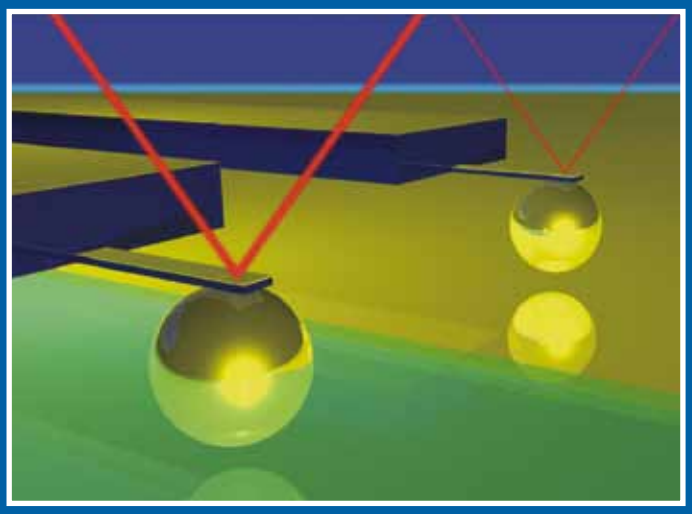
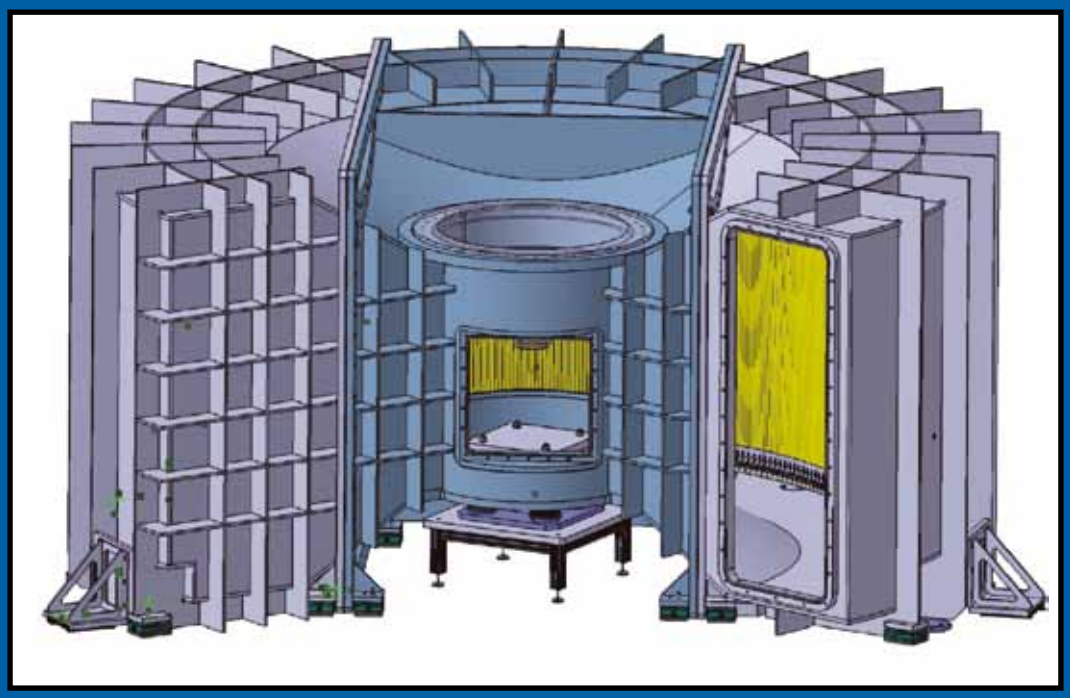
NEVAC blad

JAARGANG 47 / UITGAVE 1

NEVACdag 2009

Universiteit Leiden





Verder in de uitgave:

Orgaan van de Nederlandse Vacuumvereniging

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Verschijningstijdstippen 2008
Tweede helft februari
Eerste helft mei
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.

ISSN 0169-9431

Op de voorpagina

De NEVACdag 2009 vindt 9 mei plaats in Leiden. De twee figuren op de voorkant zijn afkomstig uit abstracts behorende bij twee voordrachten die tijdens de NEVACdag gegeven worden. Eén figuur toont het ontwerp van een vacuümkamer voor neutronenonderzoek (diameter ~7.0 m, hoogte 3.5 m, gewicht ~15 ton) bij de OnderzoeksReactor FRM II te Munchen, Duitsland. Het tweede figuur geeft een artistieke impressie van het idee achter het experiment voor een regelbare Casimir kracht. Deze figuren koppelen dus aan vacuüm op grote en kleine schaal.

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Dr. P.A. Zeijlmans van Emmichoven, vice-voorzitter
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Contributies
Contributie € 18,- per jaar
Bedrijfsleden € 136,- per jaar
Studenten/promovendi € 4,50 per jaar

Inhoud

Agenda

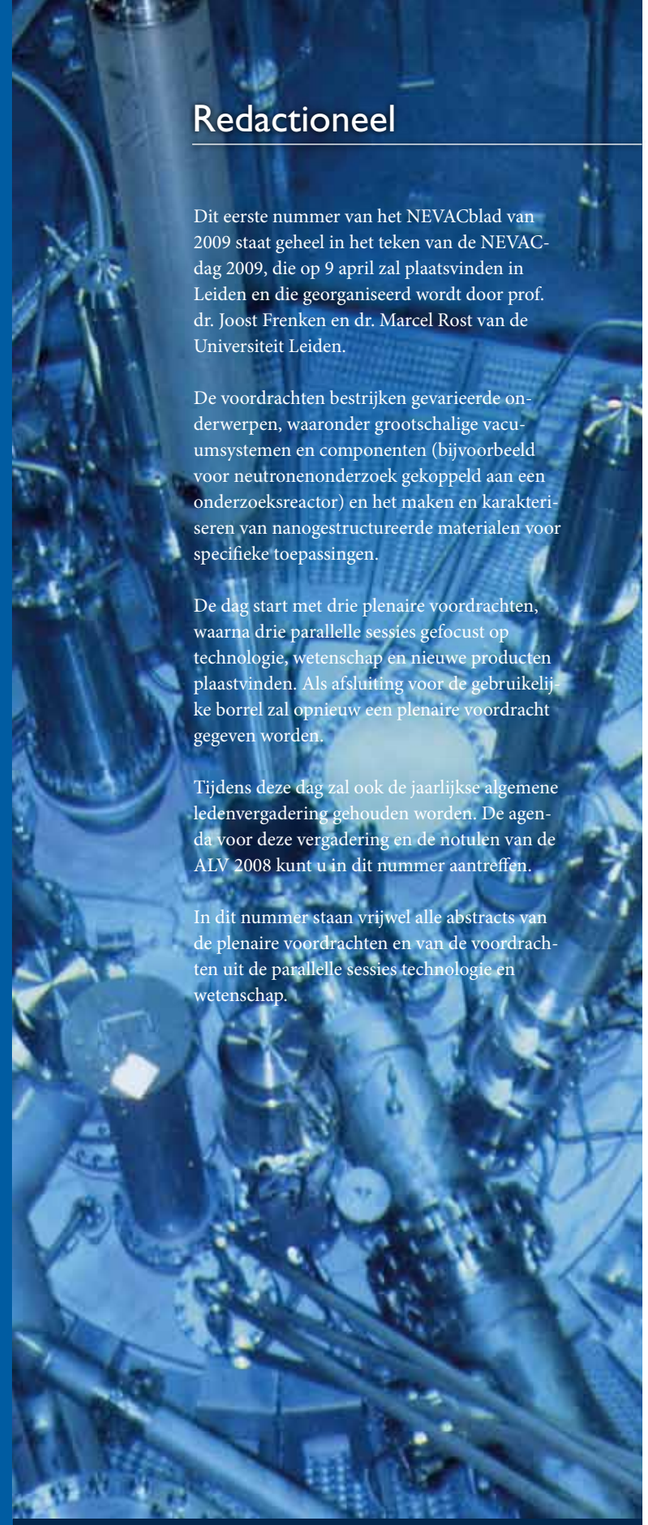
9 april 2009
NEVACdag, Leiden, Nederland
Voor meer informatie zie: http://www.nevac.nl/

