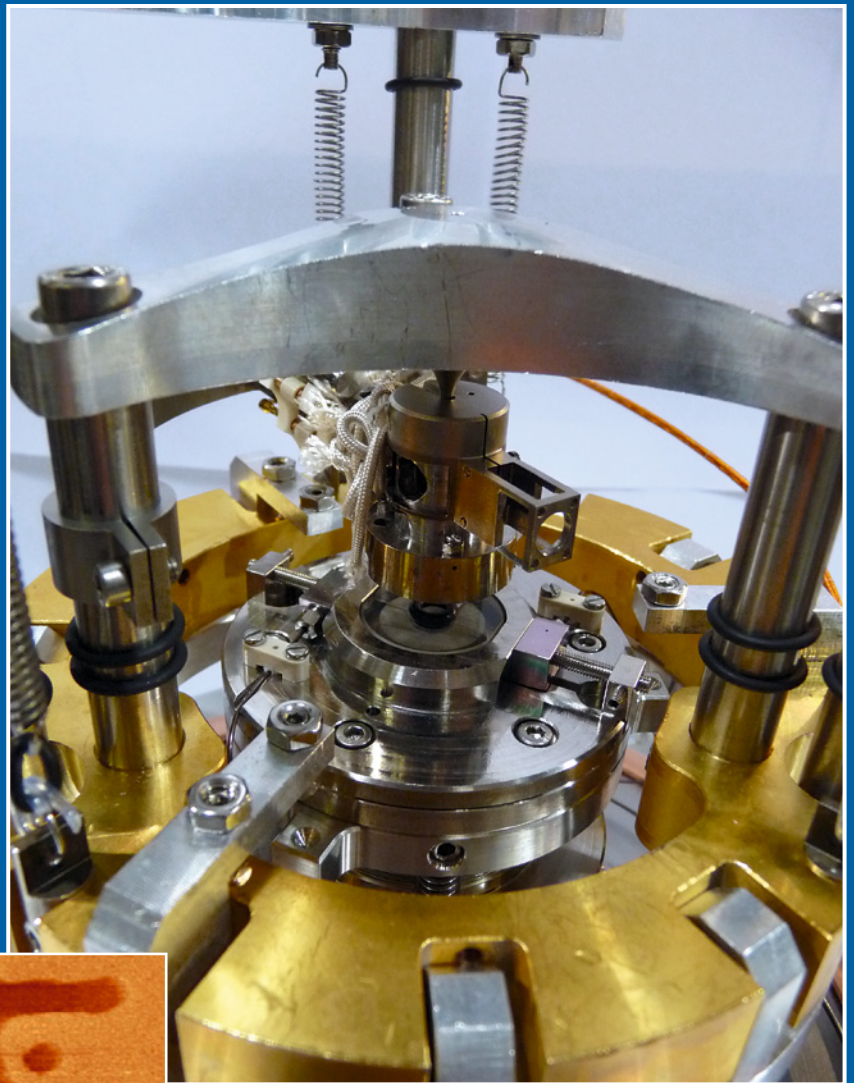


# NEVAC

*blad*

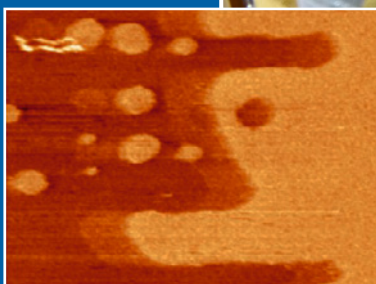
JAARGANG 49 / UITGAVE 1

## NEVACdag 2011 Universiteit Twente



**Verder in de uitgave:**

- Notulen van de Algemene Ledenvergadering 2010
- Abstracts NEVACdag
- Switching Casimir forces using the amorphous to crystalline phase transformation in phase change materials



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Eerste helft april  
Tweede helft juni  
Tweede helft september  
Eerste helft december

### Diversen

Kopij inzenden naar het redactiesecretariaat. Lidmaatschap opgeven bij de ledenadministratie. Abonnementen opgeven bij abonnementenadministratie.

### Vergoeding kopij

Artikelen in het Nederlands van welke aard dan ook over vacuümtechniek en haar toepassingen worden door de redactie zeer op prijs gesteld. In bepaalde gevallen kan voor artikelen zonder commerciële achtergronden een vergoeding van € 20,- per pagina tekst worden gegeven. Voor studenten is er een kopij vergoeding van € 100,- per artikel.

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## Op de voorpagina

De NEVACdag 2011 vindt op 26 april plaats met als locatie de Universiteit Van Twente.

De grote figuur is een close-up foto van een STM/AFM scanner en reactor voor onderzoek aan katalyse. Voor onderzoek naar katalysereacties zijn in Leiden bijzondere versies ontwikkeld van een Scanning Tunneling Microscope (STM) en Atomaire Kracht Microscopie (AFM). Met deze systemen kan het oppervlak van modelkatalysatoren bekeken worden tijdens chemische reacties.

## Verenigingsgegevens

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### Contributies

Contributie € 20,- per jaar  
Bedrijfsleden € 150,- per jaar  
Studenten/promovendi € 5,- per jaar

## Inhoud

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## Redactioneel

Dit eerste nummer van 2011 heeft als hoofd-focus de NEVAC-dag 2011 die zal plaatsvinden in Enschede (Universiteit van Twente) en bevat o.a. het programma en de abstracts. De NEVAC-dag belooft dit jaar weer een interessante bijeenkomst te worden. Een grote variëteit aan voordrachten illustreert hoe breed vacuüm in allerlei natuurkundige, chemische, materiaalkundige en technologische vraagstukken in onze maatschappij een dominante rol speelt.

De bijeenkomst vindt dit jaar plaats op 26 April, Universiteit van Twente (locatie: de Waaier / <http://ssp.tnw.ut-twente.nl/english/nevac/index.html>).

Organisatie van NEVAC-Dag 2011:  
Harold Zandvliet / Physics of Interfaces and Nanomaterials (UT) Guus Rijnders / Inorganic Materials Science (UT)



## NEVAC prijs

**Oproep aan alle studenten en promovendi:**

Deel je onderzoek op het gebied van vacuümtechniek en

# WIN €1000,-

Stuur voor 15 januari 2012 een duidelijk en helder artikel voor een breed fysisch en chemisch publiek over jou onderzoek naar het NEVAC blad

Kijk voor meer informatie op de website van het NEVAC:

[www.nevac.nl](http://www.nevac.nl)

Het artikel kan per email worden verzonden aan: Prof. dr. P.M. Koenraad  
e-mail: [p.m.koenraad@tue.nl](mailto:p.m.koenraad@tue.nl)

De sluitingsdatum van kopij voor het tweede nummer van het NEVAC-blad 2011 is 9 mei 2011.

# Notulen van de Algemene Ledenvergadering

Aanwezig 13 leden en 4 bestuurssleden

## 1. Opening

De voorzitter opent de vergadering om 12:40. Allereerst wordt het organiserend comité in Delft bedankt voor het organiseren van deze dag.

## 2. Vaststellen van de agenda

Er worden geen aanvullingen / veranderingen aangebracht.

## 3. Mededelingen

Er zijn geen bijzondere mededelingen.

## 4. Notulen van de Algemene Ledenvergadering 2009

Er worden geen wijzigingen ingebracht; bij deze wordt de secretaris bedankt.

## 5. Jaarverslagen van de Werkgroepen en Commissies

### • Constructies

David Schijve meldt dat er geen mededelingen zijn.

### • Excursies

Kees Westerduin meldt dat de excursie naar VAT in Zwitserland een groot succes was; deze was zelfs overtekend! Martin Smit en Marco de Roos hebben een belangrijke bijdrage geleverd aan het slagen van deze excursie. De bedrijfsbezoeken werden als goed gewaardeerd. Daar men was uitgegaan van een heel laag budget had men gekozen voor een treinreis. Dit laatste was achteraf geen goede keuze: deze treinreis werd door allen als erg onaangenaam ervaren. Een volgende keer zal hier lering uit getrokken worden.

### • Opleidingen

Gerrad Beukema vindt dat de NEVAC goed onderwijs verzorgt, maar dat er op moet worden toegezien dat hier niet het principe van de eigen slager keurt zijn eigen vlees gaat gelden: het zou wenselijk zijn dat er meer mensen van buiten, bv uit de industrie ook toezicht houden op de kwaliteit van de cursussen. De heer van Langeveld geeft aan dat de commissie voldoende zelfreinigend vermogen heeft en dat er ook een lid uit de industrie in de commissie zitting heeft. Bart Kooij vraagt zich af of de cursisten hier een mening over hebben. Vanuit

de commissie kan hier geen antwoord op worden gegeven.

ASML verzorgt ook cursussen maar deze worden alleen intern georganiseerd. Norbert Koster geeft aan dat de cursus bij ASML ook een heel ander karakter heeft dan de cursussen die de NEVAC verzorgt. Ook pleit de heer Beukema voor een nauwere samenwerking met Hogescholen. Daar verdwijnt de kennis op het vacuümgebied zeer snel.

### • NEVAC-blad

Bart Kooij geeft aan dat er veel problemen zijn met het verwerven van kopij. In 2009 is het NEVAC blad maar drie maal verschenen. Het blijkt helaas ondoenlijk om het NEVAC blad gevuld te krijgen. Ook het idee om artikelen in het Engels te accepteren heeft tot nu toe geen verbetering in het aanbod gegeven. Met name de bedrijfsleden zijn niet blij als ook hen wordt gevraagd een eventuele bijdrage in het Engels aan te bieden.

