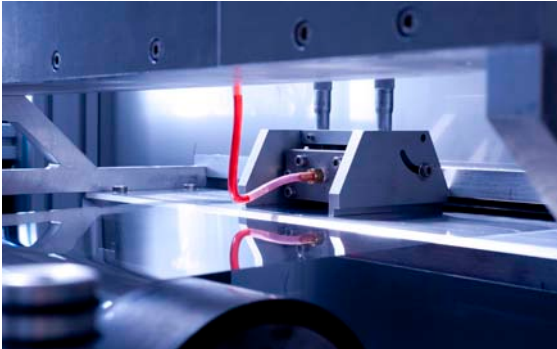


## Short Course Coating and Drying of Thin Films

With special contributions on "Printed Electronics" and "Battery Coatings"

Short course & workshop program in English language



Fundamentals and industrial applications with practical workshop in the TFT coating and printing lab

**May 19<sup>th</sup> - 22<sup>nd</sup>, 2014**

**KIT-Tagungszentrum (FTU), Seminarraum 157,  
Hermann-von-Helmholtz-Platz 1  
76344 Eggenstein-Leopoldshafen**

Organization: Prof. Dr.-Ing. Dr. h. c. Wilhelm Schabel  
Dr.-Ing. Philip Scharfer

Institute of Thermal Process Engineering  
Thin Film Technology

## 4 days short course program

29 contributions from 23 speakers (11 external)

### Schedule 19.05.2014 – Short course day 1

- 08:45** Registration and hand out of course material  
**09:15** Welcome & introduction  
**09:30** Coating & drying of thin films – introduction and motivation  
 Prof. Dr.-Ing. Dr. h. c. W. Schabel / Dr.-Ing. P. Scharfer  
**10:15** From theory to practice with pilot coating trials  
 Dipl.-Ing. Andrea Glawe (Kroenert)  
**11:15** Rheology of coating fluids  
 Prof. Dr. Norbert Willenbacher (KIT)  
**12:45** Lunch break  
**13:45** Preparation and characterization of coating solutions  
 Dipl.-Ing. Gilbert Gugler (Polytype)  
**15:00** Coffee break  
**15:30** Premetered coating methods I & II  
 Dr. Peter Schweizer (Polytype)  
**19:30** Social dinner

### Schedule 20.05.2014 – Short course day 2

- 08:30** Self-metered coating methods I & II  
 Prof. Dr. Hadj Benkreira (University of Bradford, UK)  
**10:15** Coffee break  
**10:45** Fluid flow in coating tools  
 Prof. Dr. Dr. h. c. mult. Franz Durst (FMP)  
**12:00** Lunch break  
**13:00** Applied science on curtain-coating  
 Dr.-Ing. Daniel Eggerath (Kroenert)  
**13:45** Drying of thin films I & II  
 Prof. Dr.-Ing. Dr. h. c. Wilhelm Schabel (KIT)  
**15:45** Coffee break  
**16:00** Sorption and phase equilibrium in polymer coatings  
 Dipl.-Ing. Anna-Lena Riegel (KIT)  
**16:20** Drying of polymer-particle composite films  
 Dipl.-Ing. Susanna Baesch (KIT)  
**16:40** Drying of multi-component polymer-solvent systems  
 Dipl.-Ing. David Siebel (KIT)  
**17:00** Selective drying  
 Prof. Dr.-Ing. Dr. h. c. mult. Ernst-Ulrich Schlünder (KIT)

### Schedule 21.05.2014 – Short course day 3

- 08:30** Simulation & design of industrial thin film dryer  
 Dr.-Ing. Philip Scharfer (KIT)  
**10:00** Comb-Nozzle Dryer® - a new concept for homogeneous impingement drying  
 Dipl.-Ing. Philipp Cavadini (KIT)  
**10:20** Coffee break  
**10:40** Fundamentals and processing of organic and printed electronics  
 Ir. Ike de Vries (Holst Centre)  
**11:55** Multilayer-coating of organic LEDs  
 Dipl.-Ing. Sebastian Raupp (KIT)  
**12:15** Lunch break  
**13:15** Introduction into smooth & gravure roller coating &  
 Dr.-Ing. Daniel Eggerath (Kroenert)  
**15:45**  
**14:15** Industrial coating perspectives and design of slot dies  
**16:45** Dipl.-Ing. Harald Döll (TSE)  
**13:15** Experimental workshop at the TFT coating and printing laboratory  
**15:45** - Characterization of material systems  
 - Pilot-scale coating trials  
 - Heat and mass transfer coefficients  
 - Experimental drying curves

