

BIPM – VAMAS Workshop

EMERGING MEASUREMENT CHALLENGES IN MATERIALS METROLOGY

Graham Sims, NPL, VAMAS Chair
Sèvres Cedex, France
October 25th, 2016

Outline

- Introduction to VAMAS
- Introduction to Materials Metrology –
“metrology applied to material property measurement”
- BIPM-VAMAS joint meeting

Versailles Project on Advanced Materials and Standards -- History

8th - G7 Leaders Economic Summit

June 1982 - Versailles



Formed as one of 18 cooperative projects to stimulate **world trade** in new technologies using **advanced materials** through **pre-standards research**

- Only one surviving and growing in spite of research being unfunded



...after 34 Years

Lasting and growing - G15 + EC Grouping

Canada . France . Germany . Italy . Japan . UK . USA . EC . Brazil . Mexico . Chinese Taipei . South Africa . Australia . Korea . India . China
1982 . 1983 . 2007 . 2008 . 2013

Steering Committee

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VAMAS Mission

The main objective of VAMAS is to promote world trade by innovation and adoption of advanced materials through international collaborations that provide the technical basis for harmonisation of measurement methods, leading to best practices and standards.

What is VAMAS?

Versailles project on Advanced Materials and Standards

- Undertakes pre-standards research to support trade in products using advanced materials
- Develops and optimizes test methods etc. for emerging materials with support from industry, academia and standardisers
- Encourages and increases the number of researchers involved in standardisation activities
- Validates methods through interlaboratory (round-robin) trials
- Projects are undertaken in Technical Work Areas (TWAs) that are established for set periods until work is completed

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Who can participate and how?



- Anyone, with expertise in the area of study
 - from VAMAS member or non-member regions
- Participant is able to self fund individual activity (test materials are – normally- supplied free)
- Check www.vamas.org for current projects “open” to new participants
- Propose new work area or project in existing TWA
- Contact TWA Chair, Project Leader, Steering Committee (SC) representative for region, or VAMAS Secretariat

VAMAS SC Meeting

- 41st Annual Steering Committee meeting held within MRS/ IMRC 2016 in Cancun, Mexico hosted by CENAM,
- VAMAS organised a 2 day technical seminar and a plenary lunchtime presentation by GDS within the Materials Congress,
- Mexico re-confirmed their more recent membership,
- Australia has offered to host the 2017 meeting.



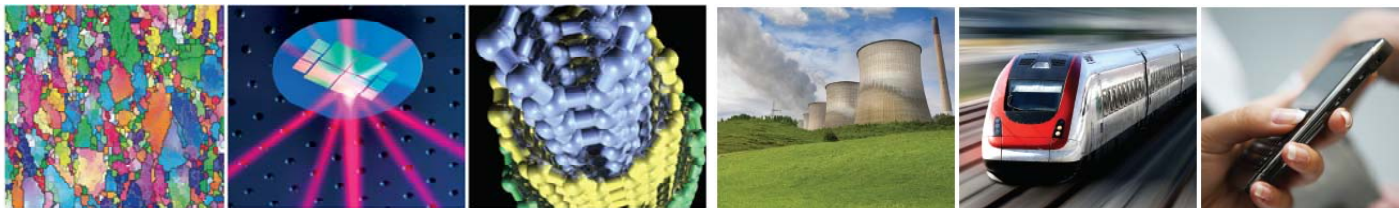
NPL Management



Technical Working Areas (TWA)

Currently active

- Surface Chemical Analysis
- Polymer Composites
- Superconducting Materials
- Mechanical Properties of Thin Films and Coatings
- Performance Related Properties of Electroceramics
- Spectrometry of Synthetic Polymers
- Nanomechanics applied to Scanning Probe Microscopy
- Creep, Crack and Fatigue Growth in Weldments
- Modulus Measurements
- **Polymer Nanocomposites**
- Nanoparticle Populations
- Materials Databases Interoperability
- Organic Electronics
- Quantitative Microstructural Analysis
- Thermoelectric Materials
- Solid Sorbents
- **Synthetic Biomaterials**
- **Graphene and related 2D Materials**
- **Raman Spectroscopy**