De voorgesteld NEVAC prijs is helaas nog niet ingevoerd. Het bestuur zal zijn uiterste best doen om met ingang van de NEVAC

dag 2011 deze prijs in te voeren. Hiervoor zal een beoordelingcommissie moet worden ingesteld.

## 6. Financieel overzicht 2009 en begroting 2010

Ad Ettema geeft een toelichting op het financieel jaaroverzicht. Betalingsdiscipline was zo'n 70%. Nu is er een acceptgiro gebruikt: betalingen zijn voor 98% binnen. Bedrijfsleden willen echter graag een factuur zien. Bestuursleden declareren geen reiskosten. Beukema vraagt naar de uitgaven van de Commissie Opleidingen: Deze hebben nog een eigen rekening/boekhouding. Westerduin merkt op dat de excursie nog niet is verwerkt in deze jaarrekening. Beukema merkt op dat er wellicht meer rente op de rekening is te verkrijgen: Dit is te bewerkelijk en levert niet zoveel op.

## 7. Verslag van de kascommissie.

De heren van Langeveld (deze was voor een dag teruggetreden als bestuurslid, omdat hij anders geen deel van de kascommissie mocht uitmaken) en Klinkhamer hebben de financiële stukken bij de penningmeester ingezien. Alles stond op de computer, dit was even wennen. Na enige toelichting kon de kascommissie de zaken goedkeuren. De

kascommissie stelt dan ook voor het bestuur te dechargeren.

## 8. Decharge van het bestuur en benoeming van de nieuwe kascommissie

Naar aanbeveling van de kascommissie wordt het bestuur bij deze gedechargeerd. Op het verzoek van het bestuur naar een nieuw lid voor de kascommissie meldt zich de heer Jan Pool; de nieuwe kascommissie bestaat dus uit de heren van Langeveld en Pool.

## 9. Bestuursmutaties

Aangezien de voorzitter (die al een jaar langer is aangebleven) zijn termijn erop heeft zitten wordt de heer Erwin Kessels voorgedragen als nieuwe voorzitter. De vergadering gaat hiermee akkoord. Erwin Kessels stelt zich voor. De heer Westerduin wil graag stoppen, maar bij gebrek aan een opvolger wil hij met een eventuele assistent het nog een jaar op zich nemen. De heer Smit biedt aan hem te helpen. De heer Wolbeer denkt erover na om deze functie over te nemen. De heer Frenken stelt zich herkiesbaar.

De heer Kessels bedankt de heer Koenraad voor de zaken die hij in zijn (verlengd) voorzitterschap heeft gerealiseerd. Met name de nieuwe website en het gemoderniseerde NEVAC blad mogen genoemd worden.

## 10. Rondvraag

De heer Schijve vraagt of het geen tijd wordt

om het Basisboek Vacuümtechniek te updaten: er is vorig jaar een nieuwe druk uitgebracht die maar zeer ten dele is aangepast. Met name de Heer Suurmeijer is hier druk mee bezig, maar eerst moet de huidige oplage verkocht worden. Er wordt vanuit de aanwezigen geopperd om te gaan drukken "on demand" zodat er geen grote voorraad boeken in voorraad hoeft te worden genomen. Hierover zal worden nagedacht.

De heer Koenraad wil ter gelegenheid van het komende evenement Het Instrument een grotere oplage van het NEVAC blad laten drukken. Er is een zg Vakuümplein ingericht en we hopen dat dit wervend zal werken.

## 11. Sluiting

De voorzitter sluit de vergadering om 13:25. Namens het bestuur Jan W.M. van Kessel, secretaris

## NEVAC ALV 2011: Kandidaatstelling NEVAC bestuursleden

Tijdens de algemene ledenvergadering op 26 april 2011 zullen nieuwe bestuursleden voor het dagelijks bestuur (DB) en het algemeen bestuur (AB) van de NEVAC verkozen worden. Hieronder staat een overzicht van de functies die vrijkomen. Tevens staan er een aantal namen van personen die zich (her)kiesbaar stellen. NEVAC leden worden opgeroepen om zich kandidaat te stellen voor de bestuursfuncties, vooral voor die functies waar nog geen kandidaten beschikbaar zijn. Indien u zich kandidaat wilt stellen kunt u contact opnemen met de secretaris van de NEVAC, de heer Jan van Kessel (jwmvankessel@gmail.com).

Bestuursfunctie	Zich reeds kandidaat gestelde personen
Vice-voorzitter	
Secretaris	Jan van Kessel
Penningmeester	Ad Ettema
Bestuurslid Excursies	
Bestuurslid Bedrijfsleden	Pieter Heidema
Redacteur NEVAC blad	
Promovendus-bestuurslid	

## Jaarverslag 2010

# Commissie Opleidingen NEVAC

## Commissieleden:

A.D. van Langeveld (voorzitter), C.W. Hagen (TUD), J. Holstein (RUG), J.W.M. van Kessel (RU), Th. Mulder, H.J.M. Oerbekke (UT), E.P.T.M. Suurmeijer, H.J.W. Zandvliet (UT) en J.B.A. van Zon (Philips Nat.Lab.).

## Cursussen:

In het seizoen 2009/2010 werden onder auspiciën van de NEVAC cursussen vacuümtechniek en applicatiecursussen verzorgd op 3 plaatsen in de regio. Het totaal aantal cursisten bedroeg 227 en was als volgt verdeeld: Elementaire Vacuümtechniek (EVT) 40 Vacuümtechniek (VT) 26 Overige cursussen onder auspiciën van de NEVAC 161 (EVT = seizoencursus elementaire vacuümtechniek op VMBO-t niveau, VT = seizoen-cursus vacuümtechniek op MBO/HBO niveau, Overige cursussen: BVT = 1-daagse basiscursus)

vacuümtechniek, OPD = 1-daagse applicatiecursus opdamptechnieken).

In het lopende seizoen 2010/2011 worden/zijn onder auspiciën van de NEVAC cursussen vacuümtechniek en applicatiecursussen verzorgd op 5 plaatsen in de regio. Het totaal aantal cursisten bedraagt ca. 138 en is als volgt verdeeld: Elementaire Vacuümtechniek (EVT) 19 Vacuümtechniek (VT) 13 Overige cursussen onder auspiciën van de NEVAC (BVT, OPD, UHCV) 106 (EVT = seizoencursus elementaire vacuümtechniek op VMBO-t niveau, VT = seizoen-cursus vacuümtechniek op MBO/HBO niveau, Overige cursussen: BVT = basiscursus vacuümtechniek, OPD = applicatiecursus opdamptechnieken, UHCV = Introductie in ultrahog/ultraclean vacuüm, verzorgd door The Institute Eindhoven).

## NEVAC-examens:

De schriftelijke examens 2010 werden op maandag 19 april op 2 niveaus afgenomen, t.w. Elementaire Vacuümtechniek (EVT) en Vacuümtechniek (VT). Voor het examen EVT verschenen 36 kandidaten; hiervan zijn er 25 geslaagd. Van de 21 kandidaten voor het examen VT zijn er 17 geslaagd.

De examenopgaven 2010 met uitwerkingen staan op de NEVAC-website: <http://www.nevac.nl> en kunnen daarvan worden gedownload.

De schriftelijke NEVAC-examens EVT en VT 2011 zijn gepland op maandag 18 april. Er worden in 2011 geen examens VTPlus afgenomen.

A.D. van Langeveld, Voorzitter

De NEVAC dag zal dit jaar op 26 April plaatsvinden te Enschede (Universiteit Twente). De organisatoren, Guus Rijniers en Harold Zandvliet, hebben geprobeerd een interessant programma samen te stellen.

Een nieuw element in het programma zal de NEVAC prijs zijn. De prijs staat open voor zowel studenten als promovendi. Om mee te dingen naar de NEVAC prijs moest voor 1 februari 2011 een duidelijk en helder verhaal voor een breed fysisch en chemisch publiek over het eigen onderzoek naar de NEVAC gezonden worden. Alle ingestuurde inzendingen die aan de eisen van het NEVAC blad voldoen komen in aanmerking voor publicatie in het NEVAC blad. Bovendien krijgen de auteurs een vergoeding van € 100,- per pagina. De beste inzending wordt beloond met de NEVAC prijs. De prijswinnaar zal uitgenodigd worden om tijdens de NEVAC dag een presentatie over zijn bijdrage te geven.