13-17 april 2009
Materials Research Society Spring Meeting, San Francisco, CA, USA
Voor meer informatie zie: http://www.mrs.org/s_mrs/sec.asp?CID=10891&DID=201200

28-30 april 2009
Tenth International Vacuum Electronics Conference - IVEC 2009, Rome, Italië
Voor meer informatie zie: http://www.congrex.nl/09a01/

9-14 mei
Society of Vacuum Coaters Annual Technical Conference, Santa Clara, CA, USA
Voor meer informatie zie: http://www.svc.org/ConferencesExhibits/Technical-Conference-Overview.cfm

26-29 mei
53rd International Conference on EIPBN (lithography), San Jose, California, USA
Voor meer informatie zie: http://www.avs.org/calendar.popup.aspx?id=545



Redactioneel

Dit eerste nummer van het NEVACblad van 2009 staat geheel in het teken van de NEVAC-dag 2009, die op 9 april zal plaatsvinden in Leiden en die georganiseerd wordt door prof. dr. Joost Frenken en dr. Marcel Rost van de Universiteit Leiden.

De voordrachten bestrijken gevarieerde onderwerpen, waaronder grootschalige vacuümsystemen en componenten (bijvoorbeeld voor neutronenonderzoek gekoppeld aan een onderzoeksreactor) en het maken en karakteriseren van nanogestructureerde materialen voor specifieke toepassingen.

De dag start met drie plenaire voordrachten, waarna drie parallelle sessies gefocust op technologie, wetenschap en nieuwe producten plaastvinden. Als afsluiting voor de gebruikelijke borrel zal opnieuw een plenaire voordracht gegeven worden.

Tijdens deze dag zal ook de jaarlijkse algemene ledenvergadering gehouden worden. De agenda voor deze vergadering en de notulen van de ALV 2008 kunt u in dit nummer aantreffen.

In dit nummer staan vrijwel alle abstracts van de plenaire voordrachten en van de voordrachten uit de parallelle sessies technologie en wetenschap.

De sluitingsdatum van kopij voor het tweede nummer van het NEVAC-blad 2009 is 6 mei 2009.

NEVAC-dag 2009 in Leiden

Dit jaar zal het jaarlijkse symposium van onze vereniging, de NEVAC-dag, plaatsvinden op donderdag 9 april in Leiden. Leiden heeft veel met vacuüm. Niet alleen zijn en waren diverse prominente NEVAC-leden verbonden aan de Universiteit Leiden, maar ook groeit in Leiden het aantal experimenten waarbij vacuüm een essentiële rol speelt nog steeds gestaag. Een van de redenen hiervoor is dat er in Leiden steeds meer experimentele surface science te vinden is, en dat niet alleen in de afdeling natuurkunde, maar ook bij de astrofysica en bij de scheikunde.

Een belangrijke trend die men kan herkennen bij de surface science in het algemeen en vooral bij die in Leiden, is dat steeds meer experimenten niet onder vacuümomstandigheden plaatsvinden, maar juist bij 'realistische' omstandigheden, bijvoorbeeld onder significante gasdrukken of in een vloeistof. Wordt daardoor het vacuüm gaandeweg minder belangrijk? Interessant genoeg is het antwoord hierop: nee! Er zijn zoveel dierbare experimentele technieken die goed vacuüm vereisen, dat we er waarschijnlijk nooit onderuit zullen komen om zelfs onze hoge-druk experimenten op de een of andere manier te combineren met state-of-the-art ultrahoog vacuüm. Onze meetopstellingen worden hierdoor juist steeds interessanter en vanuit vacuümtechnisch oogpunt beschouwd, veeleisender en 'aantrekkelijker'. De hier gesignaleerde trend fungeert momenteel als motor achter ontwikkelingen op het gebied van een aantal, traditioneel met vacuüm geassocieerde meettechnieken, waarvan ook in het symposium inspirerende voorbeelden te vinden zijn.

Voor de NEVAC-dag hebben we een interessant programma voor u samengesteld met bijdragen voor een breed gehoor in de plenaire sessie en met, naar beproefd NEVAC-recept, drie parallelle middagsessies, gewijd aan wetenschap, vacuüm-techniek en nieuwe producten. Als extra element hebben we dit jaar een speciale studentensessie toegevoegd met presentaties en posters door en voor studenten en een competitie met als prijs een publicatie in het NEVAC-blad. De producten zullen verder vertegenwoordigd zijn in de bedrijvententoonstelling die de gehele dag toegankelijk zal zijn. Daarnaast bieden we uitgebreid ruimte aan uw posters en staat ook de jaarvergadering van onze vereniging op het programma.

Wij hopen u allen op 9 april in Leiden te mogen verwelkomen!

Marcel Rost, Pedro Zeijlmans van Emmichoven, Marco de Roos en Joost Frenken

Programma

9.30 **Ontvangst, inschrijving, koffie/thee**
10.10 **Welkomstwoord en opening**
10.15 **Rolf Möller** (Duisburg-Essen)
Electronic transport on the nanoscale: ballistic transmission and Ohm's law
10.50 **Elias Vlieg** (RU)
Random and regular defects in III-V nanowires
11.25 **Frank de Groot** (UU): Soft X-ray absorption spectroscopy
Experiments in UHV, the mbar range, ambient conditions and high-pressure
12.00 **Lunch, Algemene Ledenvergadering, postersessie, tentoonstelling**

Sessie wetenschap

14.00 **Davide Iannuzzi** (VU):
The Casimir effect: harnessing the quantum vacuum
14.30 **Guocai Dong** (UL):
Formation of graphene and boron nitride nanomesh overlayers on Rh(111)
15.00 **Koffie/thee-pauze**
15.30 **Fredrik Creemer** (TUD):
Atomic-resolution electron microscopy at ambient pressure

Sessie techniek

14.00 **Maarten Bischoff** (FEI):
The TEAM project: detection of single atoms and buried defects in three dimensions by aberration-corrected electron microscopy with 50pm resolution
14.30 **Frank Esser** (FZ-Jülich):
Design and Manufacturing Aspects of Vacuum Chambers for Science Applications
15.00 **Koffie/thee-pauze**
15.30 **Peter Munk** (PANalytical):
Characterization of Nanoparticles and Nanosized Pores by X-Ray Diffractometry and Small-Angle X-Ray Scattering (SAXS)

Sessie nieuwe producten

14.00 **4 korte presentaties**
15.00 **Koffie/thee-pauze**
15.30 **2 korte presentaties**

Slot

16.05 **Guus Rijnders** (UT):
Monitoring oxide thin film growth with in-situ scanning force microscopy

16.40 **Afsluiting**
16.45 **Receptie, borrel**

ALV TNO Eindhoven 18 april 2008

Notulen van de Algemene Ledenvergadering

Aanwezig ~ 20 leden.
Van het bestuur: Paul Koenraad, Pedro Zeijlmans van Emmichoven, Liesbeth van Pieterson, Kees Westerduin, Mark Driessen en Jan van Kessel (notulen)

Opening

Vaststellen van de agenda
Wordt ongewijzigd overgenomen

Mededelingen
- NEVAC website
  De afgelopen weken is een opzet gemaakt van een nieuwe website die voor geautoriseerde leden toegankelijk is (een Content Management Systeem). Er zijn nog wat kleine probleempjes, maar we hopen deze binnen twee weken te hebben opgelost. Vandaar dat er helaas op dit moment nog geen presentatie gegeven kan worden.
- Voor belangstellende, de tijdelijke gegevens: www.creativecreation.nl/nevac/
- NU (2009): is de website weer: www.nevac.nl

Notulen van de ALV 2007

Jaarverslagen van de Werkgroepen en Commissies
- **NEVAC blad**
  hoofdredacteur Bart Kooi. Verzoek artikelen (ook technische) aan te bieden.

