Fraunhofer
FEP

FRAUNHOFER INSTITUTE FOR ELECTRON BEAM AND PLASMA TECHNOLOGY FEP

## SPECIAL SEMINAR

# FUNCTIONAL COATINGS FOR OPTICS, SENSORS AND ELECTRONICS

VTE
ВАКУУМТЕХЭКСПО

VacuumTechExpo

APRIL 16TH, 2013
SOKOLNIKI ECC | MOSCOW, RUSSIA

# PROGRAM

## TUESDAY, APRIL 16TH

| | |
|---|---|
| 10:00 – 10:10 | **Opening**<br>**W. SCHÖNBERGER**<br>*Fraunhofer-Institut für Elektronenstrahl- und Plasmatechnik FEP* |
| | **SESSION 1 I OPTICS** |
| 10:10 – 10:30 | **Прецизионные покрытия в промышленном масштабе: требования, реализация, применения**<br>**W. SCHÖNBERGER, P. FRACH, H. BARTZSCH, D. GLÖß**<br>*Fraunhofer-Institut für Elektronenstrahl- und Plasmatechnik FEP* |
| 10:30 – 11:00 | **Вакуумная Оптика – Ultra High Vacuum (UHV) подходящие оптические компоненты**<br>**S. JANKE, T. RIETMANN, M. FLÄMMICH , U. BERGNER**<br>*VACOM Vakuum Komponenten & Messtechnik GmbH* |
| 11:00 – 11:30 | **COFFEE BREAK** |
| 11:30 – 12:00 | **Вакуумная установка для нанесения прецизионных оптических плёнок**<br>**M. RUDIN**<br>*FHR Anlagenbau GmbH* |
| 12:00 – 12:40 | **Ultrashort thermal annealing in the (sub)millisecond range: modification/crystallization of layers on heat sensitive substrates (e.g. PET foil)**<br>**T. GEBEL[1], J. WEBER[1], H. LIEPACK[1], M. NEUBERT[2], R. ENDLER[2], W. SKORUPA[2]**<br>*[1] DTF Technology GmbH*<br>*[2] Helmholtz-Zentrum Dresden-Rossendorf HZDR* |
| 12:40 – 13:20 | **LUNCH** |
| 13:20 – 14:00 | **Industrial Magnetron Sputtering on Glass and Polymer Webs – Coatings for Windows and Display Applications**<br>**J. STRÜMPFEL**<br>*VON ARDENNE Anlagentechnik GmbH* |

# PROGRAM

| TUESDAY, APRIL 16TH | |
|---|---|
| | **SESSION 2 I SENSOR TECHNOLOGY** |
| 14:00 – 14:40 | **Roll-to-Roll Coating Products with High Productivity for Packaging and Electronic Applications**<br>D. LUKAS<br>*Applied Materials GmbH & Co. KG* |
| 14:40 – 15:20 | **High Frequency Ultrasonic Sensors based on reactive sputtered Aluminum Nitride Thin Films**<br>H. HEUER[1], T. HERZOG[1], S. WALTER[1], D. GLÖSS[2], H. BARTZSCH[2]<br>*[1] Fraunhofer-Institut für Zerstörungsfreie Prüfverfahren Institutsteil Dresden (IZFP-D)*<br>*[2] Fraunhofer-Institut für Elektronenstrahl- und Plasmatechnik FEP* |
| 15:20 – 15:50 | **Сенсоры давления для применения в областях высоких температур и давлений, основанные на новых принципах сенсорики**<br>W. BRODE, R. KOPPERT, D. HIRSCH<br>*Siegert TFT GmbH* |
| 15:50 – 16:10 | **COFFEE BREAK** |
| 16:10 – 16:50 | **Various PVD-Coatings for sensor technology applications**<br>T. MÜLLER<br>*Creavac Creative Vakuumbeschichtung GmbH* |
| 16:50 – 17:30 | **Нанесение функциональных слоёв на поверхность полимерных плёнок**<br>M. FAHLAND<br>*Fraunhofer-Institut für Elektronenstrahl- und Plasmatechnik FEP* |
| | **END** |