### Program NEVAC day 2011

University of Twente, April 26<sup>th</sup> 2011 (location: de Waaier)

<b>9:45-10:00</b>	<b>Registration</b>	<b>12:30</b>	<b>Lunch/Posters/Exhibition</b>	<b>Pulsed Laser Evaporation equipment</b> Dr. M. Dekkers, Solmates	
	<b>Plenary Session (Waaier 4)</b>	<b>Parallel session Science (Waaier 4)</b>			
<b>10:15-10:25</b>	<b>Opening by the chairman</b>	<b>14:00-14:20</b>	<b>The surface science of solar fuel production</b> Dr. M. Sturm, FOM/Rijnhuizen	<b>14:30-15:00</b>	<b>Title to be announced</b> Dr. E. Granneman, Levitech
<b>10:25-11:00</b>	<b>Interface-sensitive x-ray spectroscopy of oxide heterostructures</b> Prof. M. Sing, University of Würzburg	<b>14:20-14:40</b>	<b>Metal-organic coordination networks of perylene derivatives on Cu(111)</b> Dr. M. Stöhr, RUG	<b>15:00-15:30</b>	<b>Coffee/tea break, posters, exhibition</b>
<b>11:00-11:35</b>	<b>Reaction dynamics in a magnetized hydrogen plasma unravelled by optical spectroscopic techniques</b> Dr. Engeln, TU/e	<b>14:40-15:00</b>	<b>Currents and Forces: combining STM and AFM to study molecular electronics</b> Dr. B. Hendriksen, RU Nijmegen	<b>Plenary Session (Waaier 4)</b>	
<b>11:35-12:00</b>	<b>NEVAC prize</b>	<b>Parallel session Applied Vacuum technology (Waaier 3)</b>		<b>15:30-16:10</b>	<b>Shake, rattle and slip: surprises in atomic-scale friction</b> Prof. J. Frenken, UL
<b>12:00</b>	<b>Annual meeting NEVAC/ Posters/Exhibition</b>	<b>14:00-14:30</b>	<b>PZT deposition solution for 4 to 8 inch wafers by automated</b>	<b>16:10-16:15</b>	<b>Closure by the chairman</b>
				<b>16:20-</b>	<b>Drinks</b>

Sign on NEVAC day (deadline April 14<sup>th</sup> 2011): <http://ssp.tnw.utwente.nl/english/nevac/index.html>

## Interface-sensitive x-ray spectroscopy of oxide heterostructures

Michael Sing, Experimentelle Physik 4, Universität Würzburg, D-97074 Würzburg, Germany

Transition metal oxides display a huge variety of intrinsic functionalities such as ferroelectricity, magnetism, superconductivity, or multiferroic behavior. With the developments of thin film deposition techniques such as pulsed laser deposition during the last decade it is nowadays possible to epitaxially grow oxide heterostructures with atomic precision. At their interfaces new phases emerge due

to the rearrangement of charge, spins, orbitals, and lattice and the resulting re-balancing of their mutual interactions. A case in point is the quasi-two-dimensional electron gas (q2-DEG) at the interface of LaAlO<sub>3</sub>/SrTiO<sub>3</sub> (LAO/STO) [1], which even becomes superconducting below  $\approx 200$ mK [2].

The great appeal of these new material sys-

tems lies in the possibility to electrostatically modify the interfaces either by varying the thickness of the polar layers in the range of several unit cells [3] or by applying a gate voltage [3,4]. While thus being of enormous interest from both the fundamental and the applicational point of view, such kind of structures pose huge challenges to spectroscopy since the spectroscopic method of choice at the same time has to provide a sufficiently large probing depth and the required contrast to access and probe the physical properties of the buried interfaces.

In my talk I will show how hard x-ray photoemission spectroscopy (HAXPES) [5] and inelastic x-ray scattering (RIXS) [6] can be used to obtain information on the electronic and chemical structure of buried interfaces in oxide heterostructures (see Fig. 1).

#### References

- [1] A. Ohtomo and H.Y. Hwang, *Nature* 427, 423 (2004).
- [2] N. Reyren et al., *Science* 317, 1196 (2007).
- [3] S. Thiel et al., *Science* 313, 1942 (2006).
- [4] A. D. Caviglia et al., *Nature* 456, 624 (2008).
- [5] M. Sing et al., *Phys. Rev. Lett.* 102, 176805 (2009).
- [6] G. Berner et al., *Phys. Rev. B* 82, 241405(R) (2010).

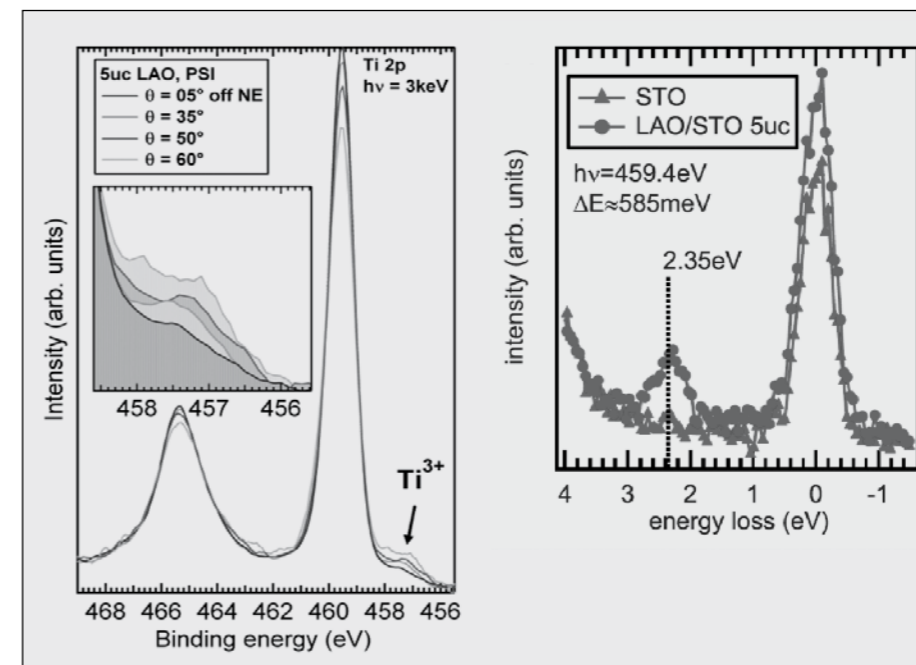


Fig. 1: Ti 2p HAXPES spectra (left) and RIXS spectra at the Ti L edge (right) of LAO/STO. The spectral weight, marked by Ti<sup>3+</sup>, and the peak at 2.35eV, respectively, are direct evidence of extra electrons and hence the q2-DEG at the LAO/STO interface.

## Reaction dynamics in a magnetized hydrogen plasma unravelled by optical spectroscopic techniques

W.E.N. van Harskamp, D.C. Schram, M.C.M. van de Sanden, R. Engeln, Eindhoven University of Technology, P.O. Box 513, 5600 MB, Eindhoven (The Netherlands) e-mail: r.engeln@tue.nl

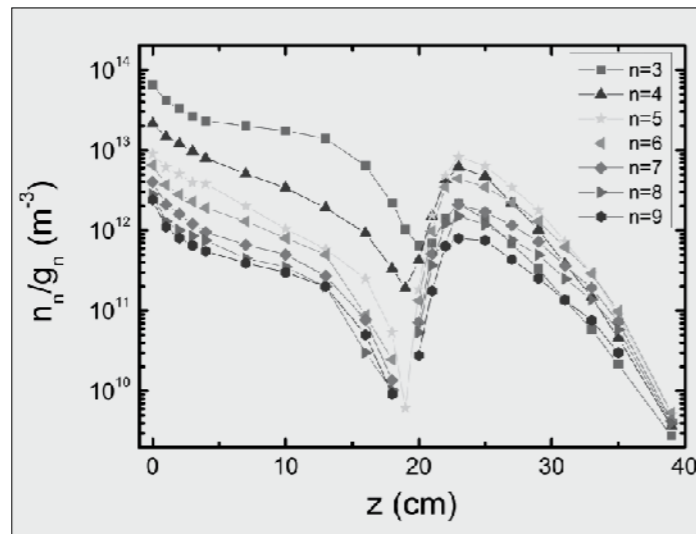
A pure hydrogen plasma jet with an axial magnetic field has been investigated. To obtain a detailed picture of the reaction dynamics of the neutral plasma species, emission spectroscopy, tunable diode laser absorption spectroscopy and VUV laser induced fluorescence has been employed to detect hydrogen atoms and molecules.

#### 1. Introduction

The development of efficient sources of reactive hydrogen radicals is important in many research fields and applications. For instance, atomic hydrogen radicals serve as primary reactive particles for surface modification or thin film deposition. For fusion plasma heating, one of the main research

challenges is to develop efficient negative ion sources. A promising route is via dissociative attachment of ro-vibrationally excited hydrogen molecules H<sub>2</sub><sup>v</sup>. The ro-vibrationally excited molecules are important precursors in volume reactions leading to excited hydrogen atoms. During my presentation I will discuss the importance of

Figure 1: Densities per statistical weight of excited atomic hydrogen as function of the distance from the exit of the plasma source,  $z$ , obtained by Abel inversion of optical emission measurements.



several molecular activated recombination (MAR) processes in an expanding thermal hydrogen plasma, and especially, the formation of excited atoms via the mutual neutralization process of  $H^-$  and  $H^{2+}$ .

## 2. Results and discussion

When an expanding hydrogen plasma jet, produced from a cascaded arc source, is weakly magnetized, the emission of the expanding plasma jet is dominated by the red  $H_\alpha$  emission in the first centimeters from the exit of the source, but changes to blue at larger distances from the exit due to higher Balmer lines ( $n > 4$ ) (see Figure 1).

Since electron energies in the jet are too low (1 eV and less) to excite atomic hydrogen to the state  $n = 3$ , a possible formation route is via mutual recombination of atomic ions:  $H^+ + H^- \rightarrow H + H(n = 2, 3)$ . After 22 cm  $H_\beta$  to  $H_\delta$  light becomes dominant (i.e. the reason for the blue appearance of the jet

at larger  $z$ ) and the corresponding weighted densities  $n/g$  become higher than the one for  $n = 3$  (see Figure 1). The proposed formation mechanism for these highly excited hydrogen atoms is the mutual recombination reaction of positive molecular ( $H_2^+$ ) and negative atomic ions ( $H^-$ ).

The molecular ions are produced in charge exchange reactions of  $H_2^{r,v}$  with  $H^+$ , while the latter are formed by dissociative attachment of electrons with  $H_2r,v$ . Both processes depend strongly on the internal excitation ( $r,v$ ) of the neutral molecule. In earlier

studies we have shown the presence of large densities of these highly ro-vibrationally excited hydrogen molecules [2]. During my presentation I will focus on the reaction dynamics and kinetics leading to excited molecular and atomic hydrogen.

