Short Abstracts

S1-1 Information Security

Smart Grid and Cyber Security

Annabelle Lee, Computer Security Division, Information Technology Laboratory, National Institute of Standard and Technology

The talk will give an overview of the Smart Grid Interoperability Panel - Cyber Security Working Group that is lead by NIST. We are addressing the high level cyber security requirements for the Smart Grid.

FIPS 140-3 Non-Invasive Attack Testing

Hirofumi Sakane, Research Center for Information Security, National Institute of Advanced Industrial Science and Technology, and Computer Security Division, National Institute of Standards and Technology

Various information security standards are in effect worldwide. These standards are updated periodically to address new attack and defense technologies. Thus, FIPS 140-3 is planned to supersede FIPS 140-2, the current federal standard on security requirements for cryptographic modules.

This talk summarizes the joint effort NIST and AIST have undertaken to update portions of FIPS 140-2. In this talk we introduce Non-Invasive Attacks, which the draft standard FIPS 140-3 addresses in a new section. We also briefly discuss information security concerns in Smart Grid technologies, using smart meters and EV charging systems as examples. The Cyber Security Coordination Task Group has listed all applicable existing information security standards to be reviewed. FIPS 140-2 is listed as a guide to cryptographic suites. We expect that once FIPS 140-3 is signed off, it will supersede FIPS 140-2 for Smart Grid Cyber Security as well.

S1-2 Solid State Lighting

Development of Photometric Measurement Techniques for Solid State Lighting (SSL)

Tatsuya Zama, Photometry and Radiometry Division, National Metrology Institute of Japan (NMIJ), AIST

Reducing energy consumption is necessary for reducing carbon dioxide (CO_2) emissions. Modern society consumes considerable amount of energy for lighting, therefore improving luminous efficiency (the ratio of total luminous flux to power: lm/W) of light sources is important. Solid State Lighting(SSL) are expected to become widely used in the near future because SSL has the potential to achieve higher luminous efficiency. However the evaluation of the luminous flux of SSL is not easy and it is consequently indispensable to develop luminous flux evaluation method for SSL and to ensure reliability of luminous efficiency of SSL. A substitution method using a standard lamp with an integrating sphere has been traditionally used to evaluate total luminous flux of light sources. However, the substitution method cannot be applied to most of SSL products, whose angular intensity distribution differs from standard lamp. If the angular intensity distribution of the lamp under-test is different from that of the standard lamp, the uncertainty of total luminous flux is mainly due to spatial non-uniformity of the wall reflectance in integrating sphere,

In the presentation, we mention a beam scanner, which is designed jointly by AIST and NIST, for evaluating the non-uniformity, and also mention briefly the present state of our research of photometric measurement for Light-Emitting Diodes(LEDs) and SSL .

NIST’s Role in Standardization of Solid State Lighting

Yoshi Ohno, Optical Technology Division, Physics Laboratory, National Institute of Standard and Technology

This presentation will first overview the approaches taken by the U.S. Department of Energy and Environmental Protection Agency to promote solid state lighting (SSL) in the USA, through the Energy Star and several other programs. Several new national standards have been developed in American National Standards Institute (ANSI) and Illuminating Engineering Society of North America (IESNA) to support the Energy Star SSL program, and NIST took leading roles in developing some of the standards developed. Energy Star also requires an accreditation program for testing laboratories in this field, which has been developed by the Optical Technology Division and National Voluntary Laboratory Accreditation Program (NVLAP) at NIST. Our Division provides technical support for the NVLAP SSL program including technical assessment and round robin testing for SSL. We work closely with the Department of Energy on these activities.

The Optical Technology Division also conducts research needed for new standards on measurement and test methods for LEDs and SSL products. We recently developed a practical method for measurement of high-power LEDs to solve the difficulty in reproducible measurements of LEDs at high temperature conditions. Based on this method, new standards are being developed in the International Commission on Illumination (CIE) and IESNA committees led by NIST. We also recently started Vision Science project to address the color quality issues of solid state lighting . The existing standard for color rendering is obsolete and creating several problems with white LED sources. We developed a new metric for color quality of light sources to solve these problems, which is proposed for a new standard in the CIE. We also started a new research on measurement of LED lifetime, under support by DOE, to develop further standards on this subject.

Standard committees are the grate places for us to learn the problems and needs in the industry, and we feedback our research to new standards solving the problems, forming a good cycle of cooperation between NIST and the industry.