- **Opleidingen**
  De cursussen EVT en VT zijn redelijk goed bezet. Dit jaar waren er geen kandidaten HVPlus. De schriftelijke examens zijn afgenomen (9 kandidaten EVT en 20 kandidaten VT). Deze worden nu nagekeken. Gerrad Beukema vraagt waarom duidelijk lager aantal kandidaten dan voorgaande jaren.
  Jan van Kessel antwoordt: er worden ook cursussen aangeboden door Het Mikrocentrum en door de Fa. Settels van Amelsfoort (hierbij zijn ook NEVAC docenten betrokken). Zij gebruiken meestal wel het Basisboek Vacuümtechniek van de NEVAC.

- **Odula**
  Helaas is Bernard Dam niet aanwezig en kan hierover verder niets worden gemeld. Pedro meldt dat er wel een NEVAC studentendag is georganiseerd, waar 20 studenten aanwezig waren. Er waren 2 prijzen te winnen nl een voor de beste poster en een voor de beste presentatie.

- **Constructies**
  Dit jaar is er weer een Instrument, waar ook dit jaar weer een presentatie van de NEVAC zal zijn.(21 mei as)
  Er was ook een idee om weer eens een bedrijf te bezoeken, maar dat is niet gerealiseerd.

De Heer Pool merkt op dat er dit jaar helaas een overlap is met de Fysicadag. Het NEVAC bestuur zal zijn uiterste best doen om overlap met andere symposia zoveel mogelijk te vermijden.

- **Buitenlandse betrekkingen**
  Joost Frenken is niet aanwezig, er is geen informatie ontvangen.

- **Excursies**
  Afgelopen jaar is er een zeer succesvolle excursie naar China georganiseerd. Er waren 35 deelnemers; 18 daarvan deden ook mee aan het verlengde programma. De heer Westerduin meldt dat er voorlopig wordt gekeken of er in 2009 een reis naar Rusland mogelijk is. Leden die ideeën hebben worden verzocht die aan hem kenbaar te maken.

- **Bedrijfsleden**
  Er wordt weer veel gebruik gemaakt van de mogelijkheid tot expositie tijdens de NEVAC dag: dit voorziet duidelijk in een behoefte!

Financieel overzicht 2007 en begroting 2008
Liesbeth van Pieterson geeft een toelichting op de begroting. Afwijkend op de begroting zijn de uitgave van het nieuwe NEVAC blad en de kosten voor de nieuwe website. Ook blijkt van het Basisboek Vacuümtechniek nog maar een beperkte voorraad beschikbaar te zijn. In overleg met de heer Suurmeijer wordt gekeken hoe we tot een nieuwe uitgave kunnen komen. De heer Zeijlmans van Emmichoven zal zich namens het bestuur hiermee bezighouden.

Verslag van de kascommissie
De kascommissie (de heren R. Wolbeer en Th. Mulder) hebben de kas gecontroleerd en in orde bevonden. Zij worden bedankt voor gedane moeite.

Decharge van de huidige en benoeming van de nieuwe kascommissie
De Heer Wolbeer is bereidt ook komende keer de kas te controleren; na enige aarzeling biedt Th. Klinkhamer zich aan deze taak (weer) op zich te nemen.

Bestuursmutaties
Liesbeth van Pieterson had al aangegeven dat zij haar taak als penningmeester wilde beëindigen. De heer Ettema biedt aan deze functie op zich te nemen. De aanwezigen stemmen daarmee in.

Rondvraag

Sluiting
Namens het bestuur:
Jan W.M. van Kessel
secretaris

Uitnodiging

Hierbij nodig ik u van harte uit voor de Jaarvergadering 2009 van de NEVAC.
Agenda
1 Opening.
2 Vaststellen van de agenda.
3 Mededelingen.
4 Notulen van de Algemene Ledenvergadering 2008.
5 Jaarverslagen van de Werkgroepen en Commissies.
6 Financieel overzicht 2008 en begroting 2009.
7 Verslag van de kascommissie.
8 Decharge van de huidige en benoeming van de nieuwe kascommissie.
9 Bestuursmutaties.
10 Rondvraag.
11 Sluiting.

Namens het bestuur: Jan W.M. van Kessel, secretaris

Jaarverslag 2008 Commissie Opleidingen NEVAC

Commissieleden:
A.D. van Langeveld (voorzitter), J.W.M. van Kessel (RU), M. Mulder (t/m 29 augustus 2008), 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.).

Mutaties:
M. Mulder heeft onder dankzegging door de CO zijn commissielidmaatschap per 29 augustus beëindigd.

Cursussen:
In het seizoen 2007/2008 werden onder auspiciën van de NEVAC cursussen vacuümtechniek en applicatiecursussen verzorgd op 5 plaatsen in de regio. Het totaal aantal cursisten bedroeg ca. 240 en was als volgt verdeeld:

Almelo (in-company training Urenco):	VT 8
Amersfoort (in-company training High Voltage):	VT 4
Delft:	EVT 3, VT 3
Eindhoven:	EVT 3, VT 5
Eindhoven (trainingen.o.v.v. Bureau SettelsvanAmelsfoort):	UHVE 50, CONS 139, OPD 10
Groningen:	EVT 4
Groningen (in-company training KVI)	VTPlus 12

(EVT = seizoencursus elementaire vacuümtechniek op VMBO-t niveau, VT = seizoencursus vacuümtechniek op MBO/HBO niveau, VTPLus = seizoencursus vacuümtechniek op HBO/academisch niveau, UHVE = introductie in ultrahoogvacuüm essentials, CONS = construeren in uhv, OPD = 1-daagse applicatiecursus opdamptechnieken)

In het lopende seizoen 2008/2009 worden/zijn onder auspiciën van de NEVAC cursussen vacuümtechniek en applicatiecursussen verzorgd op 5 plaatsen in de regio. Het totaal aantal cursisten bedraagt ca. 325 en is als volgt verdeeld:

Almelo (in-company training Urenco):	EVT 15, VT 11
Nieuwegein (in-company training FOM-Rijnhuizen):	VT 10
Delft:	EVT 1, VT 7
Eindhoven:	EVT 3, VT 3
Eindhoven (trainingen.o.v.v. Bureau SettelsvanAmelsfoort):	UHVE 154, CONS 86, PROD 13
Groningen:	EVT 6, BVT 5, VT 3, OPD 7

(EVT = seizoencursus elementaire vacuümtechniek op VMBO-t niveau, VT = seizoencursus vacuümtechniek op MBO/HBO niveau, UHVE = introductie in ultrahoogvacuüm essentials, CONS = construeren in uhv, PROD = produceren t.b.v. uhv, BVT = 1-daagse basiscursus vacuümtechniek, OPD = 1-daagse applicatiecursus opdamptechnieken)

NEVAC-examens:
De schriftelijke examens 2008 werden op maandag 7 april op 2 niveaus afgenomen, t.w. Elementaire Vacuümtechniek (EVT) en Vacuümtechniek (VT). De mondelinge examens VT waren op 15 mei.
Voor het examen EVT verschenen 10 kandidaten; zij zijn alle 10 geslaagd. Van de 18 kandidaten voor het examen VT zijn er 12 geslaagd.

De examenopgaven 2008 staan op de NEVAC-website: http://www.nevac.nl en kunnen daarvan worden gedownload.

De schriftelijke NEVAC-examens EVT en VT 2009 zijn gepland op maandag 6 april. Er worden in 2009 geen examens VTPlus afgenomen.

A.D. van Langeveld,
Voorzitter

Electronic transport on the nanoscale: ballistic transmission and Ohm's law

R. Möller[2], J. Homoth[1], M. Wenderoth[1], T. Druga[1], L. Winking[1], R.G. Ulbrich[1], Ch. Bobisch[2], B. Weyers[2], A. Bannani[2], E. Zubkov[2], A. Bernhart[2], M. Kaspers[2]

[1] 4. Physikalisches Institut, University of Göttingen, 37077 Göttingen, Germany, [2]Department of Physics and Center of Nano Integration Duisburg-Essen (CeNIDE), University of Duisburg-Essen, 47048 Duisburg, Germany

If a current of electrons flows through a conductor it is impeded by local scattering at defects as well as phonon scattering. Both effects contribute to the voltage drop observed for a macroscopic conductor as described by Ohm's law. Although this concept is well established the voltage has not yet been measured around individual defects on the atomic scale. By restricting the current to a surface layer the voltage drop at a monoatomic step was directly evaluated in real space. For the Si(111) -√3x√3 -Ag surface a monotonous transition with a width below 1 nm is found. The numerical analysis of the data reveals how the current flows through the complicated network given by the interplay between defect free terraces and steps.