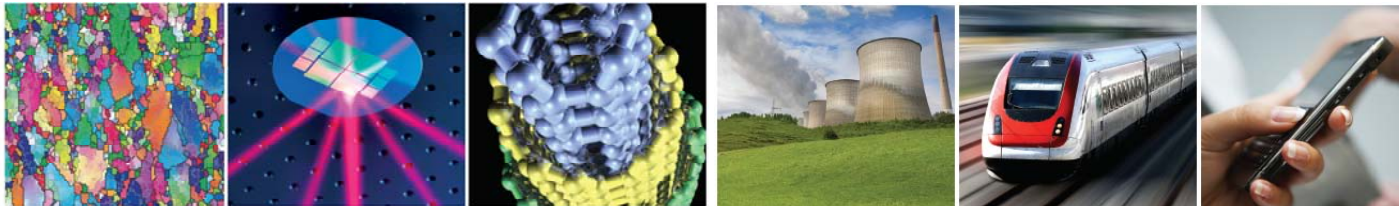


Over 45 active projects

Technical Working Areas (TWA)

Completed

- Wear test methods
- Ceramics for structural applications
- Multiphase Polymers
- Superconducting and Cryogenic Structural Materials
- Biomaterials
- Hot Salt Corrosion Resistance
- Weld Characteristics
- Computerised Materials Data
- Creep Crack Growth
- Efficient Test Procedures for Polymers
- Unified classified system for advanced ceramics
- Low cycle fatigue
- Unified classified system for advanced ceramics
- Metal matrix composites
- Cryogenic structural elements
- Statistical techniques for interlaboratory studies
- Mechanical Measurements for Hardmetals
- Thermal Properties of Thin Films
- Creep, Fatigue Crack Growth in Components
- Full Field Optical Stress and Strain Measurement
- Characterisation Methods for Ceramic Powders and Green Bodies
- Tissue engineering





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[Structure](#)

[Representatives](#)

[Technical Working Areas](#)

[Connections](#)

[Members Area](#)

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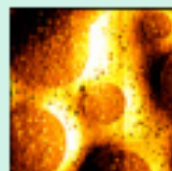
Versailles Project on Advanced Materials and Standards (VAMAS)

VAMAS supports world trade in products dependent on advanced materials technologies, through International collaborative projects aimed at providing the technical basis for harmonized measurements, testing, specifications, and standards.

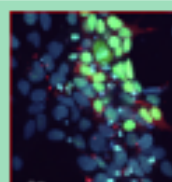


The 41st Steering Committee Meeting of VAMAS was held alongside the 25th International Materials Research Congress in August 2016. VAMAS Technical studies covering various TWAs were presented within a dedicated symposium [Materials Properties and Pre-Normative Standardization Initiatives](#) as part of the Congress.

TECHNICAL WORK AREAS (2016) **NEW!**



- Synthetic Biomaterials (TWA 40)
- Graphene and related 2D Materials (TWA 41)
- Raman Spectroscopy and Microscopy (TWA 42)



INTERNATIONAL INTERCOMPARISON EXERCISES

For a listing of some of the current interlaboratory exercises [select this link](#).

For more information, or to express your interest to participate, please contact the relevant [TWA Chairs](#) or the [VAMAS Secretariat](#).



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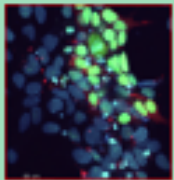


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www.vamas.org



• [Raman Spectroscopy and Microscopy \(TWA 42\)](#)



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Current Materials Drivers

- International standards organisation increasingly require precision data to be given
- Open data initiatives will increase need for evidence of the validation of measurements and resultant data (see also IMRR initiative on data quality metrics)
- “Gold”, “Silver” and “Bronze” grading further developed in IMRR

Gold = calibrated equipment + standard method + well-characterised material

- Main activities of VAMAS are:
 - drafting procedures for standardisation *that are used for*
 - method validation using interlaboratory trials *yielding*
 - precision data (repeatability, reproducibility)

Development of Materials Metrology

- Initial proposer to CIPM by VAMAS supported by ANMET (APEC) for consideration of “the application of metrology best practice to the measurement of material properties”
- Ad-hoc **BIPM/VAMAS** group led by Bennett/Sims reviewed “**evolving needs for materials metrology**” (BIPM report and Metrological paper - Bennett S., Sims G., Metrologia, 2010, 47, S01-S17) (>600 downloads)



MoU signed with BIPM in 2008 to “develop the subject of materials metrology”

Evolving Need for Metrology in Material Property Measurements

Report of the CIPM *ad hoc* Working Group on Materials Metrology (WGMM)

2008

Bureau international
des poids et mesures

Organisation intergouvernementale
de la Convention du Mètre

AD-HOC WORKING GROUP ON MATERIALS METROLOGY (WGMM)

