-metallic inclusions in steel samples after ultrasonic fatigue test (C04).



Working Group 3: "Thermo-mechanical characteristics of filter materials and structures" (Coordination: Dipl.-Wi.-Ing. Yvonne Klemm)

- Determination of the modulus of elasticity with a new method of casted Al_2O_3-C rods,
- Test discrepancy of mechanical properties between pressed and casted Al_2O_3-C material, therefore usage of properties of the pressed material for the development of a material law, repeated tests of samples in C02 in case crack-free samples can be casted in A01 (B05),
- Development of a solution for the preparation of plane filter samples, CT scans of the filter (forwarding to B05), development of a model experiment with ideal sample together with B05 and S01 (C02),
- Casted samples of A01 have also cracks - no influence on small samples for Small Punch Test, therefore test of a new manufacturing process for micro samples using a spraying slurry (C03).



Working Group 2: "Modeling and designing of the filter geometry" (Coordination: Dipl.-Ing. Eric Werzner)

- Preparation and validation of colloidal-probe(Al_2O_3)-cantilevers for high temperature atomic force microscopy (B01),
- Direct numerical simulations of the unsteady three-dimensional flow field inside an idealized porous medium (B02),
- Development of a simplified model for the determination of the separation probability of particles moving through the filter (B02, B06),
- Evaluation of the influence of process parameters on the agglomeration efficiency in homogeneous isotropic turbulence based on theoretical calculations and numerical simulations,
- Numerical investigation of the influence of filter permeability on filtration efficiency in the induction furnace of the steel casting simulator (B06, C01),
- Generation of artificial filter structures on the basis of Kelvin cells, matching the geometric properties of a ceramic foam, and evaluation of agreement using effective properties (B02, B05),
- Numerical investigation on the preheating of air through the melt and calibration of the Hot Disk system for evaluating the effective thermal conductivity of the filters (B03),
- Implementation of an algorithm for in situ compression of particles and point clouds for the sub-projects B02 and B06, as well as development of a system for the visualization of in situ compressed voxel data by volume rendering (S02).

Working Group 4: "Mechanical properties, metallic materials, critical inclusions" (Coordination: Dr.-Ing. Dominik Krewerth)

- Generation of new sample material of the tempering steel G42CrMo4 (AISI 4140) in collaboration with subprojects A01, C01, C04, and C05, using the metal casting simulator; deployment of novel filter materials coated with carbon nano tubes (CNT) (produced in A01) as well as carbon-bonded Al_2O_3-C filters; variation of dipping times in the metal casting simulator for both filters,
- Continuous research on the microstructure of non-metallic inlcusions conducted by Dipl.-Ing. Johannes Gleinig and Birgit Witschel (C04, S01), in order to characterize mechanisms of emerging non-metallic inlcusion clusters and agglomerates within the casting model by employing deep reactive etching and excavating inclusions,
- Planning of new casting tests using AlSi7Mg in collaboration with the Constellium corporation as well as subprojects A02, C04, C05, S01, and S03.

REACTIVE FILTER MATERIALS FOR AVOIDING H_2-POROSITY IN ALUMINUM CASTING

Author: Beate Fankhänel
(Subproject C06(N))

The new subproject C06(N) is focusing on the investigation of new reactive filter materials based on spodumene to avoid H_2-porosity in aluminum casting. First results concerning the influence of the new filter material in comparison to Al_2O_3 on the wetting behavior of an aluminum alloy could be already confirmed.

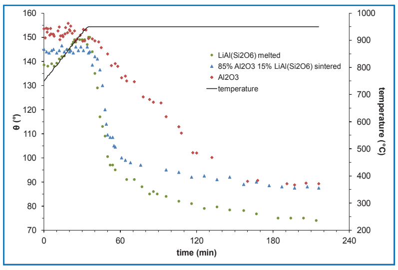
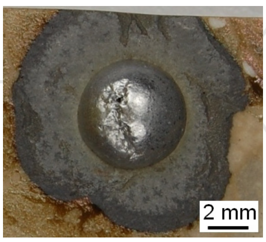
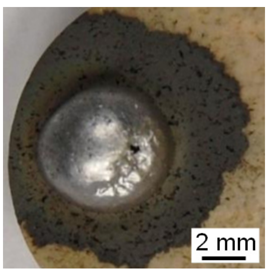


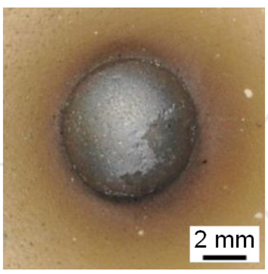
Figure 1: Development of the contact angle of an AlSi5Mg alloy droplet dependent on the type of substrate.