### Schedule 22.05.2014 – Short course day 4

- 08:15** Drying and morphology formation of semiconducting thin films  
 Dipl.-Ing. Felix Buss (KIT)  
**08:45** Development and up-scaling of solution processed organic photovoltaic modules  
 Dr. Michael Niggemann (Eight19)  
**09:15** Coffee break  
**09:45** Industrial manufacturing of lithium-ion battery cells  
 Dr. André Mecklenburg (Evonik Litarion)  
**11:00** Coffee break  
**11:15** Coating of lithium-ion battery electrodes  
 Dipl.-Ing. Marcel Schmitt (KIT)  
**11:45** Drying of lithium-ion battery electrodes - Drying process in laboratory and fabrication  
 Dipl.-Ing. Stefan Jaiser (KIT)  
**12:15** Drying of lithium-ion battery electrodes - Process influence on electrode properties  
 Dipl.-Ing. Michael Baunach (KIT)

## Introduction

The short course "Coating and Drying of Thin Films" addresses engineers, scientists and technicians working in the areas of coatings, functional films, sensors, adhesives, paints, automotive coatings, patches, optical foils, tapes, diagnostics, membranes, printed electronics, fuel cells, battery coatings, who intend to get insight into fundamental and industrial aspects or to deepen their expertise.

Leading international scientists and experts from industry will report on topics of coating technologies, flow modeling, rheology, preparation of coating fluids and about fundamentals and industrial aspects of drying technology. Common problems will be discussed interactively, starting from basic process understanding up to the presentation of recent research results and new trends in industry and academia with special emphasis on "Printed Electronics" and "Battery Coatings".

Within the scope of the short course, coating processes and drying technology are explained by easily accessible examples, both in lectures as well as in a practical workshop in the "TFT Coating and Printing Lab" instructed by TFT staff (see photos below).



## Registration fees

	Early Bird (until 15.04.14)	later
General	€ 1450.–	€ 1550.–
GVT Members	€ 1400.–	€ 1500.–

## Payment and cancellation

According to §4 Nr. 22a UStG the registration fee is purchase tax free. The number of participants is limited. Registration fees include a short course folder with documentation of the course lectures and the practical workshop, coffee, refreshments, lunch and the "social dinner" on Monday evening. A certificate of participation is handed out individually.

## Venue

The short course takes place at the KIT-Tagungszentrum (FTU), Seminarraum 157, Hermann-von-Helmholtz-Platz 1 in 76344 Eggenstein-Leopoldshafen.

## Hotel recommendations

Hotel Kaiserhof, Hotel Novotel Karlsruhe City, City Partner Hotel Berliner Hof, Hotel Rio

## Further information

[www.tft.kit.edu](http://www.tft.kit.edu) – TFT Hochschulkurs

## Feedbacks about the last course in 2013 (German)

### Course:

- "Inhaltlich sehr interessant, offene wissenschaftliche Diskussionen, sehr gute persönliche Atmosphäre und Kontakte"
- "Sehr gut organisiert, exzellent ausgewählte Themen, sehr motivierte Referenten"
- "Sehr breites Spektrum, sehr tiefgehend"
- "Weiter so!"

### Workshop:

- "Sehr anschaulich und professionell"
- "Sehr gut für Vertiefung und Anschaulichkeit"
- "Sehr gut ergänzend zur Theorie und Möglichkeiten zu fragen"
- "Sehr interessant, dürfte noch weiter ausgebaut werden"

See more about previous years and comments on:



## Contact

Short course organization:

Dipl.-Ing. Anna-Lena Riegel: [anna-lena.riegel@kit.edu](mailto:anna-lena.riegel@kit.edu)

Phone: +49 721 608-48723

Registration:

Anna-Maria Hipp: [gvt-hochschulkurse@gvt.org](mailto:gvt-hochschulkurse@gvt.org)

Phone: +49 69 7564-118

Journey, hotels, etc.:

Office TFT: [margit.morvay@kit.edu](mailto:margit.morvay@kit.edu)





**Prof. Dr.-Ing. Dr. h. c. Wilhelm Schabel (KIT)** is the head of "Thin Film Technology" (TFT) at the Karlsruhe Institute of Technology (KIT) since 2009. He is an expert in thin film technologies for industrial coating and drying applications, in particular. In 2004 he received his PhD in the field of film drying. In addition to his academic work, he gained industrial experience in coating technology

as research and project engineer at LOFO High Tech Film GmbH (former Lonza films) near Basel (2007-2008). For his dissertation, he received the "Carl Freudenberg Prize" (2005). Furthermore, he is "Arnold Eucken Award" laureate of the VDI (2007). In 2008, he has been honored with the "L. E. Scriven Award" at the biennial meeting of the International Society of Coating Science and Technology (ISCST). He works as chairman in various national and international committees (ECS, ISCST) and holds the „Vice President Europe“ of the ISCST since 2012. He is author and co-author of numerous book chapters, essays and, among other things, guest editor of Chemical Engineering & Processing.