MEMBERSHIP

Chairman:	Bennett, Seton	NPL
Secretary:	Sims, Graham	NPL
Attending members:	Achete, Carlos	INMETRO
	Amis, Eric	NIST
	Baba, Tetsuya	NMIJ
	Bahng, Gun Woong	KRISS
	Charlet, Philippe	LNE
	Choi, Seong-Jai	KRISS
	Emons, Hendrik	IRMM
	Kaars, Bob	CCQM
	Kasai, Junichi	NIMS
	Kayser, Rich	NIST
	Kustikov, Yury	VNIIM
	Lexow, Juegen	BAM
	Leaman, Dana	ILAC
	Mitani, Yoshito	CENAM
	Prins, Sara	NMISA
	Roebben, Gert	IRMM
	Westwood, Stephen	BIPM
Corresponding members:	Buck, Wolfgang	PTB
	Diatlev, Alexey	VNIIM
	da Jornada, João	INMETRO
	Germak, Alexandro	IMGC
	Okaji, Masahiro	NMIJ
	Roebuck, Bryan	NPL
	Squirrell, Alan	ILAC
	Tanaka, Mitsuru	CCM
	Thomas, David	NPL
	Uemasta, Yoshi	ILAC
	Wallard, Andrew	BIPM

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Downloaded
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2008

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TWA/CC Alignment - 2014

VAMAS Technical Work Area	Primary CC	Secondary CC			
TWA 2 - Surface Chemical Analysis	CCQM	CCL			
TWA 5 - Polymer Composites	CCT	CCL	CCM	CCAUV	
TWA 16 - Superconducting Materials	CCEM	CCL	CCM	CCT	
TWA 22 - Mechanical Properties of Thin Films and Coatings	CCM	CCL	CCT	CCAUV	CCU
TWA 24 - Performance Related Properties for Electroceramics	CCEM	CCL	CCM		
TWA 26 - Full field optical stress and strain measurement	CCL				
TWA 28 - Quantitative mass Spectroscopy of Synthetic Polymers	CCM	CCQM			
TWA 29 - Nanomechanics applied to Scanning Probe Microscopy	CCL	CCEM			
TWA 31 - Crack growth in Weldments under Creep/Fatigue Loading	CCL	CCTF			
TWA 32 - Modulus Measurements	CCL	CCM			
TWA 33 - Polymer Nanocomposites	CCL	CCQM	CCEM	CCTF	
TWA 34 - Nanoparticle Populations	CCL	CCQM			
TWA 34 – Materials Databases Interoperability					
TWA 36 - Organic Electronics	CCEM	CCM	CCPR		
TWA 37 - Quantitative Microstructural Analysis	CCL	CCQM			



Versailles Project on Advanced Materials and Standards (VAMAS)

→ VAMAS supports world trade in products dependent on advanced materials technologies, through international collaborative projects aimed at providing the technical basis for harmonized measurements, testing, specifications, and standards.

The BIPM's collaboration with VAMAS builds on the recommendations of the CIPM *ad hoc* Working Group on Materials Metrology (see the WGMM report *Evolving Need for Metrology in Material Property Measurements* (2008)). As in other areas, the BIPM works to promote improved traceability, better comparability of data and the availability of appropriate reference materials, all of which are important for regulators, manufacturers, standards bodies and accreditation bodies.

→ Formal relationship:

- BIPM-VAMAS MoU

→ Links between the BIPM and the VAMAS:

- The BIPM and VAMAS work together to identify and solve issues of metrological traceability, estimation of measurement uncertainty and the use of SI units for measurements of (and related to) materials properties.
- VAMAS gave a presentation during the March 2014 CIPM bureau meeting to exchange understanding on matters relating to materials metrology.

→ BIPM contact(s):

- Mr Andy Henson

→ VAMAS contact(s):

- Prof. Graham Sims (NPL), VAMAS Chair
- Mr Sam Gnaniah (NPL), VAMAS Secretary

Organization:



Recommendations: To CIPM

- (1) The Working Group recommends that the CIPM should sign a Cooperation Agreement with VAMAS in order to ensure an ongoing dialogue and actions with a view to identifying key traceability issues affecting the accuracy and repeatability of the measurement of materials properties.
- (2) The Working Group recommends that the CIPM should instigate a further review in 3 or 4 years time to evaluate the progress made and determine what further action, if any, is required.

Recommendations: To Consultative Committees

The Working Group recommends that CC working groups should be established to stimulate comparisons, establish measurement capabilities in NMIs and identify suitable certified reference materials with known uncertainties.

(3) The Working Group recommends that the CCEM should establish a working group on electromagnetic properties of materials.

(4) The Working Group recommends that the CCAUV should establish a working group on acoustic properties.