## References

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# The surface science of solar fuel production

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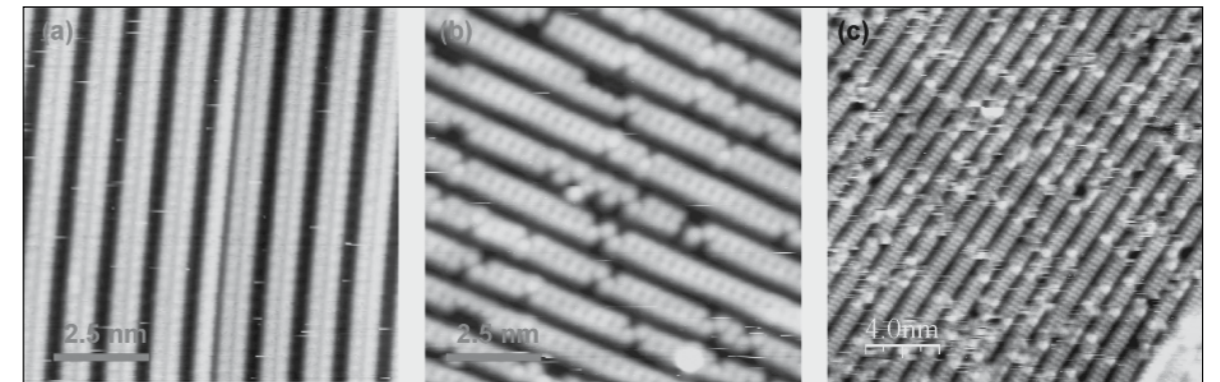


Figure 1. Atomic resolution scanning tunneling microscopy images of water adsorption on  $V_2O_5(001)$  films on  $Au(111)$ . As-prepared films without point defects (a) are not reactive towards water adsorption. Electron irradiation creates oxygen vacancies, visible as black points in (b). Upon water adsorption (c) OH groups are formed on these defects [2].

Solar energy is by far the most abundant source of renewable energy. However, sunlight is an intermittent power source, such that large scale use of solar energy requires a suitable strategy for energy storage [1]. Production of solar fuels with the aid of inorganic photocatalytic materials combines the harvesting of solar energy with energy storage. Light irradiation of the photocatalyst, a metal oxide semiconductor, generates charge carriers that drive the splitting of water in hydrogen and oxygen. This process may be combined with photocatalytic  $CO_2$  reduction in order to produce liquid hydrocarbons or alcohols as fuel.

Practical photocatalysts are complex nanostructured materials, with a complex interplay between structure, defects and reactivity.

Therefore, it is very difficult to investigate the fundamentals of the relevant surface processes on real catalysts, although such knowledge is essential for designing better photocatalysts. Surface science studies on model catalysts, thin metal oxide films deposited in ultra-high vacuum, have greatly improved the insight in many catalytic processes, see e.g. [3]. These flat layers can be studied with techniques such as temperature-programmed desorption, reflection-absorption infrared spectroscopy and scanning tunnelling microscopy. It was demonstrated (see Figure 1) that the influence of oxygen vacancies on catalytic reactions can be investigated and understood down to the atomic level [4,5]. In this talk it will be outlined how these methods will be applied for studying model systems for

photocatalytic solar fuel production.

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# Metal-organic coordination networks of perylene derivatives on Cu(III)

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During the last decade, the bottom-up self-assembly of organic molecules as building blocks on metal surfaces has attracted

considerable attention. It is known that the self-assembly is affected by the fine tuning of different parameters, the most general

being molecule-surface and molecule-molecule interactions. The incorporation of metal adatoms in the self-assembled

molecular network was shown to be one possibility for obtaining relatively rigid and stable arrangements.

We reported for two different perylene derivatives (DPDI and TAPP) the formation of nanoporous networks on Cu(111) [1]. For DPDI, a hexagonal network is formed

upon annealing the sample at 200°C. During this annealing step, DPDI is dehydrogenated and Cu adatoms are available through the detachment of Cu atoms from the step edges. A metal-organic network is formed by incorporation of three adatoms in each vertex where they interact with the N functionalities of three DPDI molecules

(see Figure 1a). In the case of TAPP, the sample needs to be annealed as well (temperatures of 150°C are sufficient) in order to generate Cu adatoms. Four of these Cu adatoms are found in one vertex of the square-like network where they interact with the N functionalities of four TAPP molecules. In both cases, one Cu adatom interacts with the N atoms of two neighboring molecules.

For both systems, scanning tunneling microscopy, low energy electron diffraction, photoemission spectroscopy and X-ray standing wave measurements as well as DFT calculations were carried out to obtain a thorough understanding of the involved interactions. Furthermore, the findings for the two systems are compared to identify common features and differences.

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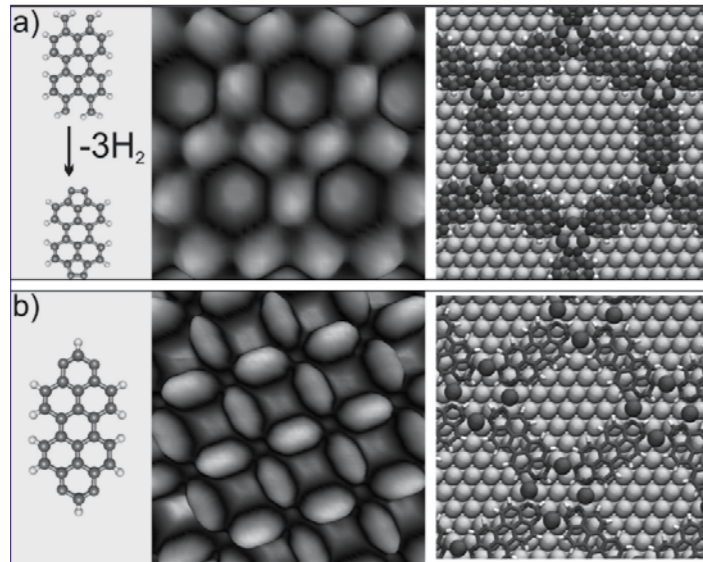


Figure 1: a) For DPDI coverages  $< 0.7$  ML on Cu(111) and annealing the sample at temperatures  $> 200^\circ\text{C}$ , a porous hexagonal network is formed (see STM image ( $6 \times 6\text{ nm}^2$ ) and corresponding model). The DPDI molecule is dehydrogenated and the dehydro-DPDI molecules can now interact with Cu adatoms to form the commensurate network structure. b) For submonolayer coverage of TAPP on Cu(111) and annealing the sample at temperatures  $> 150^\circ\text{C}$ , a porous square-like network is formed which is commensurate to the Cu substrate (see STM image ( $6 \times 6\text{ nm}^2$ ) and corresponding model).

### Abstracts - NEVAC DAG / Parallel session Science 3

## Currents and Forces: combining STM and AFM to study molecular electronics

Bas Hendriksen, *Institute for Molecules and Materials, Radboud University Nijmegen*

Single organic molecules can be used as electronic components in so-called molecular electronics. Scanning tunneling microscopy (STM) and atomic force microscopy (AFM) are routinely used to image individual molecules, which are adsorbed on surfaces, and probe their electronic properties. Here, I will give three examples of how the combination of STM and AFM can be used to probe the physical properties of layers of molecules. In particular by using conducting AFM probes to electrically contact molecular layers and perform electrostatic force measurements (KPFM).

(1) Oligothiophenes are semi-conducting

molecules commonly used in plastic electronics. Using conducting-probe AFM we determined the charge transport laterally through an oligothiophene monolayer and we were able to directly related the transport properties to the crystal structure of the monolayer. (2) Metal porphyrins, known from nature as part of hemoglobin and chlorophyll, are organic molecules, which receive wide interest for application in single molecule electronics. By a combination of STM and KPFM we show how the various lattice structures of a monolayer of porphyrins determine the electronic properties of the layer. (3) Polyoxometalates are metal-oxide cages of nanometer size,

which can contain a functional element for applications as (inorganic) molecular electronics. We studied tungsten oxide clusters, which contain sulfur atoms and which provide thermochromic switching behavior of the clusters. By the combination of STM and AFM experiments we were able to determine the expected switching action of these clusters.

In all three examples I will emphasize how the combination of the detection of forces and currents (STM+AFM) provides physical information, which is inaccessible by a single method.

### Abstracts - NEVAC DAG / Parallel session Applied Vacuum technology I

## PZT deposition solution for 4 to 8 inch wafers by automated Pulsed Laser Evaporation equipment

Matthijn Dekkers, Arjen Janssens & Joska Broekmaat, *SolMateS BV, Drienerlolaan 5 (HTF building), 7522NB, Enschede*

Pulsed Laser Deposition [PLD] is a known research tool for deposition of thin films. It is recognized that this technique offers some advantages compared to other Physical Vapour Deposition (PVD) methods such as; high deposition rate, decoupling of vacuum chamber and energy source, tuneable kinetic energy of deposited species and stoichiometric transfer from target to substrate. This makes PLD a suitable tool for thin film deposition of complex materials using multicomponent targets. However,

this technique is not yet widely used for high volume production due to scaling issues to large surfaces. SolMateS has developed various technological innovations which makes it possible to use PLD technique on large surfaces. A prototype system currently processes piezo layers (PbZrTiO<sub>3</sub>) on 6 inch wafers. The piezo layer (PZT) is the core building block of new Si-integrated 'More than Moore' products, such as inkjet printheads, optical switches, ultrasound imaging, energy harvest-

ing, micro (fuel) pumps and other MEMS. Up to now, no standard deposition techniques were available to apply PZT directly onto Si wafers. Our equipment and processes will overcome this manufacturing hurdle of direct application on wafers. SolMateS develops its products in relation to concrete current and future market demands. Our product is therefore not only a piece of hardware technology, but an innovative production solution for thin film processing.

