The Science of Sliding: Improving Hips and Cars By Understanding Friction


The way Laurence Marks sees it, friction needs a fan club to really understand it. And like any proper fan base, it needs a catchy name. Will "tribologists" do? Tribology is the science of interacting surfaces in motion - the science of sliding, from the Greek "tribein", "to rub" - and Dr. Marks is one of its foremost practitioners. He will present some of his latest research on the topic at the AVS 60th Symposium and Exhibition, held Oct. 27 - Nov. 1 in Long Beach, Calif.

"Friction is one of the most under-appreciated issues in energy," says Dr. Marks, professor of materials science and engineering at Northwestern University in Evanston, Ill. "Consider cars for example. By some estimates, about one third of the fuel energy in automobiles goes to overcoming frictional losses. If we could reduce friction substantially, a lot of the energy problems we face in the world would go away."

And many new possibilities might arise. For example, Dr. Marks and his collaborators envision one day manipulating natural biological lubricants in the hip to produce a regenerative medicine fix for arthritis - a thin film of self-healing, self-renewing lubricant so bones of aging joints slide pain-free.

The Marks' team uses a novel imaging technique based on an extremely high-powered microscope tentatively tried after World War II. The team revived and refined the technology to produce images that reveal the mechanisms of solid lubricants. This approach brings new insights into what is happening at the tribopassive layer of materials, which is buried and hidden from traditional observational means due to its extremely small size.

How small? "The imaging technology we are using is able to look directly at the interactions at the nanoscale, atomic level," explains Dr. Marks. This means the lab visualizes and seeks to manipulate materials measured in nanometers - where 1 nanometer is 1 billionth of a meter. At this scale, a piece of matter 10 nanometers in size is 1,000 times smaller than a human hair. Innovative, interesting things happen at the nanoscale as a result of the novel properties and possibilities that emerge when tiny players interact, which is why nanotechnology is, increasingly, a focus of advanced research. This is particularly true for biological systems because proteins that controls cellular functions are this size, around 1-20 nanometers. If researchers can successfully manipulate proteins, they can control function and processes in the body - such as getting old hip joints to slide smoothly again.

A novel extension of the Marks' lab hip work is their investigation into the formation
Vacuums Provide Solid Ground for New Definition of Kilogram: The Weight of
the Kilogram May Rest on the Emptiness of a Vacuum

Presentation: VT-MOM1, "The Important Role of Vacuum Technology in the
Redefinition of the Kilogram," 8:20 a.m., Monday, Oct. 28.

Of all the standard units currently in use around the world, the kilogram - the
official unit of mass in the International System of Units (SI) - is the only one that
still relies on a physical object for its definition. The official kilogram, called the
International Prototype Kilogram (IPK), is stored in a bureau just outside of Paris,
France, and has served as the standard to which all the nations' prototypical
kilograms have been compared for the last 125 years. Every few decades, the
national prototypes are carried, usually by hand, to France, where they are
measured against the IPK.

But discrepancies between the national prototypes and the official specimen have
been increasing at a rate of 0.050 milligrams (mg) every 100 years. And no one
knows why.

"It's not really clear if the IPK is getting lighter or the national prototypes are
getting heavier," says Patrick Abbott of the National Institute of Standards and
Technology (NIST) in Gaithersburg, Maryland. Loss of mass due to wear is unlikely
because the IPK is hardly ever taken out of its vault. To address these
discrepancies, an international assembly of metrologists decided in 2007 to wean
itself off of the prototype and redefine the kilogram using something more reliable:
the Planck-defined kilogram.

The metrologists eventually chose Planck's constant, which describes the
relationship between the energy of a photon and the frequency of light it emits. Its
value has been measured with a relative uncertainty of between 30x10^-9 and
35x10^-9. However, to assure agreement between the current IPK system and the
Planck-defined kilogram, researchers will need to improve their measurements to a
relative uncertainty of 20x10^-9. And to get better measurements, they will need
the ability to perform state-of-the-art metrology in a vacuum.

Vacuum mass measurements are Abbott's specialty, and redefining the kilogram is
a main focus of his present work. "I studied under Dr. Bruce Kendall, a longtime
member of AVS and a pioneer in vacuum technology," he says. After working in the
Pressure and Vacuum group at NIST for 15 years, Abbott joined the Mass and Force
group and began working on the kilogram.