# ABSTRACTS

## Прецизионные покрытия в промышленном масштабе: требования, реализация, применения

**W. SCHÖNBERGER, P. FRACH, H. BARTZSCH, D. GLÖß**
*Fraunhofer FEP | Winterbergstraße 28 | 01277 Dresden, Germany*

В статье представлен краткий обзор о технологии изготовления прецизионных покрытий в промышленном масштабе, а также даны примеры их применения. В качестве примера технологии производства описано реактивное магнетронное распыление. Возможная реализация изготовления прецизионных покрытий в промышленном масштабе продемонстрирована с помощью конструктивного комплекса, производимого в Институте Фраунхофер электронно-лучевых и плазменных технологий (FEP).

The paper gives a short review about the requirements and manufacturing technology of precision coatings in industrial scale. Some application examples of precision coatings are shown. The technology description is focused on the reactive sputtering. The technological key components developed by Fraunhofer FEP are combined with process know-how into integrated packages to allow the realization of new processes. Examples for these integrated packages are shown in the presentation.

# ABSTRACTS

## Вакуумная Оптика – Ultra High Vacuum (UHV) подходящие оптические компоненты

**S. JANKE, T. RIETMANN, M. FLÄMMICH , U. BERGNER**
*VACOM Vakuum Komponenten & Messtechnik GmbH | Gabelsberger Str. 9 | 07749 Jena, Germany*

Основная проблема вакуумной оптики состоит в том, чтобы сбалансировать различные требования, предъявляемые к подобным продуктам двумя направлениями - отраслевой оптикой и вакуумными технологиями. Для решения этой проблемы требуется не только установление точных параметров производственного процесса, но и внимательный выбор исходных материалов, соответствующих требованиям двух областей - ультравысокого вакуума (UHV) и точной оптики. Поскольку вид соединения компонентов должен гарантировать совместимость с UHV, необходимо определение, развитие, оптимизация и применение специфических технологий. В конечном счете все технические параметры продукта должны быть оптимированы применительно к требованиям пользователя, которые он ставит к вакууму и к оптике.

Презентация сосредоточится на темах, важных для создания герметичных соединений между оптическими элементами и вакуумными компонентами. Практическое применение выбранных критических факторов будет показано на нескольких примерах. Будут отмечены примеры влияния полученных результатов на системные параметры и указаны возможные проблемы, возникающие в процессе создания элементов вакуумной оптики. Кроме того, будет представлен краткий обзор продуктов, демонстрирующих успешную комбинацию оптики и вакуума.

# ABSTRACTS

## Вакуумная установка для нанесения прецизионных оптических плёнок

**M. RUDIN**
*FHR Anlagenbau GmbH | Am Hügel 2 | 01458 Ottendorf-Okrilla, Germany*

Промышленная установка FHR.STAR500 разработана специально для нанесения удовлет-воряющих высшим требованиям по качеству и равномерности прецезионных одно- и многослойных покрытий.

В качестве источников используются магнетроны постоянного тока и импульсные (ВЧ) магнетроны. В установке могут обрабатываться детали диаметром до 200 мм и весом до 2 кг. Вследствии применения направления напыления „снизу-вверх“ покрытия имеют минимальное количество загрязнения. При напылении детали могут быть нагреты до 300°C.

# ABSTRACTS

## Ultrashort thermal annealing in the (sub)millisecond range: modification/crystallization of layers on heat sensitive substrates (e.g. PET foil)

**T. GEBEL[1], J. WEBER[1], H. LIEPACK[1], M. NEUBERT[2], R. ENDLER[2], W. SKORUPA[2]**
*[1] DTF Technology GmbH | Am Promigberg 16 | 01108 Dresden, Germany*
*[2] Helmholtz-Zentrum Dresden-Rossendorf HZDR | Bautzner Landstraße 400 | 01328 Dresden, Germany*

Future applications in electronics, optics and photovoltaics are more and more influenced by systems based on flexible substrates. This causes a strong demand for new low temperature deposition technologies of semiconductor or metallic materials on these flexible substrates (e.g. PET, polymer foils or paper). However, the optical and electrical properties of such layers deposited at low temperatures need to be improved by subsequent annealing. Such annealing steps are typically limited in temperature (<200°C) by the substrate properties, which implies relative long annealing times – which is in contradiction to the intended use of fast in-line or roll-to-roll processing. This is the driving force to establish new annealing technologies for surface modification, in order to integrate these steps into high-speed / high throughput fabrication equipment.