### Abstracts - NEVAC DAG / Plenair 3

## Shake, rattle and slip: surprises in atomic-scale friction

Joost Frenken, *Kamerlingh Onnes Laboratory, Leiden University*

The atomic-scale origin of the friction force is shrouded in mystery, in spite of the apparent simplicity of the subject. Modern instruments, such as Friction Force Microscopes, have introduced the possibility to address lateral forces with extreme sensitivity, down to the piconewton level, thereby providing direct access to the friction force in atomically sharp contacts: nanotribology.

Sensitive lateral force measurements have been performed with a dedicated Friction Force Microscope (FFM) [1], featuring a specialized lateral force sensor, the Triboliver™ [2]. Our experiments and model calculations are revealing a multitude of

surprises. In this talk I will focus on our observation of lattice effects that can lead to superb slipperiness ('superlubricity') [3], and thermal effects that can dramatically lower friction ('thermo-lubricity') in a variety of ways [4].

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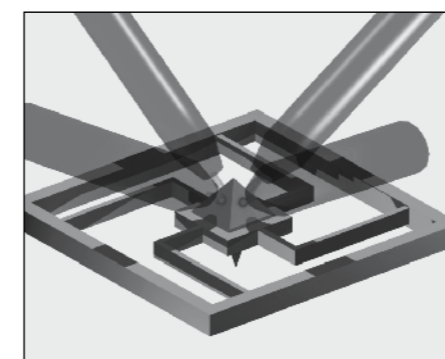
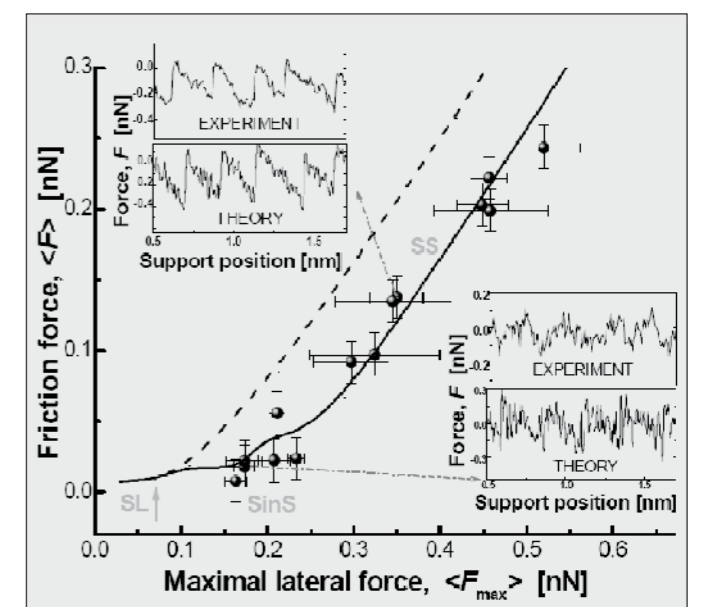


Figure 1. Schematic of the Triboliver™ [2] with its four-fiber interferometer detection system [1], with which sensitive, fully three-dimensional force measurements are performed: the normal force and the two components of the lateral (friction) forces. The etched metal tip is held in the center of the device.

Figure 2. Comparison between measured [3] and calculated [4] lateral forces between a graphite flake and a graphite surface. The friction force (vertical axis) is defined as the average lateral force, while the horizontal axis shows the maximum lateral force. The insets show measured and computed force variations at different points in the curve. They demonstrate that the character of the motion is very different at low and high levels of friction, which results from the dominating influence of rapid thermal fluctuations in the motion of the tip apex.



## Next Generation Mass Spectrometer for Vacuum Systems

The new Simplicity Solutions™ 830 Vacuum Quality Measurement (VQMTM) system transforms complex measurement data into comprehensive, easily usable information over the complete 1-135 amu measurement range under vacuum pressures from UHV to 10<sup>-5</sup> Torr. The 830 VQM system consists of an ion trap mass spectrometer gauge, a VQM Controller and VQM Viewer software that provides the ratio of each gas to others in the measurement range and optionally, the partial pressures of each gas.

Autoresonant ion trap mass spectrometer technology is used which represents an entirely new way of mass selectively ejecting ions from a purely electrostatic ion trap. Ion creation includes capturing all ions within the trap. An electrostatic field keeps them oscillating at their resonant frequency (which is inversely proportional to the square root of their mass/charge). The ions are ejected through an autoresonant energy pumping process using a low amplitude RF frequency scan.



RGA quadrupole systems currently in use are generally larger, draw much more power due to the high power RF systems that are required to operate the transducer, and are relatively slow needing ~2 second measurement times for the 1-135 amu range. Advantages of the 830 VQM include:

- 23x faster (85ms scan rate better captures fast transients)
- 1/5 the power (8W typical)
- Small size (reduces outgassing)
- Simple calibration (any single gas in the system)
- Accurate representation of low amu gases (no zero blast issue)
- Remote operation (electronics can be remote from gauge and is not required to be matched to the gauge)
- Cleanliness (no poles being used to filter unwanted ions)

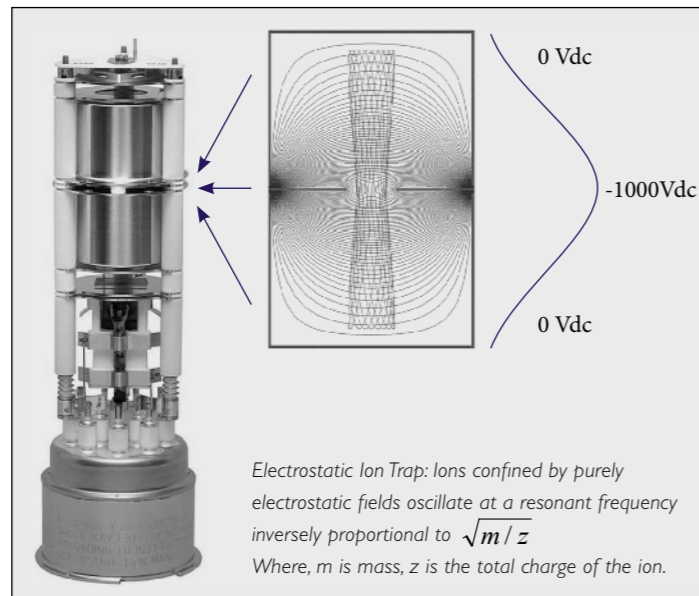
To convert the raw spectral data into easily usable information, the VQM Viewer software provides a full set of features and functions to enable quick vacuum quality measurement and data logging:



- Intuitive user interface
- Digital signal processing
- Single point calibration
- Mass spectrum output
- Top 10 gas display
- Pressure vs. time trend
- Spectral histogram
- Leak detection
- Control of gauge settings

The 830 VQM is typically used for any manufacturing process that occurs in a vacuum (glass coating, semiconductor manufacturing, gold plating, etc.). Primary usage includes leak detection, contamination monitoring, process monitoring, validation of gas quality after periodic maintenance, and general gas quality monitoring.

Simplicity Solutions from Granville-Phillips is an expanding line of gas analysis instrumentation that couples the highest performance technology with intelligent functional design to allow the user to focus on measurement results rather than the interpretation of measurement data. Providing unparalleled speed, power, and functionality. The Simplicity Solutions VQM combines innovative technology with intuitive ease of use to take the complexity out of gas analysis for users across a broad range of applications and industries.



## Switching Casimir forces using the amorphous to crystalline phase transformation in phase change materials

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**Abstract:** In this work we demonstrate a controllable variation in the Casimir force using phase change materials. Changes in the force of up to 20% at separations of ~100 nm between Au and AgInSbTe (AIST) surfaces were achieved upon crystallization of an amorphous sample of AIST. This material is well known for its structural transformation, which produces a significant change in the optical properties and is exploited in optical data storage systems. The finding paves the way to the control of forces in nanosystems, such as micro- or nanoswitches by stimulating the phase change transition via localized heat sources.