Currently, researchers use two types of experiment to measure Planck's constant,
and both require vacuums. One method involves determining the number of atoms
in a high-purity silicon sphere with a nominal mass of 1 kilogram. The other, called
the watt balance, measures the constant by an indirect or "virtual" comparison of
mechanical power to electromagnetic power. Using a vacuum ensures that there is
no contamination from particles in the air and reduces uncertainty in some of the
measurements that are conducted with laser interferometry.

While many teams around the world are working to find the level of vacuum that is
good enough to get results without being too difficult to build or maintain, Abbott's
group is looking beyond redefinition and toward making these measurements
practical. "Whenever redefinition occurs, a robust method will be required to
disseminate the kilogram realized in a vacuum to a world that works in air," Abbott
says. His group is creating a system that will bridge the vacuum-air interface using

"The Kilogram May Rest on the Emptiness of a Vacuum"
a magnetic suspension technique. The set-up will allow a direct comparison between the mass of a standard kilogram in a vacuum and the mass of a specimen in the atmosphere of a normal room.

Though his NIST team still has a long way to go, he says, its progress has been steady. "This is the only project of its type in the world," Abbott says, "and we believe that it will be critical in the accurate dissemination of the redefined kilogram."

Abbott will present his team's work, as well as an overview of efforts in vacuum technology to redefine the kilogram, at the AVS 60th Symposium and Exhibition, held Oct. 27 - Nov. 1 in Long Beach, Calif. Researchers hope to have a new definition of the kilogram by 2018.
I am happy to report on the 57th International Conference on Electron, Ion, and Photon Beam Technology and Nanofabrication, held in musical Nashville, Tennessee. Industry, academia, and government organizations from all over the world (25 countries and 5 continents) were represented, and reported on the latest advances in electron-, ion- and/or photon-beam technologies and nanofabrication.

The conference has come a long way from its modest beginnings serving as the communications forum for important new nanolithography and nanofabrication advances. The conference showcased exciting developments in Nanoimprint Lithography (NIL) for example and continues to have a robust NIL presence today. Our strength areas in novel nanolithography, nanofabrication, electron beam and ion beam technologies were well represented. Important newer areas such as directed self-assembly, nanophotonics, nanobiology, 3D nanofabrication, novel imaging and nanomaterials like carbon and diamond, are came on strong as well.

At this year's conference, we were honored to have four outstanding plenary speakers from industry and academia, covering wide-ranging topics involving nanofabrication that would have an impact on our future. In addition, there were 40 exceptional invited speakers and posters, covering important areas on unconventional nanoelectronics and nanofabrication, future of EUV, novel imaging, nano-energy, nanobiology as well as carbon-based devices/systems.

The conference is healthy with over 300 abstract submissions this year. To contain all the contributions within three days is no mean feat. As well as the three parallel oral sessions, there was a large and excellent poster session with more than 170 posters. The poster session ran immediately following the Plenary Session on Wednesday May 29. There were also four high-quality invited posters, following on from tradition, selected from last year's Micro and Nano Engineering (MNE) Conference poster awards. The high quality technical program for this conference would not have been possible without the hard work and dedication of many people. Special thanks go to the members of the Steering and Advisory Committees, to the Section Heads, and to the Reviewers. They have been helpful throughout, guiding the course of the program, helping select invited speakers, and generating over 1300 reviews for the contributed submissions.

I want to emphasize of the importance of the participation of students in our conference. They are the lifeline that has kept this conference relevant for over a half a century. In recognition of our students we have decided to try for the first time a Mentorship Hour where students have the opportunity to talk one-on-one with more senior members of our community on career advice. The Mentorship Hour was a resounding success with 115+ participants among mentorees and mentors, who stayed way over the programmed hour talking to each other.

Overall the conference had 460 attendees, 80 exhibitor participants representing 36 companies, which was the second largest in our conference history. We continue to...
strive in supporting student travel to our conference. This year we have received major support for student travel from Argonne National Laboratory, NSF, Raith USA, NuFlare, and IBM.

Looking forward to see you all at next year's EIPBN 2014 conference to be held at the Omni Shoreham Hotel, May 27-30, 2014, in Washington DC.