**Dr.-Ing. Philip Scharfer (KIT)** is head of the group "Thin Film Technology" (TFT) at the Karlsruhe Institute of Technology (KIT) together with Prof. Schabel. He received his PhD in process engineering from the University of Karlsruhe (TH) in 2009. In addition to his practical skills and his expertise as a consultant, Dr. Scharfer is an expert in the fields of drying and thermodynamics of thin

films. He deals with measuring methods for the investigation of polymer film drying and develops numerical simulation tools for industrial dryer applications. Since 2009, Dr. Scharfer is a member of the scientific committee of the European Coating Symposium (ECS), since 2012 member of the Board of Directors of the International Society of Coating Science and Technology (ISCST).



**Dr. Michael Niggemann (Eight19)** has more than 10 years of experience in the development, investigation and scale-up of organic solar cells and was previously heading the organic photovoltaics activity at the Fraunhofer Institute for Solar Energy Systems (ISE) in Freiburg, Germany. He holds a Doctorate in Natural Sciences from the Faculty of Applied Sciences at the Albert-

Ludwigs-University of Freiburg, Germany. In 2009 he was involved with the technology development of organic solar cells in the Optoelectronics Group of the Cavendish Laboratory at the University of Cambridge. Since 2010 he is CTO of Eight19 Ltd in Cambridge.



**Prof. Dr.-Ing. Dr. h. c. mult. Ernst-Ulrich Schlünder (KIT)** received his PhD from the Technical University of Darmstadt in 1962. Until 1966 he headed the department of heat and mass transfer at the Max Planck Institute for Flow Research in Göttingen. In 1967, a professorship (successor Prof. Kirschbaum) was offered to him at the University of Karlsruhe (TH) where he founded the first Institute of Thermal Process Engineering in Germany. His research in the field

of thermal separation processes, heat and mass transfer and drying technology have been honored with numerous awards. Prof. Schlünder wrote a large number of scientific articles and textbooks, including being editor in chief and founder of the journal Chemical Engineering & Processing. Under his chairmanship, the references VDI-Wärmeatlas and HEDH were minted over several decades. During his career, Prof. Schlünder taught as a visiting professor at IIT Madras, UC Berkeley, ENSIC Nancy, the University of Canterbury and the University of Cambridge. After his retirement, he taught at the University of Miami, and after his return to Germany he did further research at the MPI Magdeburg until 2008. Since 2009 he gives guest lectures on selected topics in mass transfer and selective drying within the KIT „Network of Excellent Retired Scientists“.



**Dr. Peter M. Schweizer (Polytype)** received his PhD in Mechanical Engineering from the Swiss Federal Institute of Technology in 1979, and he did post-doctoral research in coating flows at the University of Minnesota with Prof. Scriven from 1979 – 1980. From 1981 – 1986, Dr. Schweizer worked in the Coating Flow Research Group at Kodak in Rochester, New York. From 1987 – 1996, he worked at ILFORD in Fribourg, Switzerland, where he assumed responsibilities for Process Technology and Engineering. From 1997 – 2000, Dr. Schweizer was Managing Director of TSE Troller Schweizer Engineering in Switzerland. Since 2001, he works for Polytype Converting in Fribourg, Switzerland, a supplier of coating and drying processes and a manufacturer of coating machines, where he is responsible for process development. Dr. Schweizer is co-editor of the book entitled Liquid Film Coating, which appeared in 1997. In 2006, he received the John A. Tallmadge Award for Contributions to Coating Technology from the International Society for Coating Science and Technology.

From 1997 – 2000, Dr. Schweizer was Managing Director of TSE Troller Schweizer Engineering in Switzerland. Since 2001, he works for Polytype Converting in Fribourg, Switzerland, a supplier of coating and drying processes and a manufacturer of coating machines, where he is responsible for process development. Dr. Schweizer is co-editor of the book entitled Liquid Film Coating, which appeared in 1997. In 2006, he received the John A. Tallmadge Award for Contributions to Coating Technology from the International Society for Coating Science and Technology.