Article: Casimir forces [1-8] arise between two surfaces due to the quantum zero-point energy of the electromagnetic field. The surfaces restrict the allowed wavelengths and thus the number of field modes within the cavity, which locally depresses the zero point energy of the electromagnetic field. The reduction depends on the separation between

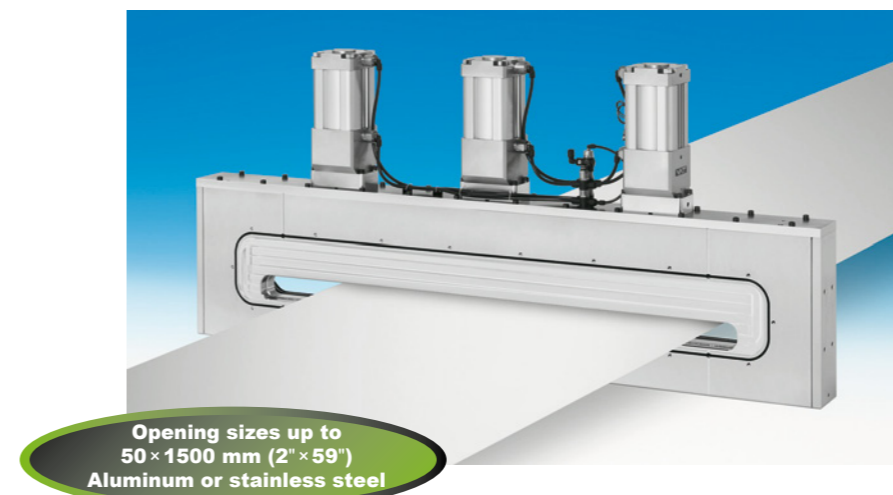
the plates thus there is a force between them, which for normal materials is always attractive [1]. The zero point energy manifests itself as quantum fluctuations, which in the small separation limit give rise to the familiar van der Waals force. The original calculation of the Casimir force assumed two parallel plates with an infinite conductivity [1]. This was

later modified to include the dielectric properties of real materials and the intervening medium [2, 3], providing the first glimpse of possible methods to control the magnitude and even the direction of the force. This finding has motivated our attempts to manipulate the dielectric properties of a material and hence generate force contrast [9-11]. A particularly exciting possibility is to produce a 'switchable' force by employing materials whose optical properties can be changed in situ in response to a simple stimulus [9, 10]. So far the only significant contrast that has been demonstrated is only between different materials [11]. To obtain a large Casimir force contrast for a single material requires a large modification of its dielectric response, which has not been achieved in materials used up to now. Here we demonstrate that phase change



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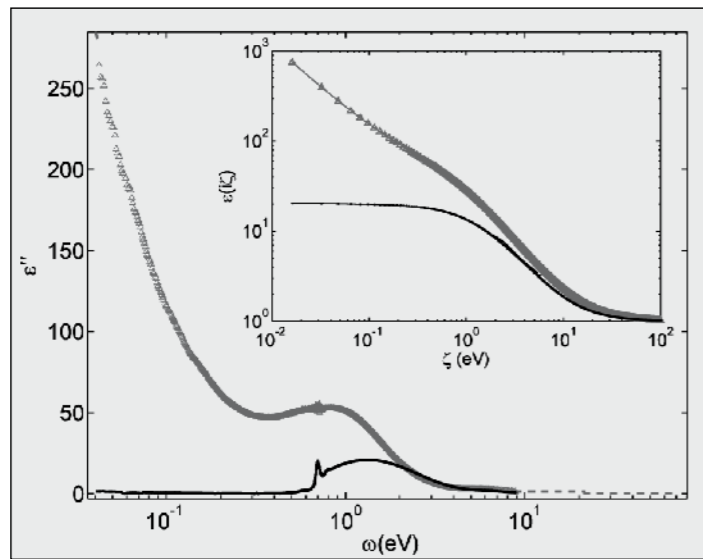


Figure 1 Absorptive part of the dielectric function for the crystalline (triangles) and amorphous (solid line-circles) state of the AIST film obtained with ellipsometry as a function of frequency. The inset shows the same dielectric functions at imaginary frequencies  $\zeta$ , which are necessary for the Casimir force calculations using Lifshitz theory.

materials (PCMs) [12-21], which are renowned to switch reproducibly between an amorphous and a crystalline phase, are very promising candidates to achieve a significant force contrast without a change of composition. These materials are already used in rewritable optical data storage [13, 14, 23-25], where the pronounced optical contrast between the amorphous and crystalline state is employed to store information. This storage principle employs a focussed laser beam to locally heat a disk with a thin film of phase change material. Upon a variation of the power and length of the laser pulse the material can be reversibly switched between the amorphous and the crystalline phase many times. Here we will show that the pronounced contrast of optical properties enables a significant change of the Casimir force upon the phase transformation, not previously found in any material [9, 10]. The good cyclability of phase change materials ensures the realization of a switchable Casimir force device.

In order to measure Casimir forces in PCMs, we prepared 1  $\mu\text{m}$  thick amorphous AgInSbTe (AIST) thin films onto standard Al coated Si wafers, of which half of the AIST films were annealed to the crystalline state. The samples were optically characterized by ellipsometry in the frequency range  $\omega=0.04$ - $8.9$  eV (see Fig. 1). For the crystalline sample the ellipsometry measurements were directly inverted to obtain the dielectric function [22]. For the amorphous film, because it is transparent in the infrared (IR) range, the system was modelled as an amorphous film above an optically thick Al substrate. The

substrate optical properties are important only in IR range, where absorption of the film is very weak. Therefore, it is justified to use tabulated data for the Al substrate.

Since the crystalline film exhibits metallic conductivity, a Drude model was fitted to measured IR data enabling extrapolation

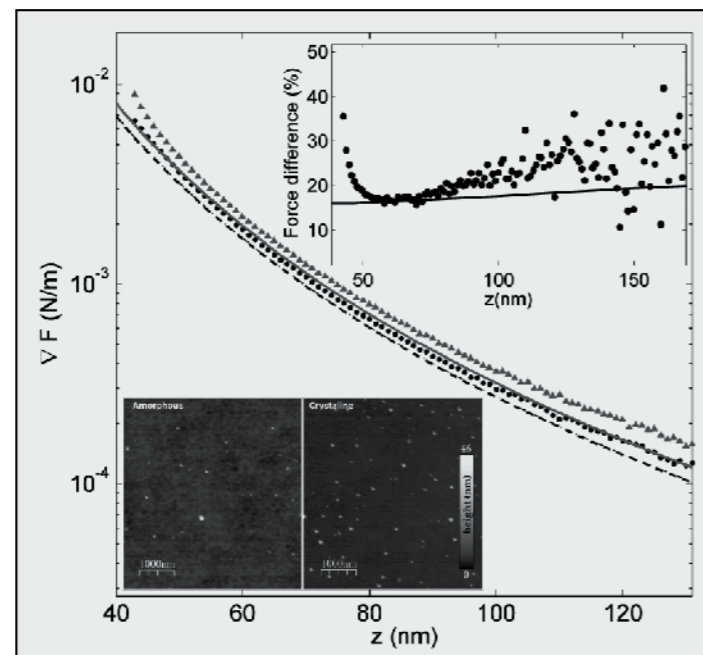


Figure 2 Casimir force gradient measurement for the crystalline ( $\Delta$ ) and amorphous ( $\bullet$ ) phase. The calculated force gradient are depicted as solid and dashed lines for the crystalline and amorphous phase, respectively. The upper inset shows the relative difference between the two force states, normalized with respect the amorphous state, for both the experimental ( $\bullet$ ) and theoretical ( $—$ ) data. This inset demonstrates clearly that theory can qualitatively reproduce the measured difference of the Casimir force. The lower inset shows an AFM topography of amorphous (left) and crystalline (right) films.

below  $\omega < 0.04$  eV, where data is not available. For the amorphous state this range has an insignificant effect on the force. At high frequencies  $\omega > 8.9$  eV, where absorption is already small, the imaginary part of the dielectric function was extrapolated as  $\sim 1/\omega^3$ . The extrapolations are justified by a good Kramers-Kronig (KK) consistency for amorphous and crystalline films, and good agreement with the permittivities of the films found previously [23]. As can be seen from Fig. 1, the transformation from the amorphous to the crystalline state leads to drastic changes of the optical properties. These pronounced changes have been recently attributed to a change of bonding upon crystallization [13, 14, 23]. The large change of the dielectric function upon crystallization suggests that a significant change in the Casimir force should be observed.

The measured dielectric response allows Casimir force calculations using the Lifshitz theory (Fig. 2) [2, 3], for which the force depends on the dielectric function at imaginary frequencies (inset Fig. 1). However, such forces are also affected by the surface roughness. The typical roughness of the samples was a few nm rms, but with a few isolated local peaks as evidenced by atomic force microscopy (AFM) analysis (lower inset in

Fig.2). This small roughness is negligible for the Casimir force calculation at separations above 70 nm [26]. The Casimir force measurements, as in Fig. 2, were performed using dynamic AFM mode within an ultra high vacuum (UHV) Atomic Force Microscope (Omicron VT STM/AFM) [27, 28]. Forces were measured in the sphere-plate geometry between a Au coated (100 nm thick) sphere 20.2  $\mu\text{m}$  in diameter, attached to the end of a cantilever. The latter initially vibrates at its resonant frequency, 83.6 kHz, far from the surface. As the sphere approaches the PCM surface, we measure the frequency shift induced by the sphere-plate interaction, which is proportional to the force gradient in the linear approximation. Each experimental force curve is an average of 13 measurements taken in different areas on both samples.

The force measurement method and the experimental set-up are described in detail in [28]. Indeed, precise comparison of force measurements with theory is only possible if we determine electrostatically several, a priori unknown, parameters such as the starting separation distance  $Z_0$  for the force measurement (corresponding here to the shortest separation), the cantilever spring constant  $k$ , and the contact potential difference  $V_0$  [28]. The calibration is performed by measuring the force gradient versus separation distance for two different applied bias voltages  $V_b$  on the sphere yielding a gap voltage  $\Delta V = V_b - V_0$ . The contact potential  $V_0$  may not be constant [11, 27, 29] but instead can depend on the separation distance  $Z$  between sphere and sample surface. Prior to force acquisition, the determination of  $V_0$  is performed at only one distance  $Z_0 = 42.8 \pm 0.5$  nm for the amorphous, and  $Z_0 = 42.9 \pm 0.4$  nm for the crystalline phase sample. Then we define  $V_0 = 0$  at  $Z = Z_0$  as the reference potential, and the two values are chosen for  $V_b$  (-0.5 V, +0.5 V) to obtain the electrostatic force curves. Determination of  $Z_0$  and  $k$  is achieved by fitting the average of these two force measurements after subtraction of the Casimir contribution (measured for  $V_b = 0$  V), without the calibration being affected by variations in  $V_0$ . [28]. The fit gives consistent spring constants, namely,  $k = 10.8 \pm 0.3$  N/m for the amorphous film, and  $k = 10.7 \pm 0.3$  N/m for the crystalline film.