(a) $LiAl(Si_2O_6)$ melted on Al_2O_3



(b) 85% Al_2O_3 15% $LiAl(Si_2O_6)$ sintered



(c) Al_2O_3

Figure 2: Top views of the solidified sessile drops of an AlSi5Mg alloy on spodumene containing substrates (a) and (b) as well as on a pure Al_2O_3 surface (c).

In aluminum casting oxidic and other nonmetallic inclusions in the melt can lead to defects and macro-pores in the casting products. Additionally and more important a high content of dissolved hydrogen can produce macro-pores and lead to defects in the components. But an exclusive reduction of the oxides, which act as pore-seeds, during melt filtration could lead to larger pore sizes as well, how it was to be seen from the results of an earlier research project [1]. That means only a proper pore-seed to released hydrogen ratio in the metal melt can finally affect a reduction in pore size. Therefore, it is essential not only to remove the inclusions, which act as pore-seeds, but also to reduce the hydrogen content of the melt.

A new active filter material that is able to remove the dissolved hydrogen by a reaction with the metal melt can be a solution of the problem. A significant lower number of pores in the casting products as well as a reduction in pore size can be expected under optimal conditions. For this reason the properties of reactive filter materials for the metal melt filtration in aluminum casting based on spodumene $LiAl(Si_2O_6)$ will be investigated in detail in terms of the new subproject C06. Comprehensive investigations of the reaction kinetics between hydrogen and $LiAl(Si_2O_6)$ are to be done as a basis of this research.

Investigations of the wettability of an AlSi5Mg alloy on spodumene containing substrates in comparison to pure alumina [2] showed that spodumene activates another development in adjusting the final contact angle. Not only the initial value of the contact angle, after completing the formation of the droplet, is reduced in presence of $LiAl(Si_2O_6)$ also the final value decreased from 90° (Al_2O_3) to 75° in case of a pure $LiAl(Si_2O_6)$ surface, see Fig. 1.

However, the progression of the wetting curve is particularly interesting for the new research project. That means the faster decrease of the contact angel after the completion of the droplet's formation and the earlier beginning of deoxidation in presence of spodumene suggest chemical reactions between the lithium containing substrates and the metal melt. The development of the droplets shape during the sessile drop tests supports this assumption as well. Investigations of the solidified droplets and the appropriate substrates showed a reaction zone which has been developed around the droplets on the spodumene containing substrates. In case of the alumina substrate as typical for non-reactive systems no reaction layer was created. The difference was already visible to the naked eye as it can be seen in Fig. 2. Obviously a reaction between the $LiAl(Si_2O_6)$ and the metal and/or the oxide on the metal's surface took place resulting in a faster contact between the metal melt and the substrate comparing to a pure alumina surface. Furthermore, a crater, probably due to a droplet's loss of mass or a gaseous reaction product, was formed on the surface of these droplets. This crater also can be an indication for a reaction between the spodumene and the alloy. Therefore, a reaction between the $LiAl(Si_2O_6)$ and the hydrogen solved in the liquid metal is assumed. Lithium hydride could be such a gaseous reaction product under the conditions of the sessile drop experiments. Fundamental investigations are now to be done to analyze the reaction products and to understand the reaction kinetics. ■

[1] Fankhänel, B., Stelter, M., Vogel, W., Klug, T. (2014): Optimierung der Eigenschaften von Aluminiumgussteilen durch homogene Verteilung von Mikroporen, World of Metallurgy – Erzmetall 67 (5), pp. 277-286.
[2] Fankhänel, B., Stelter, M., Voigt, C., Aneziris, C. G. (2015): Wettability of AlSi5Mg on spodumene, Metallurgical and Materials Transaction B 46 (3), pp. 1535-1541.

EFFECT OF THE FILTER SURFACE CHEMISTRY ON THE FILTRATION OF ALUMINUM

Subproject A02 deals with the preparation of filters with different properties. In the first period of the CRC 920 the influence of the filter surface chemistry on the filtration was investigated with the help of casting trials and SEM investigations.