Flash lamp annealing (FLA) on a (sub)millisecond scale allows the annealing of just near surface layers at high temperatures (>500°C) without damaging deeper layers or the bulk material. Results of optical and electrical parameters after FLA treatment of different layers and semiconductor materials are presented in the talk. The influences of flash duration, energy density and multi-flash operation are discussed. Additionally, issues concerning the use of FLA treatment for high-throughput applications are addressed.

# ABSTRACTS

## Industrial Magnetron Sputtering on Glass and Polymer Webs – Coatings for Windows and Display Applications

**J. STRÜMPFEL**
*VON ARDENNE Anlagentechnik GmbH | Plattleite 19/29 | 01324 Dresden, Germany*

Vacuum coatings provided by Magnetron sputtering are essentially used in both Architectural and Solar technologies. Relevant photovoltaic applications like crystalline silicon wafers and particularly thin film solar modules on glass are implementing large area deposition processes. Therefore Magnetron Sputtering of different materials is widely used to efficiently provide high performance single layers or layer stacks. Coatings are sputtered to achieve dedicated specifications for barrier films made by oxides or nitrides on glass, for transparent conductive oxides (TCO) as front contact and for metallic contact films for back side metallization. Due to the recent PV market development, the most important objective for manufacturers of solar modules is to establish technical solutions which allow sustainable cost reduction and module efficiency improvement. Today, industrial vacuum coaters implement several highly productive processes like pump down, transportation and heating-up recipes of different substrate formats and sputter deposition. The absorber layer of silicon based thin-film solar cell on glass must always be deposited onto a TCO coated glass substrate. Still most of the manufacturers for solar modules are currently using standard $SnO_2$:F coated glass. Instead, the industrial application of sputter technologies producing transparent conductive oxide layers on glass, so called TCO glass, is a promising alternative offering possibilities for the solar cell manufacturers for both cost reduction and cell efficiency improvements. Using such sputtered and tailored ZnO:Al type TCO films, advanced efficiencies of > 11% were achieved in laboratory scale. The sputter deposition processes at 350°C temperature has to be optimized regarding high optical transmittance, carrier mobility and low resistivity. Reliable and industrially approved ZnO:Al ceramic tube targets for rotatable magnetrons have been developed. Using RDM type dual rotatable magnetrons operated in DC/DC mode, superior film properties versus former planar cathodes have been achieved. Due to the very high power density applied with tube targets, deposition rates beyond 200 nm m/min per tube have been obtained. Other features for cost reduction are high target utilization of > 85%, low maintenance efforts and reduced flaking. The specific light absorbing properties of amorphous silicon (a-Si) and micro crystalline silicon (µc-Si) require a tailored surface structure of the TCO to optimize the energy yield of the solar cell. This can be achieved by a subsequent wet chemical etching process of the naturally smooth sputtered TCO surface. To characterize these light scattering properties, the haze of the TCO glass is measured. Optimized optical, electrical and surface properties of the TCO layer throughout the entire wavelength range is a prerequisite for best cell efficiency of all types of thin-film silicon solar cells. Such Results will be displayed briefly.

# ABSTRACTS

## Roll-to-Roll Coating Products with High Productivity for Packaging and Electronic Applications

**D. LUKAS**
*Applied Materials GmbH & Co. KG | Siemensstraße 100 | 63755 Alzenau, Germany*

Going flexible is a major trend for a variety of applications: from commodity markets like food packaging with moderate gas permeation barrier requirements, through high-barrier applications, e.g. for electrophoretic displays or flexible PV, up to electronic applications like touch panels of even flexible displays. Applied Materials offers a roll-to-roll product portfolio to address the different requirements of these markets.