Random and regular defects in III-V nanowires

Rienk Algra[1,2,3], Willem van Enckevort[1], Elias Vlieg[1], Marcel Verheijen[2], Magnus Borgström[2], Lou-Fé Feiner[2] and Erik Bakkers[2]

[1] IMM Solid State Chemistry, Radboud University Nijmegen, [2] Philips Research Laboratories Eindhoven, [3] Materials innovations institute (M2i) Delft.

Semiconducting nanowires offer the possibility of nearly unlimited complex bottom-up design, which allows for new device concepts. Essential parameters that determine the electronic and optical properties of the nanowires are the wire crystal structure and the density of defects like stacking faults and twins. In many semiconductors stacking faults or twins are randomly formed, see figure 1. A significant feature would be to have a constant spacing between rotational twins in the wires such that a twinning superlattice is formed. It is predicted that such a structure induces a direct bandgap in normally indirect bandgap semi-conductors, such as silicon and gallium phosphide.

We have achieved controlled growth of twinning superlattices in InP and GaP nanowires [1]. Such wires are grown through the vapour-liquid-solid (VLS) mechanism, in which the growth material from a vapour is collected by a gold catalyst droplet and deposited underneath the droplet. As a first step we found that the crystal structure of the nanowires can be controlled by using impurity dopants. Zinc dopants promote the zinc-blende structure. This is the structure that is the most stable in the bulk, but in nanowires often the wurtzite structure is formed instead.

Once the zinc-blende crystal structure is enforced, the growth of the InP nanowires leads to a superlattice of twin crystals with long-range order, see figure 2. Crucial for the formation of the twinning superlattices is the wire morphology arising from the zinc-blende structure. We developed a quantitative model based on the evolution of the cross-sectional shape of the nanowire during growth. Starting from a hexagonal cross section, the shape becomes increasingly triangular. This leads to an increase in the total interfacial energy that can be reduced by forming a twin, because then the cross-section evolves towards a hexagonal shape again. Continued growth leads to the opposite triangular cross-section, after which a new twin is formed. This cyclic process results in a twinning superlattice. The spacing of the superlattices (distance between two successive twin planes) can be tuned by changing the wire diameter and the zinc dopant concentration.

[1] R.E. Algra et al., Nature 456 (2008) 369.

Figure 1. Two transmission electron microscopy (TEM) images of InP nanowires with a diameter near 20 nm and with different twin densities. These irregular defects occur for low Zn doping levels. The Au droplet is clearly visible at the tip of the nanowires.

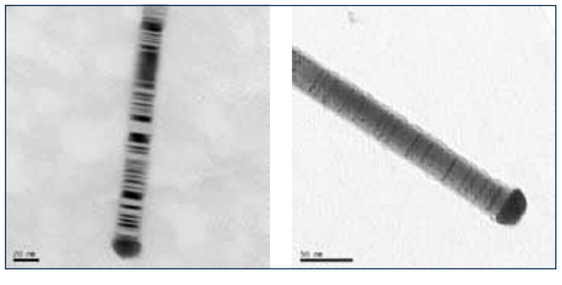
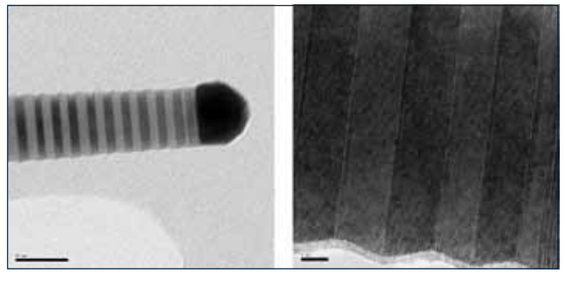


Figure 2. A 50 nm InP nanowire with regular twinning. Such twinning occurs at high Zn doping levels. The close-up at the right clearly shows the faceting of the twins, with an alternating inward and outward growth direction.



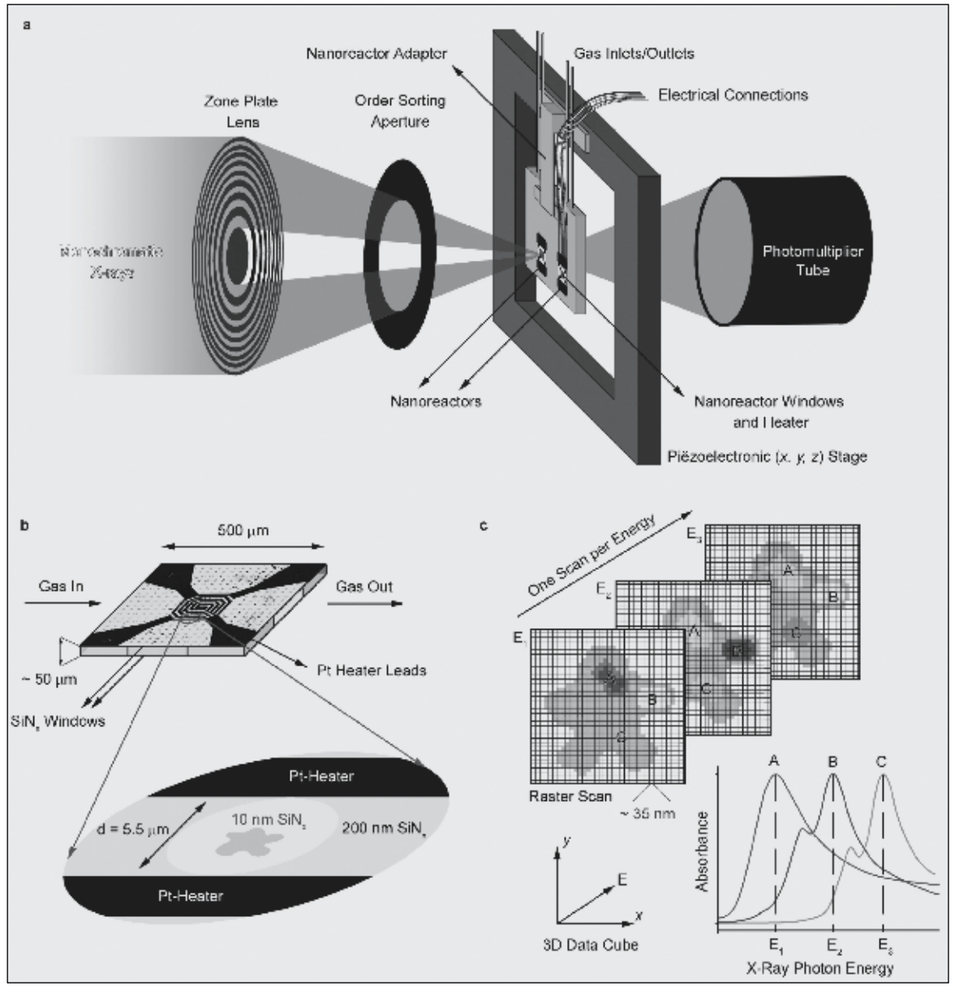
Soft X-ray absorption spectroscopy: Experiments in UHV, the mbar range, ambient conditions and high-pressure

Frank de Groot, Utrecht University, Netherlands, http://www.anorg.chem.uu.nl/people/staff/FrankdeGroot/

Soft X-ray absorption spectroscopy (XAS) is an important characterization tool in a wide range of fields, including solid state physics (superconductors, magnetic systems, etc.), bioinorganic chemistry, earth science, materials science and nanoscience. The soft x-ray absorption range contains the 1s core states of carbon, nitrogen and oxygen and the 2p core states of the 3d transition metals, where the dipole selection rule transfers the core electron into the 3d states and as such probe their properties. The 3d states are strongly affected by both intra-atomic interactions and inter-atomic bonding. In combination this can turns 3d metal systems into magnets, active sites in (bio)catalysis, etc.