Authors: Claudia Voigt, Beate Fankhänel, (Subproject A02)

In the subproject A02 alumina filters with different oxide surface chemistries alumina (Al_2O_3), spinel ($MgAl_2O_4$), mullite ($3Al_2O_3 \cdot 2SiO_2$), silicon oxide (SiO_2) and titania (TiO_2) were prepared and tested with casting trials in regard to their filtration effect. For the filtration test the five filters were casted in a production environment with AlSi7Mg. For the testing of filters in terms of the filtration effect the presence and a homogenous distribution of non-metallic inclusions is necessary. Preliminary tests showed that the usage of scrap material is a practicable way. For the tests 50% ingots and 50% scrap were used.

The aluminum alloy (300 kg) was molten in an electrical heated furnace. Before casting the melt was skimmed, cleaned and homogenized three minutes with a degassing equipment using argon. Casting was done with a melt temperature of 740°C in a combined steel and green sand mould. The vertical sample area plus feeder was made of 42CrMo with a diameter of the sample of 60 mm and a height of 165 mm and the basin, the vertical downrunner and the horizontal runner were formed with green sand. The casting trials were successfully for all five filter surface chemistries. No cold laps or filter breaking occurred. The metal composition was measured with a spark spectrometer Bruker Tasman T4 and no significant differences in metal chemistries between the sample casted without filter and the filtered samples are visible. The casted filters were evaluated with scanning electron microscope Philips XL 30 and energy-dispersive X-ray spectroscopy with regard to the quantity (number and size) and quality (chemistry) of the detected non-metallic inclusions. An overview of all of the detected inclusions is presented in Tab. 1. Every filter was examined three times (at the run in, the middle and the run out of the filter) and for every position and filter type an area of 3 mm x 2.3 mm was investigated by the SEM in the back-scattered electron mode. The number of detected inclusion was calculated. The amount of inclusions in the area of the run in is higher than in the middle and the run out of the filter. One reason for this observation is the cake mode filtration of the ceramic foam filter. An exception is the SiO_2 filter which shows a higher number of inclusions at the run in and the run out than in the middle of the filter. The largest number of inclusions was found in the $MgAl_2O_4$ filter followed by the Al_2O_3 filter. According to the numbers of inclusions the SiO_2 and $3Al_2O_3 \cdot 2SiO_2$ filter are comparable among each other. The TiO_2 possesses the smallest number of caught inclusions. A correlation between the chemistry of the captured inclusions and the chemistry of the filter surface has not yet been found. The chemical composition of the trapped inclusions is nearly equally distributed for all the filters. ■

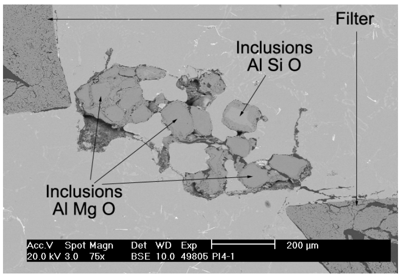


Figure 1: SEM image of the Al_2O_3 filter and captured inclusions of different chemistry.

Filter	Al_2O_3	$MgAl_2O_4$	$3Al_2O_3 \cdot 2SiO_2$	TiO_2	SiO_2
Run in					
Number of particles	68	101	39	15	40
Al Si O	24	7	1	1	1
Si O	2	6	34	14	
Al Mg O	35	52	1		37
Al O	7	36	3		2
Middle					
Number of particles	77	32	2	1	2
Al Si O	1	8	1		1
Si O	74				
Al Mg O		12	1		
Al O	2	12		1	1
Run out					
Number of particles	7	2	1	6	19
Al Si O		1	1	1	2
Si O					1
Al Mg O	5	1		5	15
Al O	2				1

Table 1: Overview of the inclusions detected in the casted filters, chemical composition and number.

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INTERACTIONS BETWEEN FILTER MATERIALS AND INCLUSIONS

Author: Lilit G. Amirkhanyan, Christian Röder (Subproject A04)

Subproject A04 is focusing on the prediction of thermodynamical properties and possible chemical reactions on filter surfaces. First principles method is used to predict thermodynamic, energetic and elastic properties without experimental data as input. Theoretical insights about active and reactive filter materials may eventually guide optimization of materials.