The experimental uncertainty in the force measurement is about 7% for both samples. Therefore, the upper inset in Fig.2 demonstrates unambigu-

ously that the gradient of the Casimir force increases in magnitude by approximately 20% as a result of the transition from the amorphous to the crystalline state. Both the size and the sign of this force change upon crystallization are in qualitative agreement with the theoretical calculations. At short separations ( $< 55$  nm) the increase in the difference is most likely to be attributed to the larger roughness of the crystalline state (lower inset Fig.2), leading to a larger force [26].

The theory based on the measured optical properties predicts a force smaller than the measured one by 8-18%. The deviation is smaller for the amorphous sample but in both cases it is larger than the experimental and theoretical errors. This deviation cannot be explained by a vertical drift of the AFM probe since the feedback loop maintains the sphere at separation  $Z_0$  from the surface (positioning accuracy better than  $\sim 0.1$  nm). In addition it cannot be explained by the fact that the electrostatics have been performed using an approximate formula for capacitance

gradient [28] which leads to an error of  $Z_0$  of  $\sim 0.2$  nm. Also, in order to check the force measurements we used a sample coated with low roughness Au ( $\sim 1$  nm rms) and it was found close agreement between the measured and theoretically predicted forces. Possible uncertainties in the optical properties of PCM due to low and high frequency extrapolations, variation of the substrate properties or film thickness are excluded since they have small influence on the force calculation.

Hence the observed deviation between theory and experiment can be attributed to surface roughness as discussed recently in [30]. Indeed, the electrostatic force involves a larger interaction area on the plate than the Casimir force [30]. Larger areas contain more high peaks so that the averaged surface of the plate will be located higher than for smaller areas [30]. This is specific to the PCM roughness as the inset in Fig. 2 shows. As a result the absolute separation as determined from the electrostatic calibration underestimates the separation in the case of the Casimir

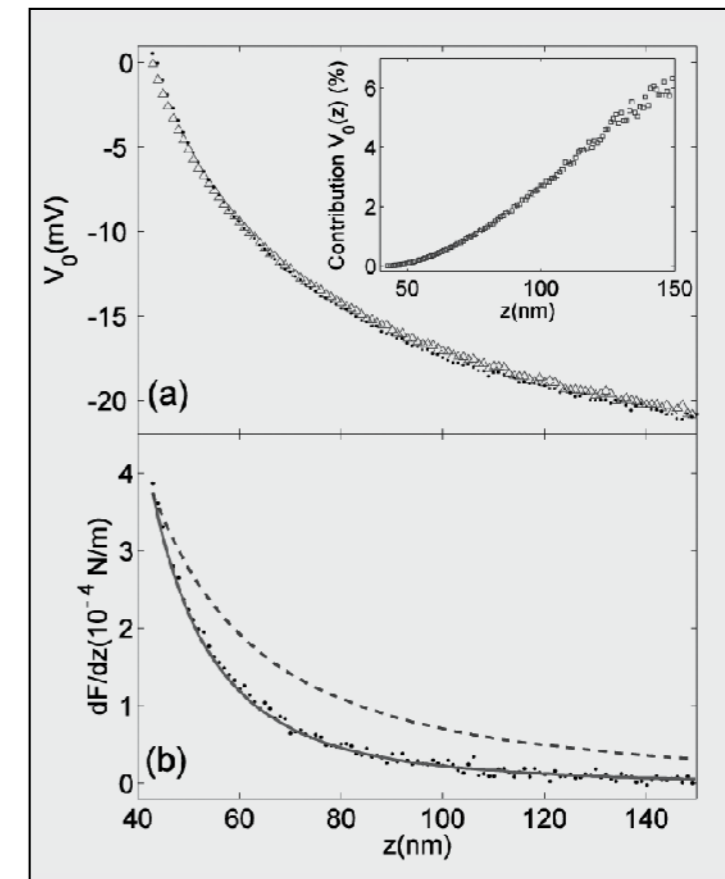


Figure 3 a) Determination of  $V_0$  for the crystalline ( $\Delta$ ) and amorphous ( $\bullet$ ) phase. The inset shows the force contribution due to varying  $V_0$ , divided by the Casimir force in percent. The latter indicates how much the remaining electrostatic interaction would contribute to the Casimir force if it was not subtracted. b) Comparison between the experimental electrostatic force gradient for  $V_b = -50$  mV ( $\bullet$ ) and the theory taking into account the measured  $V_0$  variations i.e. for  $\Delta V = -50$  mV- $V_0(z)$  ( $—$ ) and without i.e.  $\Delta V = -50$  mV ( $---$ ).

interaction. This difference can be  $\sim 1-2$  nm [30], and it is smaller for the amorphous film. In fact, if the experimental force data are shifted to the left by 1-2 nm, the agreement with the theory is restored.

It is observed that there is a residual electrostatic force  $\sim V_0(Z)^2$ , where  $V_0$  is the sphere-plate contact potential difference [28], which must be subtracted from the measured force. This is possible if  $V_0(Z)$  is known for all separations  $Z$  used for the force measurements. The variation of  $V_0(Z)$  can be extracted from the two electrostatic measurements (applied potentials  $V_b = \pm 0.5V$ ) by simple data manipulations (Fig. 3a) [28]. Variations for  $V_0$  between 0-20 mV were observed for separations 40-150 nm without significant differences between amorphous and crystalline samples. As the inset in Fig. 3a indicates, subtraction of this residual electrostatic contribution corresponds to a correction of 6 % at  $Z=150$  nm, and much less than 1% at  $Z=50$  nm as compared to the Casimir force. Therefore, even avoiding this correction, the contrast of the force gradient between the two phases (inset Fig. 2) would remain practically unaffected. Finally, in order to fully confirm our force measurements, another electrostatic measurement was performed under identical conditions as before but with  $V_b = -50$  mV (Fig. 3b). Again comparison of the force measurements with the theory, using the parameters extracted from the electrostatic calibration, shows very good agreement. Notably, as Fig. 3b shows, the agreement is better than that for the Casimir force measurements even though the force gradient for  $V_b = -50$  mV is much smaller confirming that the thermal drift is well compensated by the feedback loop.

In conclusion, as expected from the pronounced difference in the dielectric function of the amorphous and crystalline phases in phase change materials, a significant difference in the measured Casimir force between the PCM and Au is found for the two states. The measured force contrast is the largest reported to date for a switchable material [9, 10]. Although switching a large area of PCM requires high currents, when the nanometer regime is entered modest currents are sufficient to switch the PCM material. Indeed, the smaller the PCM cell the faster it can switch [24]. Switching times of a few nanoseconds already render phase change materials as very useful in electronic and optical memory applications [24]. Currently, there is a continuing effort to improve the number of switching cycles up to  $10^{15}$  making for example

PRAM (phase change random access memory) suitable to replace DRAM (Dynamic random access memory) [20]). There is a simple back of the envelope calculation, which confirms that there is no conceptual difficulty to perform an in-situ switching between the amorphous and the crystalline state in phase change materials. In 2007 alone, 10 billion rewrite optical disks were sold, which are used to read, write and erase data (CD-RW and DVD-RW). These erasable optical disks employ phase change materials such as AIST to store data by transforming the material from the amorphous to the crystalline state by employing a focused laser beam to heat the material. Let us for simplicity assume that on any of these 10 billion disks using phase change materials, every day one (!) song is recorded. With good data compression this corresponds to a file length of 2,5 MByte, i.e. 20 Million bits. Hence as a rough estimate every day on this planet  $2 \times 10^{17}$  transformations between the amorphous and the crystalline state are performed in phase change materials in-situ (in a CD- or DVD-player), in a reproducible manner. If this would not be a straightforward and reliable process, this industry could not exist. Therefore the property portfolio of suitable dielectrical properties, fast switching, good scalability down to the nanometer regime [24], and strong Casimir force contrast deem PCMs to be promising candidates for a switchable Casimir force device.