The interpretation of X-ray absorption is divided into two routes. Excitations from 1s core levels can be described from ab-initio electronic structure models, mainly DFT based software codes. The main adaptation to X-ray absorption is the inclusion of the extra potential of the core hole in the final states. Excitations from 2p core states (so-called L edges) can not be described with DFT based models. The combination of (i) the core-valence two-electron integrals (multiplets effects) and (iii) the re-ordering of the localised 3d states due to the core hole (charge transfer effects) modify the spectral shapes. Both effects can be simulated with charge transfer multiplet calculations, which allow the simulation of all core level spectra, including XAS, XMCD, XPS, XES, RIXS, resonant photoemission and Auger [1]. We have written a new program interface CTM4XAS that performs such XAS and XPS calculations [2].

Soft X-ray absorption spectra were traditionally measured under UHV conditions using electron yield detection. Such electron yield experiments need vacuum conditions to allow their detection. Soft X-ray absorption can also be measured using fluorescence yield or transmission, which in principle allows ambient conditions. The strong interaction of soft X-ray with matter dictates that the sample thickness must be in the order of a few micron and the optical path outside the vacuum must also be in the micron range. Measurements at ambient conditions also



need two windows separating UHV from 1 bar, but with minimal absorption themselves. Typically Be windows or very thin (10 nm) SiNx windows are used for this purpose.

A crucial advantage of soft X-ray absorption is that it can be measured on essentially any system under any condition, ranging from UHV to high-pressure. In addition, in recent years the spatial resolution has gone down to ~15 nm [5 nm] and the time resolution to the ~50 ps [<1 fs] range for practical and applied experiments. The numbers in square brackets give the 'world record' experiments for spatial and temporal resolution.

UHV experiments
In my talk, I will go through the complete pressure range for XAS experiments. UHV experiments are the traditional route to measure soft XAS spectra. For surface science experiments soft XAS is a crucial technique. As an example, I will show the soft XAS and magnetic circular dichroism experiments on the synthesis of metal-organic supramolecular networks on planar substrates, in particular the self-assembly of Fe and TPA molecules on Cu(100) [3].

Millibar range experiments
If one is using electron yield detection, it is difficult to increase the pressure because the electrons will ionize the gasses. One can actually make use of this effect in so-called conversion ion-yield detected XAS. We have studied the redox effects of oxidation, reduction and catalytic reaction on Fe/ZSM5 catalysts under ~5 mbar conditions between room temperature and ~500 ºC [4].

1 bar experiments
Experiments at 1 bar cannot be measured with electron yield. Instead transmission is used. The soft X-rays imply samples below ~10 micron thickness and 1 bar optical paths in the micron range. With the recent developments in nanoreactors [5], such experiments have become feasible. In addition to normal soft XAS experiments, we have also adapted the nanoreactors to be used in a Scanning Transmission X-ray Microscope (STXM). The STXM experiments make it possible to follow soft XAS edges at 1 bar flowing gas, with a spatial resolution of 20 nm. This allows the in-situ spectroscopic study of a single nanoparticle (in action). Recent STXM results show the nanoscale chemical imaging of a working catalyst, in particular the degree of reduction of iron-oxide nanoparticles [6]. The figure shows x-ray optical path in the STXM microscope (top) with a zone plate as focussing element. The nanoreactor plus its STXM-adapter are put in the beam and scanned over (x,y), while the soft XAS spectrum is measured in transmission through two 10 nm SiNx windows. At each 20x20 nm pixel the iron L edge is measured, using He, H_2 and syngas (H_2/CO mixtures) between room temperature and 500 ºC. From analysis of the iron L edge, chemical maps can be constructed [6].

High-pressure experiments
Direct soft XAS spectra can not be measured at high pressure. There is a way though to measure soft XAS spectra with hard X-rays. By making use of X-ray Raman scattering one can obtain exactly the soft XAS spectrum [7], using for example diamond anvil cells for high-pressure experiments.

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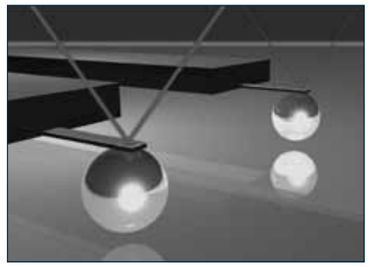
The Casimir effect: Harnessing the Quantum Vacuum

Davide Iannuzzi - Vrije Universiteit Amsterdam

One of the most spectacular consequences of quantum electrodynamics is that it does not leave room for an empty vacuum. Even in the absence of electromagnetic sources, quantum fluctuations of the electric and magnetic fields give rise to a zero-point energy that never vanishes. In 1948, H. B. G. Casimir argued that, because of the presence of this residual energy, two ideal conducting plates kept parallel in vacuum should spontaneously attract with a force that rapidly increases as they get closer. A few years later, Lifshitz extended the theory to real materials (i.e., not ideal conductors) and showed that the Casimir force is equivalent to the van der Waals interaction once retardation effects (i.e., the effects due to the fact that the interaction is not instantaneous) are accounted for. According to the Lifshitz theory, the strength of the interaction, and even its sign, depends on the dielectric properties of the two juxtaposed surfaces and of the medium in the between. This property has recently received increasing attention for its potential impact in the future design of Micro- and NanoElectroMechanical Systems (MEMS and NEMS), where mechanical pieces often moves at separations at which the Casimir-Lifshitz force might play a relevant role. It has been argued, for example, that if one could "engineer" the quantum vacuum and "tailor" the Casimir-Lifshitz force, new possibilities would open up for the implementation of novel miniaturized devices.

In this talk, after a quick overview of the theory, I will show that, while the design of the Casimir-Lifshitz force in liquids has been largely explored, the possibility to tailor this interaction mechanism in air (where MEMS and NEMS are designed to work) did not receive adequate attention. I will then focus my talk on our state-of-the-art Casimir force set-up, discussing in depth technical challenges and implemented solutions. Finally, I will present an experiment where we have demonstrated that it is possible to halve the Casimir force in air if proper materials are deposited on the interacting surfaces.

Fig. 1: Artistic sketch of the idea behind the experiment on the tunability of the Casimir force in air.



Formation of graphene and boron nitride nanomesh overlayers on Rh(111)

Guocai Dong, Elodie Fourré, Femke Tabak and Joost W.M. Frenken, Kamerlingh Onnes Laboratory, Leiden University, P.O. box 9504, 2300 RA, Leiden, The Netherlands

Boron nitride and graphene both form regular, two-dimensional films with a thickness of precisely one atom on various metal surfaces. This class of two-dimensional materials has special electronic, mechanical, and chemical properties and therefore holds great promise for a variety of appealing applications [1,2].

We have used a special Variable-Temperature Scanning Tunneling Microscope [3] to follow the formation of boron nitride layers and graphene monolayers on the (111) surface of Rh. We have employed two special features of our microscope. First, our STM allows us to observe the surface while the temperatures are varying. We show movies during substantial temperature sweeps over more than 700 K. Second, our STM can observe surfaces at relatively high temperatures. This has enabled us to observe the formation of graphene and boron nitride films under realistic growth conditions, at temperatures up to 1200 K. Our STM movies demonstrate in detail how the complex structures grow and how defects are introduced. Based on these observations we arrive at the optimal recipe for a high-quality overlayer.