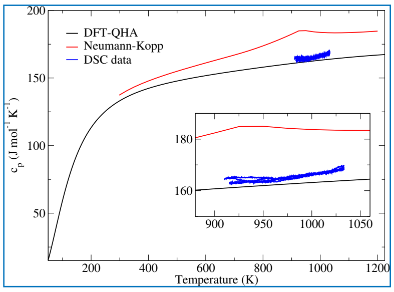

Figure 1: Specific heat for the inter-metallic τ4-Al-Fe-Si phase. The blue points have been measured in A03. We find excellent agreement with our DFT calculations (black solid line).

(Source: Amirkhanyan, J., et al., J. of Alloys and Compounds 598 (2014) 137–141.)

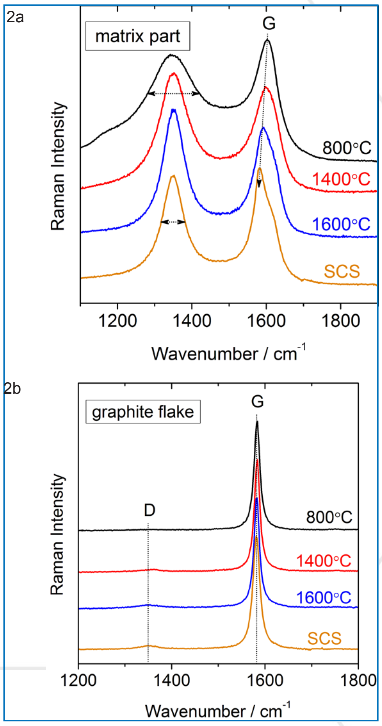

Figure 2: Raman spectra taken from (a) the matrix part and (b) the graphite flakes of each filter composition. The sample (orange curve) was used in a steel casting simulator (SCS) at a maximum temperature of about 1600°C. All spectra are shifted for clarity.

(Source: Röder et al., J. Raman Spectrosc. 45 (2014) 128-132.)

The first principles calculations are based on density functional theory (DFT), which is an approximate solution of the quantum mechanical Schrödinger equation. The method allows for example to calculate free of experimental parameters the electronic structure, interaction energies, elastic and vibrational properties and delivers information on chemical bonding. Coupling DFT with molecular dynamics allows to investigate dynamic stability of interfaces or diffusion processes. The calculated phonon dispersion as a function of the crystal volume gives access to the vibrational entropy. This is enough information to construct the Gibbs energy in the quasi-harmonic approximation. Unfortunately, the computational cost is very high which limits the size of the systems one can investigate.

In case of an inter-metallic Al-Fe-Si phase we demonstrated the predictive power of the method together with subproject A03. In Figure 1 we compare experimental results on specific heat from A03 (blue data points) with our calculations (black solid line). The agreement in that case appears to be excellent. The Neumann-Kopp-rule (red line), which is often used as an estimate, performs clearly worse and is often not accurate enough for thermodynamical modeling. The main advantage our DFT based method offers is the possibility to deliver thermodynamical information in temperature ranges which are difficult to measure or not accessible due to phase transformation.

Additionally, the project contains an experimental part, where Raman spectroscopy is used to explore different crystalline phases or carbon-coated surfaces. Raman spectroscopy is a powerful method which has been successfully applied to many ceramic and semiconducting materials. In the framework of the CRC we are interested in the characterization of metastable Al_2O_3 phases and carbon-bonded filters. Raman spectroscopy has been shown to be a versatile technique to study carbon in various forms while taking advantage of being fast, non-destructive as well as providing a high lateral resolution.

In order to characterize thermally induced structural changes of the novel carbon-bonded filter compositions, micro-Raman spectroscopy has been applied. We investigated a series of filter materials coked at temperatures between 800°C and 1600°C. Figure 2 illustrates the thermally induced changes on the Raman spectra. On one hand, the experimental data (Fig. 2b) show no influence of the thermal treatment on the initially added graphite flakes which was expected. On the other hand, performing measurements on the matrix part of the carbon-bonded filter material (Fig. 2a), the spectral position of the G mode shifts from 1602 cm^{-1} to 1590 cm^{-1} with increasing temperature. Considering the D peak, the full width at half maximum (FWHM) decreases and its intensity slightly increases with rise in temperature. However, the matrix part of the filter composition mainly consists of Al_2O_3 particles and the binder Carbores®P. By means of the heat treatment, the volatile components of Carbores®P evaporate, and the pitch forms a graphite-like structure. Analyzing the position, intensity, and FWHM of G and D peaks in the Raman spectra, the graphitic cluster size was estimated. We found an increase of the lateral cluster size with increasing coking temperature. ■

RECENT PUBLICATIONS

Project area A - Filter materials

Subproject A01

Emmel. M., Aneziris, C. G. (2015): Implementation of Novel Carbon Bonded Filter Materials for Steel Melt filtration – an Overview. refractories worldforum, Vol. 7, Iss. 1, pp. 73-82.