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ICMCTF 2011, San Diego, USA

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### 2 - 5 May 2011

5<sup>th</sup> CCM international conference on pressure and vacuum metrology and 4<sup>th</sup> International Conference IMEKO TC16, Berling, Germany

Voor meer informatie zie: <http://www.airapt.org/?q=node/82>

### 10 - 12 May 2011

EMRS Spring meeting, Nice, France

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### May 31 - June 2

SEMICON, Moscow Russia

Voor meer informatie zie: <http://www.semiconrussia.org/en/>

### 5 - 8 June 2011

6<sup>th</sup> Symposium on Functional Coatings and Surface Engineering, Montreal, Canada

Voor meer informatie zie: <http://www.fcse-montreal.ca/>

### 14 - 17 June 2011

71<sup>st</sup> annual Physical Electronics Conference, Albany, USA

Voor meer informatie zie: <http://www.physicalelectronics.org>

### 26 - 29 June 2011

ALD 2011, Cambridge MA, USA

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### 28 August - 2 September 2011

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### 16 June 2011

Vacuum Metalizing & Coating Conference 2011, Amsterdam, NOORD-HOLLAND

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### 18 - 19 October 2011

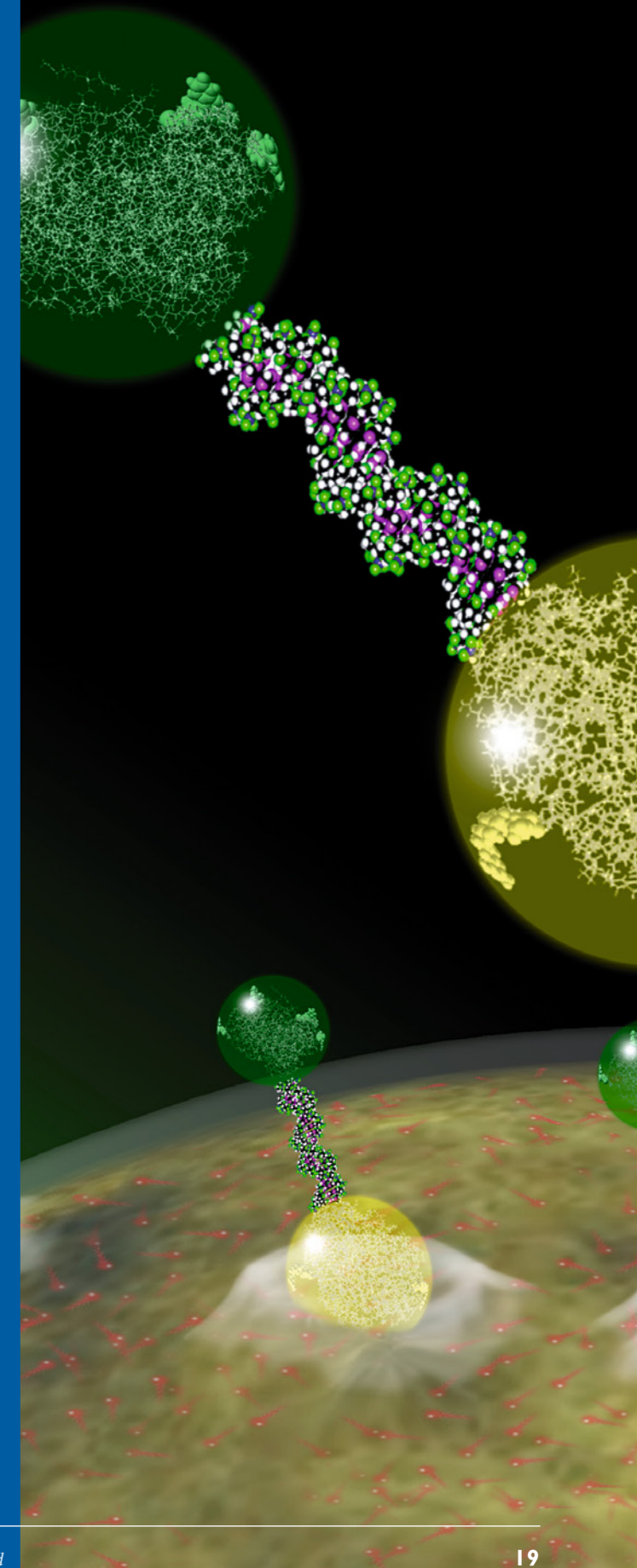
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### For the first time Pfeiffer Vacuum presents itself together with adixen

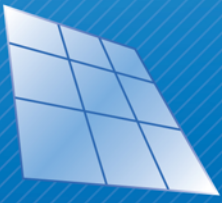
**Asslar, Germany, March 10, 2011.** On December 31, 2010, Pfeiffer Vacuum's acquisition of the Vacuum Technology Unit adixen from Alcatel-Lucent was officially sealed. For the first time Pfeiffer Vacuum presents its two brands Pfeiffer Vacuum and adixen at ComVac in Hanover, Germany, April 4 – 8, 2011.

The merger of these two companies has united two brands with outstanding international alignments under the Pfeiffer Vacuum umbrella. The significant increase in the product portfolio of Pfeiffer Vacuum means that, in the future, the company will always be able to offer its customers a perfect vacuum solution made from high-technology products.

This new portfolio includes a complete line of turbopumps featuring magnetically levitated and hybrid-bearing systems, oil-lubricated and dry-sealing low and medium vacuum pumps, leak detectors, mass spectrometers, vacuum gauges, components and vacuum chambers. This will make Pfeiffer Vacuum a competent address for all applications in the analytical, coating, semiconductor, industrial as well as research & development markets.

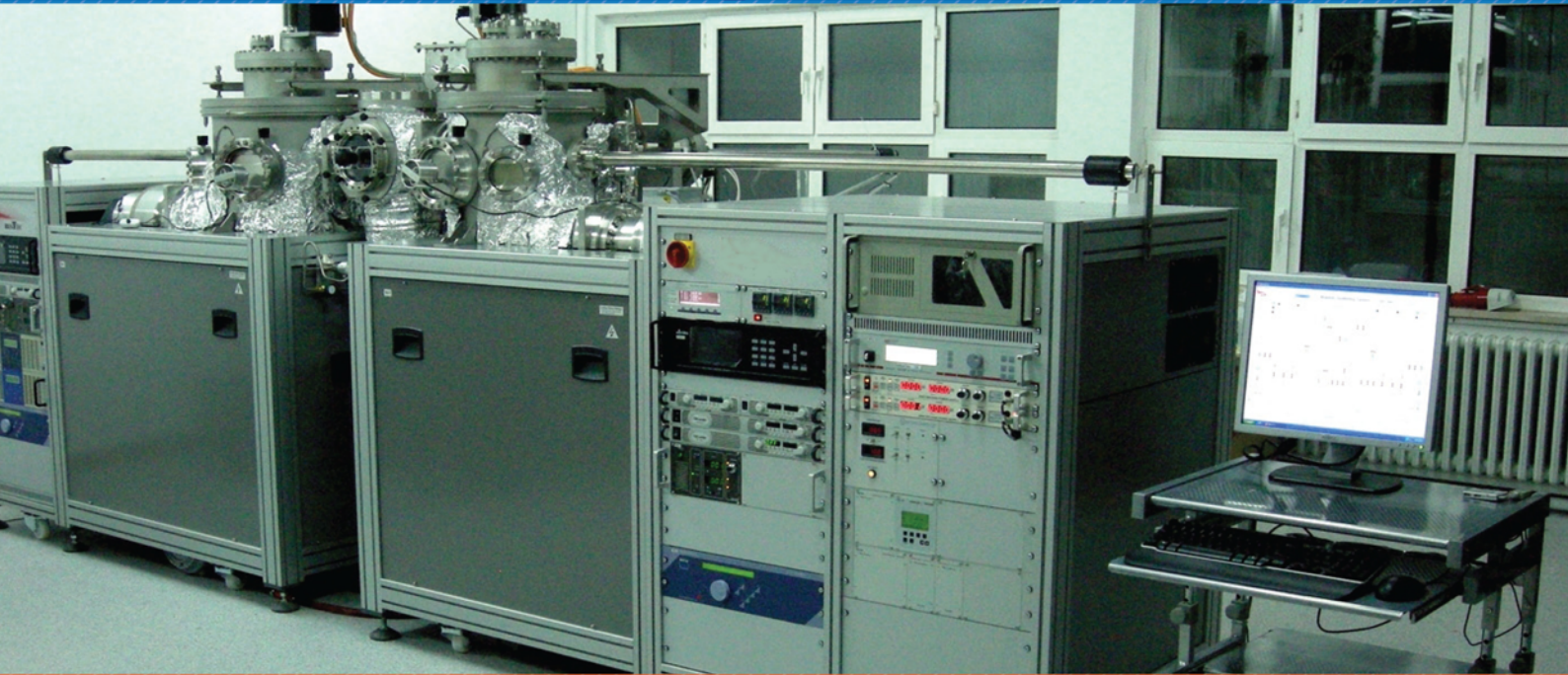
Manfred Bender, CEO of Pfeiffer Vacuum Technology AG, comments on the acquisition: "We are delighted that the transaction has now been completed. During the last few weeks, we have already taken initial steps to integrate adixen. We are confident that, together with the adixen management, we are on the road to becoming a world leader in vacuum technology".

Pfeiffer Vacuum exhibits in hall 26, at booth number E07.



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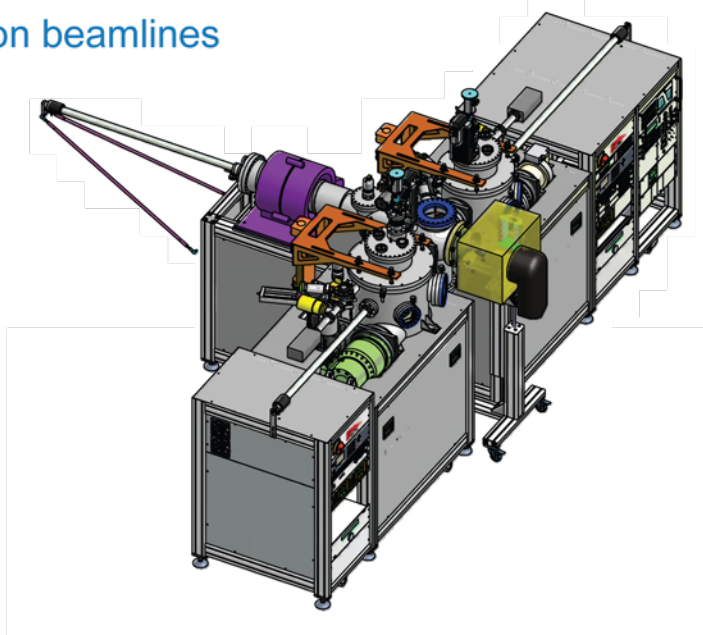
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