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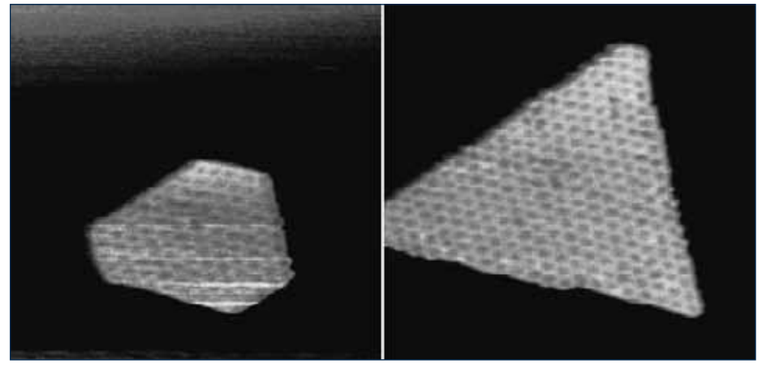

Figure 1 STM images (65 nm × 65 nm) of an h-BN island recorded at 978K during deposition of BN on the Rh (1 1 1) surface. (A) Initial island obtained by low-temperature exposure. (B) Same island after 368 s of further deposition at 978 K; note the change in shape and size and the appearance of kinks along the edges.

Atomic-resolution electron microscopy at ambient pressure

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Keywords: Environmental TEM, ETEM, microelectromechanical systemts, MEMS, gas-solid interactions, nanocrystals, heterogeneous catalysis

High-resolution TEM (HRTEM) is a powerful technique for atomic-scale imaging of nanomaterials that are kept under high vacuum conditions. However, the technique is also used in in situ studies of gas-solid interactions; an application generally referred to as environmental TEM (ETEM). ETEM at the atomic-scale is very demanding because the gas atoms scatter the electron beam and thereby degrade the resolution. A key requirement for ETEM is therefore that the number of gas atoms along the path of the electron beam is limited.

So far, ETEM has yielded to images showing atomic lattice fringes with spacing smaller than 0.2-0.3 nm. In these experiments the solid specimens were exposed to gasses at pressures up to about 10 mbar and temperatures up to several hundred degrees Celsius; see e.g. [1-4].

ETEM has led to significant new insights into the mechanisms of gas-solid reactions in a variety of nanostructured materials, such as heterogeneous catalysts [2-4]. It is, however, important that the new insights are applied with caution. The gas pressures of a few millibars are much lower than the ambient pressures of 1 bar and more in which many nanomaterials find technological application.
Because the state and properties of nanomaterials can depend strongly on the gas environment it is therefore desirable to have an instrument for atomic-scale reaction

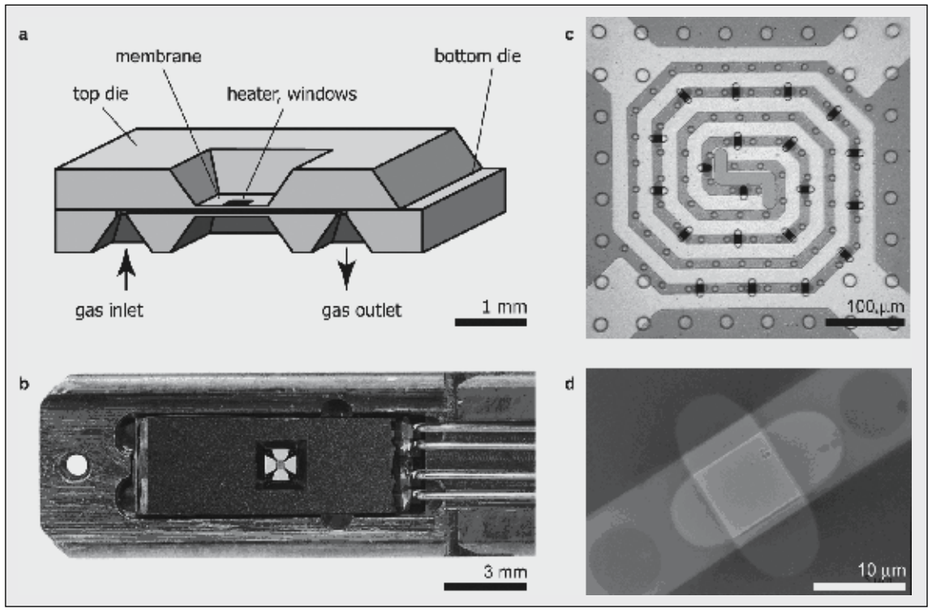

Figure 1: Construction of the MEMS nanoreactor for atomic-scale imaging at ambient pressure. a) schematic cross section; b) photograph of the reactor interfaced with the special TEM specimen holder; c) optical microscope image of the heater spiral (white) and the electron transparent windows (black); d) TEM image of two superimposed electron transparent windows.

imaging at higher pressures for research on applied nanomaterials [5].

Here we report on a novel nanoreactor that enables atomic-resolution ETEM of nanomaterials during exposure to heat and gases at ambient pressure [6]. This is achieved by miniaturizing the gas volume and heater into a microelectromechanical system (MEMS). It fits into the tip of a dedicated sample holder that can be used in a normal CM microscope of Philips/FEI. The performance of the nanoreactor was demonstrated by the in situ studies of a Cu/ZnO catalyst for methanol synthesis. The nanoreactor allowed for the direct observation of nanocrystal growth and mobility on a sub-second time scale during heating to 500 °C and exposure to 1.2 bar of H2. In the same environment, HRTEM images showed atomic lattice fringes in the Cu nanocrystals with spacings that demonstrate a spatial resolution of 0.18 nm. We anticipate that the nanoreactor will generate new insights into a variety functional nanomaterials and the way they interact with ambient environments.

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[7] This work was supported by STW, applied science foundation of NWO and the Ministry of Economic Affairs with financial contributions from FEI Company, Haldor Topsøe A/S, and the European ESTEEM project. Currently, it is part of the Smartmix project NIMIC (Nano Imaging under Industrial Conditions).

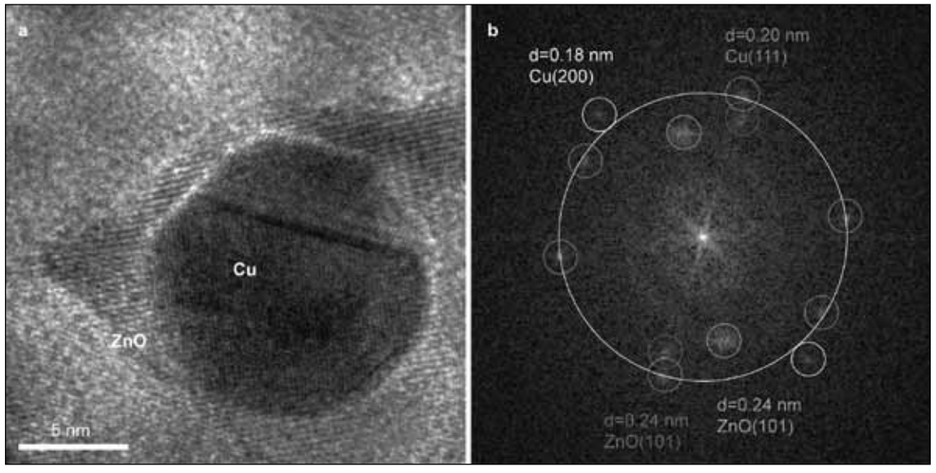

Figure 2: First TEM image at 1.2 bar pressure at 500°C with atomic-scale resolution. The image represents a catalytic Cu nanoparticle on top of a ZnO grain. a) real-space image with atomic lattice fringes; b) Fourier transform of the image attesting the resolution limit of 0.18 nm.