Storti, E., Emmel, M., Dudczig, S., Colombo, P., Aneziris, C. G. (2015): Development of multi-walled carbon nanotubes-based coatings on carbon-bonded alumina filters for steel melt filtration. Journal of European Ceramic Society, Vol. 35, Iss. 5, pp. 1569-1580, DOI 10.1016/j.jeurceramsoc.2014.11.026.

Moritz, K., Aneziris, C. G. (2015): Electrophoretic method for fabricating porous materials – application to different oxide materials. 5th International Conference on Electrophoretic Deposition: Fundamentals and Applications, Hernstein (Austria), Key Engineering Materials, Vol. 654, pp. 101-105, DOI 10.4028/www.scientific.net/KEM.654.101.

Subproject A02

Moritz, K., Ballaschk, U., Schmidt, G., Hubálková, J., Aneziris, C. G. (2015): Oxide ceramics with unidirectional pore channels by electrophoretic deposition. Journal of the European Ceramic Society, Vol. 36, Iss. 2, pp. 333-341, DOI 10.1016/j.jeurceramsoc.2015.07.006.

Sarkar, N., Park, J. G., Mazumder, S., Aneziris, C. G., Kim, I. J. (2015): Processing of particle stabilized Al_2TiO_5-$ZrTiO_4$ foam to porous ceramics. Journal of the European Ceramic Society, Vol. 35, Iss. 14, pp. 3969-3976, DOI 10.1016/j.jeurceramsoc.2015.07.004.

Sarkar, N., Park, J. G., Mazumder, S., Pokhrel, A., Aneziris, C. G., Kim, I. J. (2015): Al_2TiO_5–mullite porous ceramics from particle stabilized wet foam. Ceramics International, Vol. 41, Iss. 4, Part A, pp. 6306-6311, DOI 10.1016/j.ceramint.2015.01.056.

Sarkar, N., Park, J. G., Mazumder, S., Pokhrel, A., Aneziris, C. G., Kim, I. J. (2015): Effect of Amphiphile Chain Length on Wet Foam Stability of Porous Ceramics. Ceramics International, Vol 41, Iss. 3, Part A, pp. 4021-4027, DOI 10.1016/j.ceramint.2014.11.089.

Sarkar, N., Park, J. G., Mazumder, S., Pokhrel, A., Aneziris, C. G., Kim, I. J. (2015): Influence of amphiphile on foam stability of Al_2O_3-SiO_2 colloidal suspension to porous ceramics. Journal of Ceramic Processing Research, Vol. 16, Iss. 4, pp. 392-396.

Voigt, C., Aneziris, C. G., Hubálková, J. (2015): Rheological characterization of slurries for the preparation alumina foams via replica technique. Journal of the American Ceramic Society, Vol. 98, Iss. 5, pp. 1460-1463, DOI 10.1111/jace.13522.

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Subproject A03

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Project area C - Filter performance, materials properties

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CONFERENCES AND CALLS FOR PAPERS

2nd Doctoral Students‘ Meeting and and 2nd Member Assembly of the 2nd Program Period of the CRC 920: Nov 26/27, 2015, TU Bergakademie Freiberg.

India International Refractories Congress IREFCON 2016: Jan 20-22, 2016, Hyderabad (Indien), further information available at http://irefcon.org.

91. DKG Annual Conference & Symposium High-Performance Ceramics 2016: March 7-9, 2016, TU Bergakademie Freiberg, further information available at http://www.2016.dkg.de.

6. International Congress on Ceramics - ICC 6: Aug 21-25, 2016, Dresden, further information available at http://www.icc-6.com.

Materials Science and Engineering MSE 2016: Sep 27-29, 2016, Darmstadt, further information available at http://www.mse-congress.de.

FILTECH 2016: Oct 11-13, 2016, Cologne, further information available at http://www.filtech.de/

CellMat 2016: Dec 7-9, 2016, Dresden, further information available at http://cellmat.dgm.de/home.

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TU Bergakademie Freiberg, CRC “Multi-Functional Filters for Metal Melt Filtration - A Contribution towards Zero Defect Materials,“ Detlev Müller

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