For packaging applications, where the focus is on high productivity and therefore low cost of ownership, our product is the TopMet that is mainly used for metallizing various film substrates by a thermal evaporation process. The end market for transparent flexible barrier films is larger than for metallized films and currently is dominated by polymeric barrier layers. Some of these coatings are under scrutiny and discussion since they contain chemicals like chlorine, which are not considered to be environmentally friendly. An alternative for thick polymeric coatings can be a vacuum coating process (TopMet CLEAR) with a coating thickness several orders of magnitude thinner and in the range of only ~ 10 nanometers achieving the same or better barrier properties compared with polymeric coatings. Another advantage of vacuum based processes, the source materials for the barrier layers are usually natural occurring oxides like $SiO_X$ or $AlO_X$. By coating on substrates like PLA, fully biodegradable barrier films can be produced. The key features of this high-productivity platform and the barrier performance of various coated substrates will be described at the workshop.

Roll-to-Roll production of thin-film based electronic devices (e.g. solar cells, active matrix TFT backplanes & touch screens) combine the advantages of the use of inexpensive, lightweight & flexible substrates with high throughput production. Significant cost reduction opportunities can also be found in terms of processing tool capital cost, utilized substrate area and process gas flow when compared with batch processing systems. Nevertheless, material handling, device patterning and yield issues have limited widespread utilization of roll-to-roll manufacturing within the electronics industry. Applied Materials has developed a variety of different web handling & coating technologies/platforms to enable high-volume roll-to-roll manufacturing of flexible thin film silicon TFT backplanes and touch screen devices (SmartWeb). The work presented at the workshop therefore describes the results of TFT backplane manufacture and also highlights recent advances in film based touch panels.

# ABSTRACTS

## High Frequency Ultrasonic Sensors based on reactive sputtered Aluminum Nitride Thin Films

**H. HEUER**[1], **T. HERZOG**[1], **S. WALTER**[1], **D. GLÖß**[2], **H. BARTZSCH**[2]
[1] *Fraunhofer IZFP Dresden | Maria-Reiche-Strasse 2 | 01109 Dresden, Germany*
[2] *Fraunhofer FEP | Winterbergstraße 28 | 01277 Dresden, Germany*

Many new materials and processes require non-destructive evaluation with high resolutions. Ultrasonic methods in a frequency range up to 250 MHz are one of the most frequently used non-destructive evaluation techniques because of their versatility. The efficiency of ultrasonic sensor systems can be enhanced by a combination of acoustic microscopy and phased array ultrasonic techniques.

Aluminium nitride is a promising material for the use as a piezoelectric sensor material in the considered frequency range, which contains the potential for high frequency phased array application in the future.

Investigations were carried out on the usability of aluminum nitride thin films for the manufacturing of ultrasound transducers by the use of sensor test structures. Some design considerations were performed for different sensor designs, electrode size variations and substrate materials in this work. It could be shown that the electrode size can be smaller than 1 mm square for use as high frequency sensors. Different substrate materials are principle usable, like e.g. silicon, aluminum oxide or quartz. Additional tests showed that these sensors can also be used for high temperature application up to 200°C. The reason is the very good temperature resistance of the AlN thin films.

# ABSTRACTS

## Сенсоры давления для применения в областях высоких температур и давлений, основанные на новых принципах сенсорики

**W. BRODE, R. KOPPERT, D. HIRSCH**
*SIEGERT TFT GmbH | Robert-Friese-Str. 3 | 07629 Hermsdorf, Germany*

Несмотря на высокий уровень развития современной техники, требования к дизельным двигателям и гидравлическим системам повышается с каждым годом. Такие требования выдвигаются не только к двигателям легковых автомобилей, но и к средне- и многолитражным двигательным агрегатам энергоустановок, агрегатам горнодобывающей, строительной, железндорожной и кораблестроительной отраслей. Перспективными направлениями развития техники измерения давлений являются увеличение диапазона измеряемых давлений до 14000 и 25000 бар, равно как и повышение предела рабочих температур до 450°C. Таким образом, создание техники измерения давления делает необходимым пересмотрение действительных и поиск новых конструктивных решений всех гидравлических компонентов, в том числе и сенсоров в цепях контроля и управления. Фирма SIEGERT TFT GmbH - это инновационное предприятие с двадцатилетней историей и многолетним опытом в области тонких плёнок, прецизионных сопротивлений и сенсорики. Предприятие расположенно в Германии (земля Тюрингия) и насчитывает порядка 90 сотрудников. Основными сферами деятельности предприятия являются разработка и производство высокоточных сенсоров давления, сенсоров измерения силы, ускорения и температуры, а также широкий спектр прецизионных сопротивлений и сборок на основе тонкоплёночных технологий. Разработки сенсоров давления для применния в области высоких давлений и температур велись совместно с прозводителем гидравлических систем, сенсорной техники и одним из крупнейших автопромышленников. Результатами разработки в данных направлениях являются:

- разработка технологии производства и применения сенсорных материалов Ni:a-C:H с пьезорезистивными свойствами и повышенной чувствительностью к малым деформациям, пригодных к производству сенсоров давления с диапазоном рабочих давлений 14000 бар серийно и 25000 бар экспериментально
- разработка новых методов реактивного плазменного напыления для создания изоляционно-барьерных тонкоплёночных систем на основе $Al_2O_3$ / $SiO_2$ / $Si_3Ni_4$ с рабочим диапазоном температур до 600°C
- разработка метода реактивного плазменного напыления с плазменным дотированием атомами алюминия и создания системы резистивных тонких плёнок CrNi-O,N+Al с диапазоном рабочих температур до 450°C.

Готовые сенсоры прошли практические испытания в условиях предприятий-партнёров в масштабах тестовых серий и зарекомендовали себя, как перспективные для дальнейшего развития сенсорики давления в области высоких температур и давлений.

# ABSTRACTS

## Various PVD-Coatings for sensor technology applications

**T. MÜLLER**
*CREAVAC – Creative Vakuumbeschichtung GmbH | Löbtauer Straße 65-71 | 01159 Dresden, Germany*

PVD-coatings are daily used techniques in optical, electronical or sensory applications. There is a wide variety both in layer techniques as well as in application equipment. Creavac is working in both areas.

For coating processes are used e.g. thermal evaporators, E-beam, sputtering and pulsed laser deposition.

A very common application is in the field of EMI- shielding. The combination of such a coating with solder, magnetic or other properties is often required. The effectiveness of the shielding also depends on the layer thickness.

Solder layers are also used for piezo-electrical applications. Gold, silver and tin layers are common materials in such systems.

Another needed function is a defined reflection grade. Especially in sensor technologies is a wide area of application of these systems. Different layer systems are in use and will be lined out.

For optical sensors also colour effects are in use. Different activators like electrical, thermal or other stimuli are possible.

# ABSTRACTS

## Нанесение функциональных слоёв на поверхность полимерных плёнок

**M. FAHLAND**
*Fraunhofer FEP | Winterbergstraße 28 | 01277 Dresden, Germany*

Доклад даёт краткий обзор разных возможностей технологических решений в институте Фраунхофера FEP. Особенное внимание уделяется нанесению тонких плёнок на поверхности больших размеров. В институте существуют несколько машин с размерами близкими к серийному производству. Одними из самих больших машин являются установки рулонного типа. Ширина нанесения этих машин составляет до 600 мм. Это оборудование используется для нанесения прозрачных проводящих плёнок а также барьерных слоёв для предотвращения пропускания кислорода и водяного пара. Оба типа слоёв применяются в производстве оптоелектронных приборов. В докладе показаны примеры качества наносимых плёнок и работоспособнотъ технологии нанесения.

The contribution will provide an overview of different possibilities of technological development at Fraunhofer FEP. Special emphasis is put on large area deposition processes. Various large scale pilot production machines are available for experimental work, among them roll-to-roll vacuum coating machines with a deposition width up to 600. The equipment is mainly used for projects on transparent conductive coatings and moisture barrier layers. Both types have various applications in optoelectronics. The contribution will provide examples for both the capabilities of the coating technology and for the performance of the deposited layers.

# PARTICIPANTS

APPLIED MATERIALS®

Applied Materials provides manufacturing equipment, services and software to the global semiconductor, flat panel display, solar photovoltaic (PV) and related industries. Applied Materials is the world's largest semiconductor fabrication equipment supplier, with the capability to provide global deployment and support services. Applied also is the leading supplier of LCD fabrication equipment to the flat panel display industry, and the leading supplier of solar PV manufacturing systems to the solar industry.