S1-3 3D Imaging

3D Trends, Opportunities and Challenges

Chris Chinnock, Board Member 3D @ Home Consortium and President, Insight Media

Stereoscopic 3D has suddenly become a very hot topic of interest. TV makers, PC makers, camera companies, entertainment, sporting and gaming content creators and broadcasters are all getting behind this effort. This talk will provide a high level view of all of this activity. It will highlight some of the key trends, key players and important milestones these players hope to achieve in 3D. We will also note some potential problems with the adoption of 3D including human factors issues.

3D Image Safety: R&D for standardization of guidelines

Hiroyasu Ujike, Institute for Human Science and Biomedical Engineering, AIST

In the wake of “3D film” pronouncement in Hollywood, the 3D market are now about to expand internationally. However, there is a concern about undesirable biomedical effects caused by 3D images. To resolve the issue, we need to establish “3D Image Safety” based on ergonomics, and to develop international standard of 3D image guidelines.

To do this, we are now working on development of scientific reference database, measurements of biomedical effects, and development of 3D image evaluation system. In the talk, the progress of our those activities and the future plan will be introduced.

S2-1 Thickness

Development of Thin Film Standards for Thickness Metrology by X-ray Reflectometry

Yasushi Azuma, Material Characterization Division, National Metrology Institute of Japan, National Institute of Advanced Industrial Science and Technology

Film thickness standard materials of a SiO_2/Si ultra-thin film and a GaAs/AlAs super lattice have been development in order to calibrate measurement results and to improve accuracy of metrology. The target thickness of the each layer is less than 10 nm with uncertainty of less than the thickness of 1 monolayer. The certified value was determined based on the calibrated X-ray wavelength and angle by X-ray reflectometry (XRR). It is traceable to the International System of Units (SI). The NMIJ's traceable XRR was equipped with an encoder calibrated with the national angle standard established in NMIJ. In addition, the traceable XRR also has a self angle calibration system similar the national standard.

One considerable problem to the thickness certification is an influence of contamination on the surfaces. In order to improve accuracy, there is one of a solution that the contaminants are removed and the surfaces are protected from re-adsorption of them during the measurement. These results will be presented at the symposium.

NIST SI-traceable X-Ray Reflectometry (XRR) Measurement Capabilities for Thin Films: Instrumentation and Data Analysis

Donald Windover, Ceramics Division, Materials Science and Engineering Laboratory, National Institute of Standard and Technology

Our X-ray metrology (XRM) project team at the National Institute of Standards and Technology (NIST) works exclusively in developing Standard Reference Materials (SRMs) for the powder diffraction (PD), high-resolution x-ray diffraction (HRXRD), and X-ray reflectometry (XRR) communities. In this presentation we will show, our approach to SRM development, our current progress in the development of instrumentation and data analysis methods for XRR, and any potential areas for collaboration between AIST/NMIJ and NIST in XRR standards development.

Over the past decade, we have developed a NIST metrology platform to provide International System of Units (SI)-traceable X-ray measurements; providing SI-traceability through accurate determination of both measured angles and the X-ray wavelength in the system's various optical configurations. In addition, NIST has developed Bayesian statistical approaches to analysis of X-ray measurements to estimate parameter uncertainties and to test the validity and likelihood of given structural models. This is particularly important for XRR data, which may, due to lack of phase information in measurements, support multiple possible structural models, with highly correlated structural parameters.

S2-2 Thermal and Mechanical Properties

Thermophysical Property Standard for Thin Films in Japan

Naoyuki Taketoshi, Material properties and Metrological Statistics Division, National Metrology Institute of Japan, National Institute of Advanced Industrial Science and Technology

Thermophysical properties of thin films are as important as electrical, magnetic, and optical properties of thin films in microelectronics devices, such as storage media, LEDs, and thermoelectric devices. In order to measure thermal diffusivities of sub-micrometer thin films quantitatively, a “rear heating / front probing” type (RF-type) light pulse thermoreflectance measurement system, which has the same configuration as the macroscopic laser flash method for bulk specimens, has been developed in the National Metrology Institute of Japan (NMIJ) of AIST. A thin film face of a substrate side is heated instantaneously by picosecond pump light pulses, and heat diffuses into the thin film. Change of the front face temperature is detected by probe light pulses using the thermoreflectance technique. The service of metrological standard for thermal diffusivity measurements of thin films using this method started in 2006 and reference thin film was developed in 2009. NMIJ/AIST is engaged in not only metrological standards, but also in standardization of the measurement method, technology transfer, and construction of database. Throughout these activities, NMIJ will help thermal management and accelerate innovation in advanced industries in Japan.