The TEAM project: detection of single atoms and buried defects in three dimensions by aberration-corrected electron microscopy with 50pm resolution

M.M.J. Bischoff[1], B. Freitag[1], S. Lazar[1], C. Kisielowski[2], R. Erni[2], and S. von Harrach[1]

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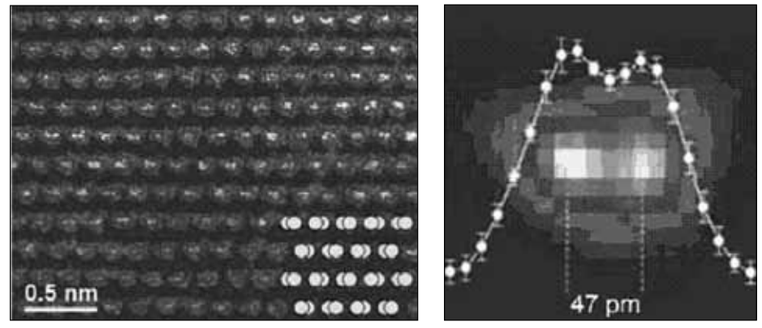
TEAM is a unique program for the Electron Microscopy community, requiring close cooperation between five National Labs supported by the US Department of Energy. Its final goal is to open a 50pm-resolution EM user-facility at the National Center of Electron Microscopy in Berkeley in October 2009. FEI Electron Optics (microscope platform, integration) and CEOS GmbH (correctors) were chosen by TEAM as the sole manufacturers to deliver the world-record breaking microscopes which should be able to resolve 50pm in both fixed beam (Transmission Electron Microscopy (TEM)) and scanning probe modes (Scanning Transmission Electron Microscopy (STEM))

Starting from a standard, commercially available FEI Titan 80-300kV microscope with resolution specification of 100pm, the microscope was further improved with respect to mechanical and electronic stability. Furthermore, the Titan was equipped with next-order aberration correcting optics and a monochromated high-brightness electron source. During the factory tests in Eindhoven, we have successfully shown 50pm resolution with improved contrast and precision in determining atomic positions [1]. Figure 1 shows that the dumbbells on Ge[114], i.e. atomic columns separated by 47pm, can be resolved with a contrast of 10-20%.



(a) *(b)*

Figure 1: (a) HRSTEM image of Ge[114]; the crystal structure shown in the inset indicates the Ge dumbbell spacing of 47pm in this projection. (b) The line trace across the dumbbell shows that the 47pm column distance is resolved with 10-20% contrast.

The instrument's new capabilities were exploited to detect a buried Σ3 {112}grain boundary with high resolution in 3D (see Figure 2) and to observe the dynamic arrangements of single atoms and atoms pair with sub-angstrom resolution [1]. Due to the higher brightness and better stability, beam-sensitive materials like carbon nanotubes and graphene [2] can be imaged without damage at atomic resolution using lower acceleration voltages.

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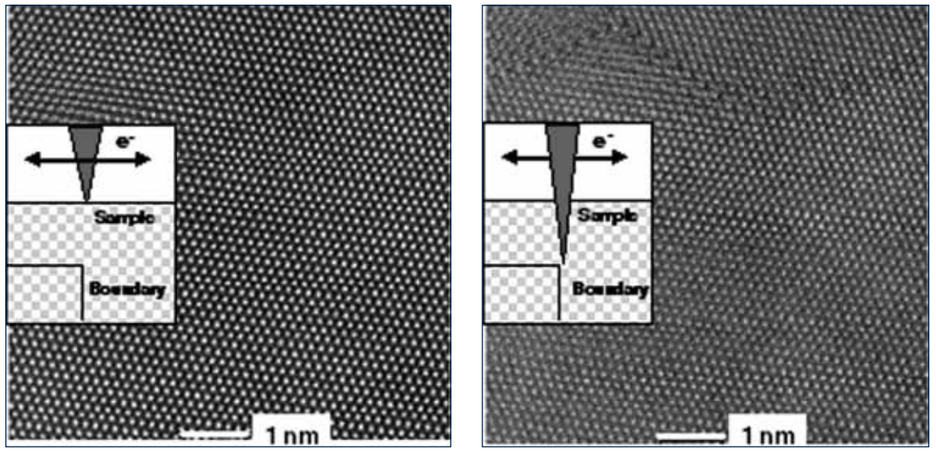


Figure 2: HRSTEM image of Au[111]: (a) the STEM probe is focussed on the sample as indicated by the sketch in the inset. (b) Σ3 {112}grain boundary in the lower section of the foil (see inset) is only revealed when the probe is focussed 6nm into the sample.

Design and Manufacturing Aspects of Vacuum Chambers for Science Applications

Dr. F. M. Esser, F. Klehr, J. Collienne, Dr. H. Glückler, W. Göpel, G. Hansen and Dr. H. M. Schmitz, Central Technology Division (ZAT), Forschungszentrum Jülich GmbH, Jülich, Germany

The Central Technology Division (ZAT) has wide experience in designing and manufacturing specialized vacuum chambers for miscellaneous applications in scientific research. Our customers are located all over the world in universities, research centers or research reactors. The vacuum chambers are used for experiments in biology or experimental studies of the atmosphere as well as for experiments for neutron science. Many applications are found in particle accelerator physics and in addition they are also often designed as a cryostat vessel required for many experiments.

Fig. 1: Vacuum chamber for biological application at FZ Jülich, Germany, manufactured at ZAT in 2008.

In the majority of cases the Work packages comprise both the mechanical design including finite element calculations and the manufacturing of the vacuum chambers. The required vacuum qualities range from about 10^{-3} mbar to better than 10^{-11} mbar. Depending on that the surface quality respectively the surface treatment of the used material plays a decisive role. In particular the treatment of the vacuum surface is very important to avoid a permanent baking system for a vacuum chamber.

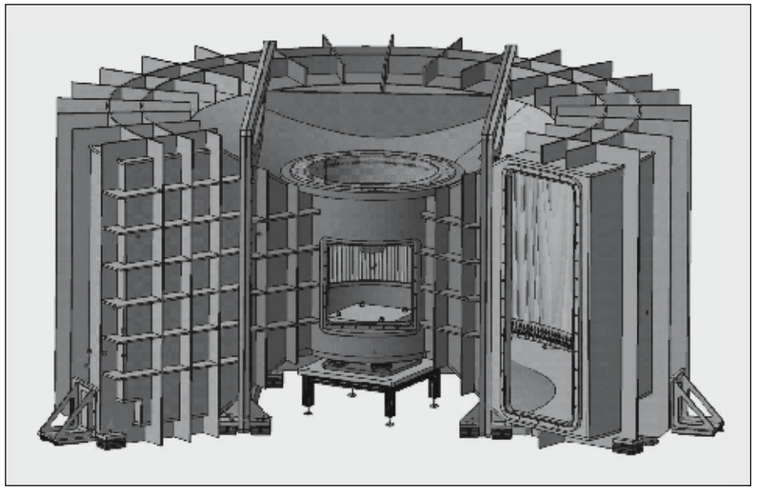
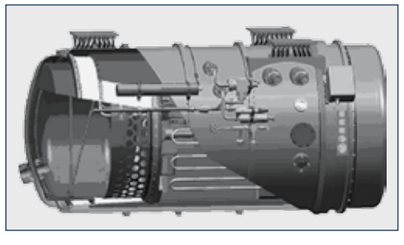


Fig. 2: Design of a vacuum chamber for neutron science (~ 7.0 m in diameter, height 3.5 m, weight about 15 t, material AlMg4,5Mn) at Research Reactor FRM II, Munich, Germany.

Furthermore, ZAT is responsible for the complete design of the vacuum system of the High Energy Storage Ring (HESR) for antiprotons as a contribution to the FAIR project at GSI in Darmstadt, Germany.

This paper will present an overview of the necessary steps when designing and manufacturing vacuum chambers and will emphasize the relevance of the surface treatment process. In addition it will present specific aspects such as requirements for material or sealing and will detail some examples.



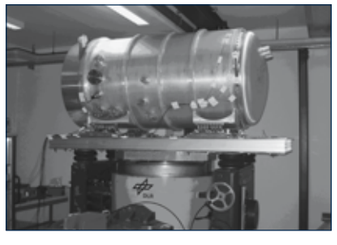


Fig. 3: Design and picture of a cryostat vessel for a flight experiment for atmosphere measurements (consortium of FZ Jülich, Uni Wuppertal, RWTH Aachen).