**Dr.-Ing. Daniel Eggerath (Kroenert)** studied Mechanical Engineering at TU Darmstadt. After that he started to work at FMP Technology GmbH in 2010 as a development engineer. In 2010 he became Head of the Coating Department. At the same time he did his PhD for 5 years in the field of slot die coating under the guidance of Prof. Dr. Dr. h.c. mult. Franz Durst at the University in Erlangen. He finished his PhD in 2012. Subsequently he started his work for Kroenert

GmbH & Co KG in 2012. He is now responsible for the Technology Center at Kroenert.



**Prof. Dr. Hadj Benkreira (University of Bradford)** received his B.Eng. and M.Sc. degrees (Chemical Engineering) from the University of Bradford (UK) in 1976 and 1977 respectively. He stayed on at Bradford and obtained his PhD in the Fluid Mechanics of Coating Flows in 1980 under the supervision of Professor WL Wilkinson (FRS). Following five years of EPSRC postdoctoral research, he joined the

academic staff of the University of Bradford in 1985 and was endowed a Personal Research Chair in 1998 for research in Thin Film Coating and in Polymer Processing. He has published widely on roll coating flows, including forward, reverse, deformable and gravure and in recent years in dynamic wetting. He is presently Associate Dean for Research & Knowledge Transfer at the School of Engineering, Design & Technology of the University of Bradford, one of the UK's leading research institutions in polymer engineering. Professor Benkreira is member of several learned societies and colleges including the UK EPSRC Peer Review College, the ISCST of which he was the Vice President in 2006-8 and the European Coating Group which he founded with colleagues in 1992 and which now organizes the biennial series of European Coating Symposia.



**Prof. Dr. Dr. h. c. mult. Franz Durst (FMP TECHNOLOGY GMBH)** studied Aeronautical Engineering at the Technical University of Stuttgart, Germany, and Process Engineering at the Imperial College of Science and Technology in London, England. He graduated from Imperial College at the London University and received his doctor's degree in 1972 (PhD). In 1972, he returned to Germany and

worked as subproject leader of various research projects at the Collaborative Research Center 80 at the University of Karlsruhe for ten years. Prof. Durst was offered a C3 professorship for Fluid Mechanics at the University of Karlsruhe in 1978 and was appointed chair of the Institute of Fluid Mechanics at the University of Erlangen-Nuremberg in 1982. He developed this institute into one of the most important institutes for fluid mechanics on a national and international level. During his active time at the University of Erlangen-Nuremberg he worked at several universities abroad. He has been awarded many prizes for his research work and, at present, is member of four academies, among them the Bavarian Academy of Sciences and the Royal Academy of Engineering. In 2006, Prof. Durst retired from the University of Erlangen-Nuremberg and founded the company FMP TECHNOLOGY GMBH, whose CEO and shareholder he has been to this day. This company is involved in coating and drying technologies.





**Dipl.-Ing. ETH Gilbert Gugler (Polytype)** received his diploma degree in material science engineering at the Swiss Federal Institute of Technology Zurich in 1992. From 1992 to 1998 he worked in the area of chemical and physical vapour deposition for space navigation applications. From 1998 on, he worked at Ilford Imaging Switzerland GmbH, a coating manufacturer and coating specialist for

high-end photo and inkjet papers. Since 2000, Mr. Gugler was responsible for the production technology department at Ilford. In 2014 he started his new challenge at Polytype Convertig AG as Senior Process Engineer for the new development group of Polytype named Coating and Fluid Technology. Here he is responsible for all coating and process topics of the group including new business development tasks. Besides his practical skills, Gilbert Gugler is an expert in multilayer curtain coating technology, starting from the preparation of coating fluids, characterisation of fluids, processing, to the multilayer curtain coating and drying.



**Dr. André Mecklenburg (Evonik Litarion)** graduated in Chemical Engineering at University of Technology in Clausthal in 1997, followed by doctoral degree in 2001 (design of components for direct methanol fuel cells). He started his career in the chemical industry at Evonik Industries (former Degussa AG) in 2000, working at different positions and chemsites within Evonik. From 2008 to 2013

he was head of process technology at Evonik Litarion GmbH (a 100 percent subsidiary of Evonik Industries) and responsible for the process chain of electrode and separator production for large format lithium ion cells at both sites Kamenz and Marl. Since 2013 Dr. Mecklenburg is responsible for the division operations focusing on production, plant maintenance and supply chain management at Evonik Litarion.



**Dipl.-Ing. H. Döll (TSE)** successfully graduated from the Technical University in Darmstadt in Mechanical Engineering in 1989. Hereafter he worked as project leader in the field of "web guiding systems" for a few years. By the end of 1997, Harald Doell changed to TSE Troller AG in Murgenthal, Switzerland. In the beginning, he was the head of the engineering team; since 2008, he is in charge of the entire application technology. Design of die internals, experiments with customers, start-ups and technical customer support are part of his assignment. Furthermore, he is giving talks at several short courses and international conferences in the US, in Europe and in Asia.