Thermoelectric and Thermophysical Metrology for Energy Conversion Applications

Joshua Martin, Ceramics Division, Materials Science and Engineering Laboratory, National Institute of Standards and Technology

Thermoelectric phenomena enable the solid-state inter-conversion of thermal and electrical energy. While the low conversion efficiency of thermoelectric devices limits their widespread commercial practicality to niche applications, they remain an integral component in NASA’s radioisotope thermoelectric generators (RTG’s) for deep space power generation, small-scale waste-heat recovery devices, temperature measurement, and electronic refrigeration. In addition, thermoelectric devices are environmentally friendly, require minimal maintenance (no moving parts), and reliably offer quiet and compact operation. The continued development of new thermoelectric materials for high temperature power conversion applications requires reliable and accurate characterization of the electrical and thermal transport properties on a wide variety of material systems. To address these challenges, we have developed an integrated suite of advanced instrumentation to measure both thermoelectric and thermophysical properties on bulk and thin film materials. These include custom tools to screen candidate material systems using combinatorial approaches (for resistivity, the Seebeck coefficient, and thermal effusivity) and a novel high temperature probe for the evaluation of thermoelectric properties on bulk materials. This talk will provide an overview of our apparatus design and

instrumentation, with emphasis on the techniques required to effectively manage uncertainty in thermoelectric measurements.

Nano-hardness and Hardness Standards

Koichiro Hattori, Acoustics and Vibration Metrology Division, National Metrology Institute of Japan, National Institute of Advanced Industrial Science and Technology (NMIJ-AIST)

Instrumented indentation test (IIT) is widely used to measure the local hardness and elastic modulus with shallow indentation depth. In the IIT, indenter penetration process is monitored, and obtained force-depth curve is analyzed with using some methods. ISO 14577 determines the analysis method for some of hardness such as H_{IT} and H_M, and also Indentation modulus. Main uncertainty sources are area function of indenter, contact point determination, frame stiffness, and the method used to analysis. Area function and its uncertainty is the most effective source of uncertainty, however, it depending on the reference used to calibration. The cause of it is that, the contact point is determined by some stiffness change at contact, contact point correction method is not detailed in the ISO, elast-plastic model used to calibration is too simple or arbitrary.

We have studied the contact point correction method with thin low-k films on silicon substrate as a sample. We found that the back-calculation by using Hertz theory is effective for soft low-k sample. Unfortunately, it is one of example, which is depending on the mechanical properties of sample. IIT is also one of typical industrial standards, that needs the unification of methods to determine the reference values. So we need the cooperation between NIST and AIST to harmonization the nano-hardness measurements.

S3-1 Form and Dimension

AFM Probe Characterization

Hiroshi Itoh, Research Institute of Instrumentation Frontier, AIST National Institute of Advanced Industrial Science and Technology

Cantilever with sharp tip is one of the key components of atomic force microscope (AFM), and it is the origin of artifacts in the AFM images. A probe characterizer for atomic force microscope (AFM) was developed to analyze the accurate probe-shape and to know the resolution of each cantilever. A reference material, which includes accurate lines and spaces, was developed using multilayer-thin films [1]. Lines and spaces ranging 3nm 70nm were fabricated using Si and SiO_2 multi-layers. Comb-shape grating with 30nm calibration grating was developed for correcting AFM images. Apparent probe shapes can be determined under various experimental parameters, and actual probe shape can be obtained under optimized set-points of force and feedback parameters. When rigid probes, such as carbon-nanotube probes, carbon-fiber probes and diamond probes, are used with probe characterizer, reliability of AFM images can be improved significantly.

[1] H. Itoh, T. Fujimoto, S. Ichimura: Rev. Sci. Instrum. 77, 103704 (2006).

Traceable AFM Dimensional Metrology at NIST: Applications and Areas of Collaboration

Ndubuisi Orji, Precision Engineering Division, Manufacturing Engineering Laboratory, National Institute of Standard and Technology

The talk will give an overview of the NIST traceable AFM dimensional metrology program. Our activities focus around AFM metrology with direct traceability to the *SI* definition of the meter using displacement interferometry. An instrument, known as the calibrated- atomic force microscope (C-AFM), supports applications in the optics, semiconductor, and other industries. It is also used to calibrate samples for standards suppliers and internal NIST customers. One of the on-going activities in this area is the development of a new traceable atomic force microscope. We will highlight some of the intended uses of this instrument.

Another thrust of the group focuses specifically on applications in the semiconductor industry. Work in this area includes developing measurement procedures using a critical dimension atomic force microscope (CD-AFM), standards development, and tip characterization techniques. In this presentation, the goals of the two main areas will be described. We will highlight key strategic collaborations with industry, and other NMIs. Such collaborations include standards development, interlaboratory comparisons, and instrument development. We will also describe some of our activities together, and possible areas for continued work.