Characterization of Nanoparticles and Nanosized Pores by X-Ray Diffractometry and Small-Angle X-Ray Scattering (SAXS)

J. Bolze, D. Beckers, P. Munk, PANalytical B.V., The Netherlands, V. Kogan, Dannalab & PANalytical B.V., The Netherlands*

This paper will present the characterization of nanopowder materials, nanocomposites and porous materials using X-ray diffraction, with specific focus on the small-angle X-ray scattering (SAXS) technique for the investigation of crystalline and amorphous materials on a length scale ranging from ca. 1 - 100 nm. Dry powders or dispersions of inorganic and organic nanoparticles can be characterized with respect to their particle size distribution, specific surface area and inner structure. In case of porous materials the specific inner surface area and pore size distribution may be determined. Compared to BET, TEM and light scattering techniques, the method is fast and no specific sample preparation is required. It has a very good precision, particularly so for very small particles and pores with a size below 10 nm. It will be demonstrated that such type of measurements are possible on a multi-purpose X-ray diffractometer platform with an option for automation in routine production control. Application examples for the characterization of photocatalytic nanoparticles, nanocomposties and porous nanopowders will be discussed.

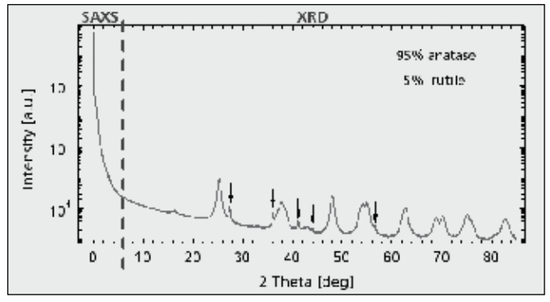
Introduction

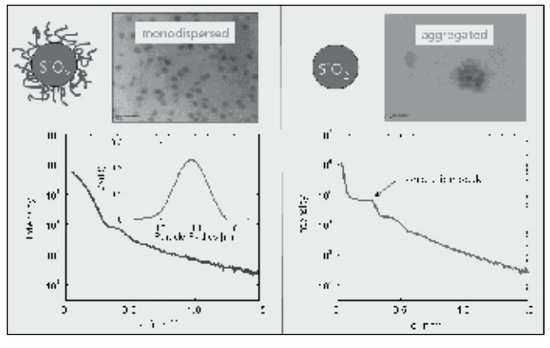
Nanoscaled materials are becoming increasingly important in various applications such as coatings, paints, cosmetics, ceramics, polymers, catalysis and drug delivery. The properties and performance characteristics of nanoparticles are to a large extent determined by their size distribution and specific surface area. Similarly, with porous materials containing nanosized pores, as used e.g. in delivery systems, separation processes or catalysis, the pore size distribution and specific surface area are key quality parameters. It is thus well recognized in the industries and research labs that produce, develop or apply such materials, that it is essential to control and quantify these aforementioned properties.

With most available experimental methods this task becomes increasingly challenging with decreasing sizes below 100 nm. As an example, laser diffraction is a well established and powerful sizing method for particles in the range of micrometers down to 100 nm. However, with particles smaller than 100 nm and the wavelength of laser light being significantly larger, this technique is becoming less suitable. For nanomaterials characterization it is thus logical to make use of methods that are based on electromagnetic radiation of a shorter wavelength. X-rays having a wavelength of the order of 1 Å are widely used in diffraction experiments for the analysis of crystalline materials with atomic resolution. Qualitative and quantitative analysis of crystalline phases can be done from the diffraction peak positions and intensities measured with XRD from powder materials. The width of the peaks can be correlated with the crystallite size of the materials.

When extending such wide-angle X-ray diffraction (XRD) measurements down to very small angles, one is probing the electron density distribution on increasingly larger length scales in the range of nanometers. The small-angle X-ray scattering (SAXS) technique (ref. [1-3]) is thus ideally suited for the structural characterization of nanoscaled materials, and among others, allows for nanoparticle and pore size analysis and specific surface area determination. This was already recognized in the 1930's and since then the method has continuously been further developed and applied. However, unlike XRD, SAXS has been used mainly by academic researchers and is still not well known in industry. With the ongoing advances in nanotechnology, it may be expected though, that this extremely versatile and powerful technique will find more applications in industrial developments and quality control.

Combined SAXS and XRD measurements on a nano-titania powder sample





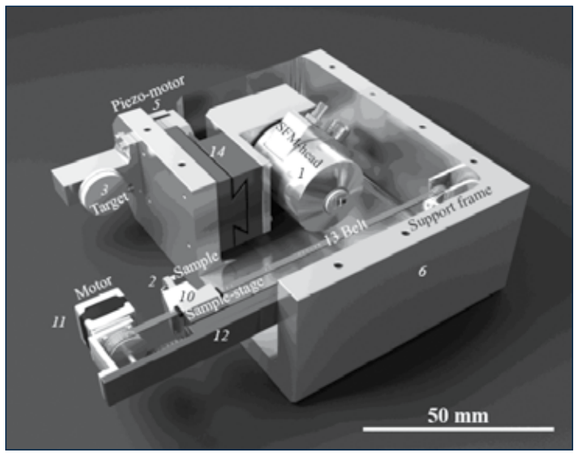
Left - TEM of PMMA-silica nanocomposite and schematic structure of the surface-modified nanoparticle filler used. Shown below are the background-corrected SAXS data and the deduced size distribution of the nanoparticles. Right - Comparison with results that were obtained when the pristine nanoparticles without surface-modification were used. Samples and electron micrographs courtesy C. Beckers, Inst. Henri Tudor / Luxembourg

Monitoring oxide thin film growth with in-situ scanning force microscopy

Guus Rijnders, Faculty of Science & Technology and MESA+ Institute for Nanotechnology, University of Twente, The Netherlands

Scanning Force Microscopy (SFM) is one of the most important tools in nanotechnology and surface science. Because of recent developments, it is nowadays also used to study dynamic processes, such as thin film growth and surface reaction mechanisms. We have realized a system (see figure 1), in which SFM can be performed during Pulsed Laser Deposition (PLD). Deposition and force microscopy are performed in one vacuum chamber and via a fast transfer (in the order of seconds) the surface of a sample can be scanned. In our system we take advantage of the pulsed deposition process, because microscopy measurements can be carried out between the pulses. This provides real-time morphology information on the microscopic scale during growth. The transfer mechanism allows switching between microscopy and deposition with a re-position accuracy of ±500 nm, which gives new opportunities to study growth processes. Furthermore, it can provide information if RHEED is not possible, for example during amorphous and polycrystalline growth. In our experiments, we used an inverted fiber SFM, based on a commercially available SFM (Ultraobjective from SIS GmbH, Germany). The piezo-scanner is thermally isolated from the heat source by placing a 20mm long macor-tube on top of the scanner. The geometry of the electrodes of the piezo scanner is such that, at the maximum applied voltage, no voltage breakdown is expected in the pressure range of interest. Using the modified SFM, measurements at elevated temperature are possible in which the maximum operating temperature merely depends on the thermal load. To minimize this load, we developed a low power heating stage. Small thermal mass heaters are designed to obtain stable monitoring at temperatures >700ºC in a high-pressure environment. In this contribution, the in-situ SFM will be presented as well as the latest equipment developments. With high-temperature microscopy, growth characterization at typical deposition conditions of complex oxides becomes feasible.

Figure 1 schematic view of the in-situ SFM-PLD setup.



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- Vacuüm flenzen, bouwdelen, afsluiters, stroomdoorvoeren, vloeistof doorvoeren, kijkvensters.
- Vacuüm drukregelafsluiters.
- Manipulatoren en sample transfers in vacuüm. Verwarming en koeling in vacuüm op (roterende) sample houders.
- Geventileerde bouten, eventueel voorzien van coating (Zilver, WS2, MoS2).
- Vacuüm drukmeters van Atm. tot 2.10^{-11} mBar. Tevens wide range sensors.
- Vacuüm pompen en revisie van ionen getter pompen.
- Speciale vacuümkamers en turn-key systemen inclusief engineering.
- Portable en Cabinet Helium lektesters.
- Sputter en e-gun componenten en systemen.
- Quartz laagdikte controllers en monitoren.
- Gloveboxes op klantspecificatie, inclusief automatische regeneratie.
- Cleanroom kleding en handschoenen.
- Spares en olie, vetten, UHV folie.

Orgaan van de Nederlandse Vacuumvereniging

NEVAC *blad*