(5) The Working Group recommends that the CCM and CCL should consider the case for a joint working group on mechanical properties of materials, with VAMAS representation.

(6) The Working Group recommends that materials WGs established by CCs should encourage participation of all important stakeholders, including ISO/IEC, ILAC and VAMAS.

Recommendations: To VAMAS

- (9) The Working Group recommends that VAMAS Steering Committee should initiate a top-down review, with other stakeholders, to identify priority actions in selected areas and draw these to the attention of CIPM, ILAC and NMIs.
- (10) The Working Group recommends that VAMAS develop with CIPM appropriate pilot studies.

Recommendations: To National Metrology Institutes

- (7) The Working Group recommends that NMIs should support materials metrology in their work programmes in order to implement and disseminate best practice in the measurement of materials properties.
- (8) The Working Group recommends that NMIs should encourage their staff to participate actively in the work of joint BIPM/VAMAS materials working groups.

EMERGING MEASUREMENT CHALLENGES IN MATERIALS METROLOGY

- The workshop will consider four themes in materials research, and will consider the new challenges for measurement science that are emerging in each of them.
- The outcomes of the workshop will include a report that summarizes the scope of the new challenges for measurement science in each of the four themes. It will also identify any requirements for additional coordination between BIPM and VAMAS to ensure that the necessary underpinning measurement traceability and infrastructure is available.

Case Study Sessions

1. Reliability of additively manufactured products.

Session Chair: Dr Graham Sims (NPL)

2. Characterization of properties and effects of nanomaterials and systems.

Session Chair: Dr Toshiyuki Fujimoto (NMIJ)

3. Characterization challenges for “beyond CMOS” technologies.

Session Chair: Dr Wolfgang Unger (BAM)

4. Reliability and performance of novel materials for protective systems.

Session Chair: Dr Michael Fasolka (NIST)

1. Reliability of additively manufactured products.

Session Chair: Dr Graham Sims (NPL)

“As the material is manufactured at the same time as the AM product, there is an increased need to provide measurements ensuring quality. These methods encompass input material characterisation and control, in-process measurements (thermal monitoring, optical imaging and geometrical monitoring) and post-manufacture assessments (e.g. dimensional measurements, surface and sub-surface monitoring, X-ray CT, property measurements, ultrasound). The current trends in application of measurements applied to these, often bespoke and small volume products, are reviewed and current priorities assessed.”

1. Reliability of additively manufactured products.

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NPL funding a PhD on this topic from Oct. 2016

2. Characterization of properties and effects of nanomaterials and systems.

Session Chair: Dr Toshiyuki Fujimoto (NMIJ)

"With the rapid spread in the application of nanotechnology to industry, a detailed understanding of what properties of nanomaterials and their interaction with surrounding systems is of paramount importance. The current situations on the measurement and characterization for nanomaterials and systems will be overviewed and problems and solutions will be discussed."

3. Characterization challenges for “beyond CMOS” technologies.

Session Chair: Dr Wolfgang Unger (BAM)

*“There are a number of promising successors to modern CMOS transistors. Examples include carbon nanotube transistors (CNFET), molecular electronic transistors (MEFTE), spintronic devices (SpinFET) and transistors based on organic materials (OrgFETs). In all these of cases existing design challenges will be overcome by using novel device concepts based on new materials. **For example, specific challenges for organic electronics are lifetime and durability.** In order to master the design technologies needed to achieve competitive systems without compromising reliability, those material properties for which traceable measurement results are important must be identified and new tools and methodologies for traceable materials testing be developed for engineering and QC in manufacturing”.*

4. Reliability and performance of novel materials for protective systems.

Session Chair: Dr Michael Fasolka (NIST)#

“A large number of occupations, from athletics to emergency responders and soldiers, require protection from impact injury. As more is understood about the range of trauma that can result from impact (especially to the brain) it has become apparent that protective systems, and the materials within them, require attention and redesign. The measurement challenges associated with characterizing the performance of emerging impact-energy absorbing materials, and with predicting their long term reliability will be examined and potential solutions discussed.”