Development of Metrological AFMs and Nanometer-scale Standards

Satoshi Gonda, Length and Dimensions Division, National Metrology Institute of Japan, National Institute of Advanced Industrial Science and Technology

Atomic force microscopes (AFMs) are widely used to measure surface form like the thickness and nano-roughness which are necessary items to control the quality of nanotechnology product. Although certified reference materials made of silicon or quartz with the size of more than 10 nanometers are available, those with the size of single or a few nanometers are not available at present. Atomic step and terrace structure developed at single crystal surface of specific materials could be intrinsic standard of step height, because the step height is expected to be consistent with the lattice constant. It is, however, still necessary to verify real atomic step height with traceable and dimensional measurement, because there might be shift length due to possible surface strain.

NMIJ’s metrological AFMs have demonstrated SI-traceable measurements of nanometer-scale dimensional standards. We will discuss how a metrological AFM can be used to ‘calibrate’ atomic fine structure. Key technologies to link nanometer-scale dimension to the unit of length will be mentioned.

S3-2 Nano-carbon Materials, Carbon Nanotubes and Fullerenes

Selective Extraction and Properties of Semiconducting Carbon Nanotubes

Said Kazaoui, Nanotube Research Center, National Institute of Advanced Industrial Science and Technology

Semiconducting single-walled carbon nanotubes (s-SWNTs) are very promising materials in nanotechnology (transistors) and energy (photoactive material in solar cells). To fulfill such expectation, we have recently developed a technique to selectively extract very high purity and well defined s-SWNTs, without metallic nanotubes and catalyst using as-synthesized SWNTs. S-SWNTs were extracted using polyfluorene in toluene solution assisted by ultrasonication and ultracentrifugation techniques.

We observed that aggregation/agglomeration of s-SWNTs influence the extraction yield, the solubility (polymer/organic solvent) and the optical properties (photoluminescence, photoconductivity). DLS method has revealed that s-SWNTs dispersion (mean-size ~30nm) aggregates (mean-size ~1mm) within few hours. Therefore, it is essential to investigate the aggregation/agglomeration mechanisms, to establish method to simply/reliably evaluate their state and to work toward international standardization. In this context the collaboration with NIST is essential.

Optical Methods to Probe Stable Carbon Nanotube Dispersions and pH-induced Aggregation of Nanoparticles

Vivek M. Prabhu, Polymers Division, Materials Science and Engineering Laboratory, National Institute of Standard and Technology

The talk will give an overview of the Complex Fluids Group in the Materials Science and Engineering Laboratory at NIST with highlights from the Nanoparticle Assembly Project. Of current interest is the characterization of transport properties of nanoparticles when dispersed in aqueous solutions. The first part of the talk will describe efforts to develop fluorescence correlation spectroscopy (FCS) to characterize the transport properties of dispersed single-walled carbon nanotubes (CNT) in aqueous solutions. The intrinsic band-gap luminescence in the near-infrared enabled high-resolution measurements of the segmental dynamics by analysis of the autocorrelation function for semi-flexible rods. The methodology was applied to (6,5) CNT and can be extended to different chirality and diameter CNT, dispersion agents, and alternative solvents. This work builds upon the efforts of NIST to develop SWCNT reference materials.

Nanoparticles are also a centerpiece to Health Care due to the similarity of interactions and size with natural nanoparticle proteins. The uptake of synthetic nanoparticles by different cellular compartments with disparate pH and salt conditions will influence nanoparticle interactions. How rapid changes in cellular environment influence the stability of nanoparticle dispersions is necessary for design of new materials, as well as classify hazards. We use dynamic light scattering to characterize the stability and initial stages of the kinetics of nanoparticle aggregation. This process was conveniently initiated by a ultraviolet light-induced pH jump. The nanoparticle aggregation kinetics was extremely sensitive to the solution pH and we find that the ultraviolet-light exposure dose is inversely correlated to the surface charge of the nanoparticles, effectively decreasing the electrostatic repulsion force between particles and leading to aggregation.

Physicochemical Characterization of Engineered Nanoparticles: The measurands that influence Nano EHS

Gerald Fraser, Optical Technology Division, Physics Laboratory, National Institute of Standard and Technology

From work ongoing with ISO/TC 229 a number of parameters have been identified as critical for characterization of nanomaterials prior to toxicological assessment. Through a consensus process within a Joint Task Group under the committee, these parameters have been assigned measurands-the quantity that is intended be measured-to aid the toxicologists in their assessments. These measurands have also been assigned measurement methods and appropriate caveats to consider when working in the nano regime. NIST is incorporating these terms, measurands and measurement methods into our Nano EHS program and is looking to establish collaborations to reduce measurement uncertainty and increase comparability of toxicological studies in order to rigorously establish connections between physicochemical properties and toxicological response.