**Contact:**
Applied Materials GmbH & Co. KG

Siemensstraße 100
63755 Alzenau, Germany

Phone +49 6023 92 6000
Fax +49 6023 92 6200

info@www.appliedmaterials.com
www.appliedmaterials.com

creavac

CREAVAC working on coating of plastic parts and offers vacuum coating equipment.
Surface finishing of plastic parts includes lacquering and PVD coating for decoratives, IR-reflection, EMI shieldings etc. In addition, CREAVAC provides further technologies, such as laser engraving, Tampon printing, testing operations or others.
In the area of coating equipment, CREAVAC is focused on technologically oriented specialised solutions including development. Besides these we offer vacuum components e.g. angle valves or port view glasses.

**Contact:**
CREAVAC –
Creative Vakuumbeschichtung GmbH

Löbtauer Straße 65-71
01159 Dresden, Germany

Phone +49 351 21838 0
Fax +49 351 21838 19

info@creavac.de
www.creavac.de

# PARTICIPANTS

DRESDEN THIN FILM DTF TECHNOLOGY

DTF Technology develops processes and equipment for thin film deposition and vacuum technologies. This includes tools for R&D and industrial environments, e.g. cluster tools, in-line systems or roll-coaters.
The following technologies are addressed:

- PVD (sputtering, evaporation, PECVD), ALD, CVD
- Ultra-short time annealing (Flash Lamp Annealing (FLA)) for the thermal treatment / modification of surface layers on temperature sensitive substrates (glass, PET foil, plastics)
- Plasma Immersion Ion Implantation (PIII) for advanced deposition and for doping processes

**Contact:**
DTF Technology GmbH

Am Promigberg 16
01108 Dresden, Germany

Phone +49 351 320 29 200
Fax +49 351 320 29 210

info@dtf-technology.de
www.dtf-technology.de

Fraunhofer FEP

Fraunhofer FEP is an institute of Europe's largest application-oriented research organization, the Fraunhofer-Gesellschaft. For more than 20 years we gathered expertise in vacuum coating technologies, electron beam surface modification processes and electron beam source development.

Vacuum roll-to-roll technologies, plasma activated high-rate deposition, pulse magnetron sputtering, high-rate plasma enhanced CVD and the development and application of electron beam sources are our specialities.

**Contact:**
Fraunhofer Institute for Electron Beam and Plasma Technology FEP

Winterbergstraße 28
01277 Dresden, Germany

Phone +49 351 2586 0
Fax +49 351 2586 105

info@fep.fraunhofer.de
www.fep.fraunhofer.de

# PARTICIPANTS

## Fraunhofer IZFP

The Fraunhofer Institute for Nondestructive Testing IZFP, located in Saarbrücken and Dresden, develops solutions for nondestructive testing (NDT). Industrial customers get help wherever quality and reliability of their products and services should be improved. In the public area the institute contributes to the topics health, energy and environment. The Dresden branch of IZFP is especially focussed to applied microelectronics and nanotechnology. Quality assurance in light weight engineering, the development of testing electronics for various application fields and high-resolution nanoanalysis are some of the main fields of activity at IZFP Dresden.

**Contact:**
Fraunhofer Institute for Nondestructive Testing IZFP, Dresden branch

Maria-Reiche-Strasse 2
01109 Dresden, Germany

Phone +49 351 888 15 501
Fax +49 351 888 15 509

info@izfp-d.fraunhofer.de
www.izfp-d.fraunhofer.de

## FHR centrotherm photovoltaics group

FHR Anlagenbau GmbH, which is based at Ottendorf-Okrilla, Germany, specializes in the development of innovative thin film technologies, sputtering and evaporation systems, as well as services in the thin film area. The FHR product portfolio comprises vacuum process systems (PVD, PECVD, ALD, RIE) and sputtering targets for applications in the fields of nanotechnologies, MEMS, electronics, displays, optics and photovoltaics. FHR offers technology and equipment for the production of CIGS solar cells and solar thermal power plants. The product range focuses strategically on foil coating systems for the production of flexible solar cells, organic solar cells, and OLED displays. Together with industrial partners and research institutions, FHR has attained a globally leading technology and market position.