Day 1 – Plenary / Ensuring the reliability of additive manufacture products session

	Chair	Presenter	Affiliation	Country	Talk
9:00					Coffee and Registration
9:30	Dae-Im Kang	Dae-Im Kang	KRISS/CIPM	KR	Welcome and purpose of the meeting
9:40		Martin Milton & Graham Sims	BIPM & VAMAS	Int	Introduction to BIPM and VAMAS
10:10	Graham Sims	Hendrik Emons	IRMM	EC	Certified Reference Materials as traceability anchor for measurements on advanced materials
10:40		Graham Sims	NPL	UK	Introduction to the case study, including range of materials relevant, primary and secondary properties, current measurement situation
11:10					Coffee
11:30	Graham Sims	Laurent Pambaguian	ESA	EC	Property measurements needed by the end-user
12:00		Wayne King	LLNL	US	Property measurement challenges, e.g. traceability, length and time scales
12:30		Klas Magnus Boivie	SINTEF	NO	Property measurement challenges - status of standardisation
13:00					

Day 1pm – Characterization of properties and effect of nano materials systems Session

	Chair	Presenter	Affiliation	Country	Talk
14:00	Toshiyuki Fujimoto	Robert Watters	Formerly NIST	US	Estimation and use of measurement uncertainty in metrology for advanced materials
14:30		Toshiyuki Fujimoto	NMIJ	JP	Introduction to the case study, including range of materials relevant, primary and secondary properties, current measurement situation
15:00		Jean-Marc Aublant	LNE	FR	Definitions and Overviews
15:30		Masanobu Awano	Univ. Keio	JP	Current topics in nano-carbon materials
16:00					Coffee
16:30	Toshiyuki Fujimoto	Erlon Ferreira	INMETRO	BR	
17:00		Harald Krug	EMPA	CH	Current topics in nano-bio systems
17:30	Dae-Im Kang				Discussion Session
18:00					Closure

Day 2 am – Plenary / Characterization challenges for "beyond CMOS" technologies session

	Chair	Presenter	Affiliation		Talk
9:00					Arrival and Coffee
9:30	Dae-Im Kang	Chong-sam Chung	Samsung	KR	Development of metrology and standards addressing measurement and characterization in the “beyond CMOS” technologies
10:00	Wolfgang Unger	Fernando Castro	NPL	UK	Introduction to the case study “Organic electronics” including range of materials relevant, primary and secondary properties, current measurement issues
10:30		Klaus Ensslin (Curt Richter)	ETH Zurich (NIST)	CH (US)	Graphene/other 2D materials quantum electronics
11:00					Coffee
11:30	Wolfgang Unger	Bob McMichael	NIST	US	Magnetic Nanostructures for Post-Complementary Metal-Oxide-Semiconductor Electronics
12:00		DIN representative (TC 201,202,229)			Property measurement challenges - status of standardisation

Day 2 pm - Reliability and performance of novel materials for protective systems session

	Chair	Presenter	Affiliation	Country	Talk
12.30	Michael Fasolka	Michael Fasolka	NIST	US	Introduction to the case study “Protective Materials” including range of materials relevant,
12.45		Richard McCallion	CPS Commission	US	Consumer Products Safety
13.00					Lunch
13:30	Michael Fasolka	Blaine Hoshizaki	University of Ottawa	CA	Measurement Needs for protection materials: Athletics
14:00		Clive Siviour	University of Oxford	UK	Properties of materials under high-strain-rate deformation
14:30		Jeff Crandall	UVA	US	Impact measurements for automotive safety, and sports and military protection
15:00					Coffee
15:30	Michael Fasolka	Richard McCallion	CPSC	US	Measurement & standards for protective equipment testing
16:00	Dae-Im Kang				Final Discussion Session
16.30					Closure



SAVE THE DATE: 20 and 21 June 2016

Continuing the tradition of joint workshops hosted at the BIPM bringing together the worlds experts on topics of interest and importance, the

International Bureau of Weights and Measures (BIPM)

and the

Versailles Project on Advanced Materials and Standards (VAMAS)

invite you to their workshop on

EMERGING MEASUREMENT CHALLENGES IN MATERIALS METROLOGY

to be held at the

BIPM

12bis Grande Rue, F-92310 Sèvres, France

Chaired by Dr Dae-Im Kang, CIPM Member (KRISS)

The workshop will include sessions on:

1. Characterization of properties and effects of nanomaterials and systems
2. Reliability of additively manufactured products
3. Characterization challenges for "beyond CMOS" technologies Session Chair
4. Reliability and performance of novel materials for protective systems

Status Report

1. Meeting organised at request of NMI Directors
2. Excellent quality meeting organised, even though speaker choice limited by lack of funding
3. Lack of response when advertised for June 2016, particularly from CCs areas in NMIs
4. Meeting postponed, with speakers generally supportive of presenting at a re-arranged date

Next Steps

5. New date to be confirmed ASAP
6. Funding of speakers to be investigated
7. Invites to be sent to speakers by BIPM/VAMAS leadership
8. NMI Directors to encourage staff to attend