**Prof. Dr. Norbert Willenbacher (KIT)** is head of the Institute of Mechanical Process Engineering and Mechanics at University of Karlsruhe (TH) and Karlsruhe Institute of Technology (KIT) since 2004. He received his diploma degree in Physics and his PhD from the University of Mainz. After his dissertation at the Max-Planck-Institute for Polymer Research in Mainz he joined BASF SE, working there as a research associate in the fields of rheology of complex fluids and adhesion of soft polymers for 15 years. His current research interests are: rheology and microstructure of colloidal suspensions, emulsions & surfactant foams including new measuring techniques like optical microrheology, high frequency mechanical rheology and ultrasonic spectroscopy, stability and flow-induced aggregation of colloidal suspensions, rheological analysis and characterization of industrial high speed coating processes including extensional rheology of thickener solutions and related coating formulations, development and implementation of methods for in-line process control, rheological phenomena in microfluidic devices and processes, molecular principles of polymer adhesion. Prof. Willenbacher is president of the German Society of Rheology and assigned member of the ProcessNet Technical Committee on Rheology. He is section editor of Current Opinion in Colloid and Interface Science and member of the Editorial Board of Rheologica Acta.



**Ir. Ike de Vries (HOLST CENTRE)** studied Chemistry and Biology at the Wageningen University, Netherlands. After graduation in 1985 he was a researcher at the Wageningen University for three years. From 1988 to 2006 Ike de Vries was project leader and process/research engineer in the field of extrusion coating and substrate development for ink jet/photo-graphic paper at Fuji Photo Film. Since 2006, he is a research scientist at the Holst Centre Institute in Eindhoven, The Netherlands. He utilizes his experience to develop new Roll to Roll (R2R) processes which enable large scale production of organic light emitting diodes (OLEDs) and organic photovoltaic (OPV). He is a board member of the European Coating Symposium (ECS) and the International Society of Coating Science and Technology (ISCST).



**Dipl.-Ing. Andrea Glawe (Kroenert)** graduated in 1992 with the Master degree for "Technical textiles and process technology" at the Technical University of Chemnitz. She started her career as scientific assistant and project leader for the Textile Research Institute Plauen GmbH between 1992 and 1993 and for the Textile Research Institute Thüringen-Vogtland e.V. Greiz between 1993 and 2001. From 2001 to 2011 she worked as Deputy sales director with responsibility for technical sales and project management at Coatema Coating Machinery GmbH in Dormagen. Between 2011 and 2012 she took her responsibility as R&D leader DRYTEC GmbH & Co KG in Norderstedt. Since February 2012 Andrea Glawe is responsible as Director R&D for all R&D activities of the KROENERT group in Hamburg.

**A total of 23 speakers, including 11 external and following 9 PhD students of the research group Thin Film Technology at KIT:**



**Dipl.-Ing. Philipp Cavadini** graduated in Aerospace Engineering at the University of Stuttgart. In his PhD, he deals with surface tension driven convection and the optimization of impinging jet systems from the viewpoint of homogeneity of the distribution of the heat and mass transfer coefficient. Mr. Cavadini will complete his doctorate in winter 2014.



**Dipl.-Ing. Michael Baunach** completed his studies in Chemical Process Engineering at the Karlsruhe Institute of Technology in 2010. In his work at the KIT/TFT he investigates the correlation between drying conditions and electrode properties. A special focus is on formation of component distributions during electrode drying. Mr. Baunach is expected to finish his PhD in 2015.



**Dipl.-Ing. Felix Buss** studied Chemical Engineering at the Karlsruhe Institute of Technology (KIT). He conducted his diploma thesis in the area of particle film drying at the University of Minnesota. Since 2011 he works as a research assistant at KIT/TFT. In his PhD he focuses on drying phenomena in nanoscale polymer films and their impact on the properties of organic solar cells. Mr. Buss is expected to finish his PhD in summer 2015.



**Dipl.-Ing. Marcel Schmitt** received his degree in process engineering at the Karlsruhe Institute of Technology in 2010, majoring in Thermal Process and Plant Engineering. Since 2011 he is working at the KIT/TFT as a research assistant. His research topic is slot die coating of functional thin films with focus on process windows, edge effects and intermittent coating methods. Mr. Schmitt is expected to finish his PhD in summer 2015.



D. Siebel (since 2011)



S. Baesch (since 2011)



S. Jaiser (since 2011)



A.-L. Riegel (since 2013)



S. Raupp (since 2013)