**Contact:**
FHR Anlagenbau GmbH

Am Hügel 2
01458 Ottendorf-Okrilla, Germany

Phone +49 35205 520 0
Fax +49 35205 520 40

postbox@fhr.de
www.fhr.de

# PARTICIPANTS

SIEGERT THINFILM TECHNOLOGY

Фирма SIEGERT TFT GmbH - это инно-вационное предприятие с двадцатилетней историей и многолетним опытом в области технологий тонких плёнок, и вакуумных напылений. Предприятие расположенно в Германии (федеральная земля Тюрингия) и насчитывает порядка 80 сотрудников. 13 из них составляют отдел исследовний и разработок и занимаются совершенствованием технологий производства, равно как и разработками новых технологических решений для реализации задач, поставленных производством и предприятиями-партнёрами. Основными сферами деятельности предприятия являются разработка и производство высокоточных сенсоров давления, силы, ускорения и температуры, а также широкий спектр прецизионных сопротивлений и сборок на основе тонкоплёночных технологий.

**Contact:**
SIEGERT Thinfilm Technology GmbH

Robert-Friese-Straße 3
07629 Hermsdorf, Germany

Phone +49 36601 858 0
Fax +49 36601 858 11

info@siegert-tft.de
www.siegert-tft.de

10$^{-n}$ mbar VACOM®

VACOM is one of the market leaders for vacuum technology and is globally active. Its leading brand Precision & Purity stands VACOM for the highest in demands in UHV, XHV and UCV.

Vacuum mechanics, vacuum metrology and vacuum optics form the core business. VACOM is specialized in innovative technologies for special demands for ultra clean and particle-free processing. VACOM is partner in high-tech industries such as analytics, EUV technology, optics or accelerators for science and medical applications, and in research.

**Contact:**
VACOM Vakuum Komponenten & Messtechnik GmbH

Gabelsbergerstraße 9
07749 Jena, Germany

Phone +49 3641 4275 0
Fax +49 3641 4275 55

info@vacom.de
www.vacom.de

## PARTICIPANTS

# VON ARDENNE

VON ARDENNE is a worldwide leading manufacturer of equipment for industrial vacuum processes of plasma and electron beam technologies. We develop and manufacture systems for the micro- and nanometer-thin coating of glass, metal strip or web. Our customers use them to manufacture for instance architectural glass, solar modules, solar absorbers and reflectors. All coating processes performed with VON ARDENNE equipment have one thing in common: The finished products save or produce energy.

**Contact:**
VON ARDENNE Anlagentechnik GmbH

Plattleite 19/29
01324 Dresden, Germany

Phone +49 351 26 37 300
Fax +49 351 26 37 308

office@vonardenne.biz
www.vonardenne.biz

# LOCATION

The Sokolniki Exhibition and Convention Centre is located in the like-named park, just a 5 minute walk from Sokolniki subway. The way from the park entrance to pavilions of the Sokolniki Exhibition and Convention Centre takes about 15 minutes, during which you can actually enjoy the beautiful views of the park.
Entrance to park is free.

**Free Shuttle**
Use a free shuttle during any exhibition period. The bus runs from Sokolniki subway to the Sokolniki Exhibition and Convention Centre. Follow the arrows at subway and in front of exhibition pavilions 2 and 4.

**By Car**
If you're driving a car, follow the 3rd Luchevoy prosek to get inside the park. Entry fee is 100 rubles. The car can be parked in designated parking lots.

**Address**
Sokolniki Exhibition and Convention Centre
7/1
5-iy Luchevoy prosek
Building 1, Pavillion 2
Moscow 107014
Russia

# ORGANIZER

The special seminar »Functional coatings for optics, sensors and electronics« is organized by the Fraunhofer Institute for Electron Beam and Plasma Technology FEP in Dresden, Germany.

Get more information about optics, sensor technology and electronics:

www.fep.fraunhofer.de

WWW.FEP.FRAUNHOFER.DE