Surface Analysis 2013-The 35th Annual Symposium on Applied Surface Analysis

By Rick Haasch, Surface Analysis 2013 Chair

Surface Analysis 2013 took place at the Frederick Seitz Materials Research Laboratory June 5-7, 2013, on the campus of the University of Illinois at Urbana-Champaign. The conference had 80+ participants and featured an exhibit with 17 companies. Rick Haasch and Julio Soares were the conference chairs, Mauro Sardela organized the vendor exhibit, and Chris Johns and Susie Lighty were the conference administrators.

The two-and-one-half-day conference consisted of a strong technical program featuring 7 invited and 19 contributed papers (9 of which were student presenters) and 6 student poster presentations. This year's conference followed the very successful 7th Advanced Materials Characterization Workshop held at the Frederick Seitz Materials Research Laboratory on June 3-4, 2013.

The conference provided a forum for scientists in all disciplines to discuss advances in surface analysis techniques and their application to thin films, semiconductors, composites, ceramics, polymers, biomaterials, catalysts, tribology, adhesion, and other material systems.

Wednesday's sessions featured invited presentations by Prof. Richard J. Matyi, Nanoscale Science and Engineering, SUNY, on "High Resolution X-ray Reflectometry for Surface- and Near-Surface Analysis;" Dr. Jessica McChesney, Argonne National Laboratory, on "New Opportunities at the Advanced Photon Source: Intermediate Energy X-ray;" and Prof. Hua Chun Zeng, Chemical and Biomolecular Engineering, National University of Singapore, on "Synthesis and Surface Characterization of Catalytic Nanomaterials."

Thursday's sessions included invited talks by Dr. Anna M. Belu, Corporate Science & Technology, Medtronic, Inc., on "Characterization of Surface and Interfaces in the Medical Device Industry;" Prof. Frank K. Urban, Florida International University, on "Numerical Ellipsometry: Data Processing for Films and Surfaces at the Nanometer Scale;" and Prof. Michael Trenary, Department of Chemistry, University of Illinois at Chicago, on "Atomically Resolved Imaging of the Oxydehydrogenation of NH3 on Pt(111)."

Friday's half-day session featured an invited presentation by past AVS President Prof. Angus Rockett, Department of Materials Science and Engineering, University of Illinois, on "Characterization of Chalcopyrite Solar Cell Materials."

Surface Analysis 2014, The 36th Annual Symposium on Applied Surface Analysis will take place June 2-4, 2014, at the Marriott Uptown, Albuquerque, NM. The meeting will feature a three-day Technical Symposium which will include a vendor exhibit with more 30 exhibitors. The meeting will be held in conjunction with the AVS New Mexico Chapter's annual symposium and include short courses for the entire week.

12th International Symposium on Sputtering Plasma Processes (ISSP2013)
By Takeo Nakano, ISSP2013 Executive Committee Chair

The 12th International Symposium on Sputtering and Plasma Processes (ISSP2013) was held at Kyoto Research Park, Kyoto, Japan with 215 participants from 14 countries/regions. ISSP has been held biennially since 1991, and had been sponsored by the Vacuum Society of Japan (VSJ), a member of IUVSTA. It was our great pleasure that we could hold this time of ISSP as a co-sponsored symposium by AVS and VSJ.

ISSP has been dedicated to promote the exchange of knowledge and ideas on sputtering and plasma processes. Participants both from academic and industrial fields enjoyed the discussion of a wide variety of aspects of these processes. During the three day symposium, 135 presentations, including 9 invited, 30 contributed oral, and 96 posters were given. As a unique feature of ISSP, authors in oral sessions, including invited speakers, were requested to put their posters at the poster session of the same day. This helped the symposium attendees to discuss with authors in a more extensive and fruitful way.

The topical theme of this symposium was "Revisit to the Fundamentals of Sputtering and Plasma Processes." Reflecting this, keynote speeches were given by two leading researchers in this field. On the first day keynote, Prof. Allan Matthews (The University of Sheffield, UK) provided a versatile review on plasma assisted PVD which covered from ion plating to HiPIMS. On the second day, Prof. Matthias Wuttig (RWTH Aachen, Germany) discussed the key factor of the formation of microstructure and texture of oxide films upon reactive sputtering. Both attracted great interests of participants, and two speakers were caught in a cross fire of questions and discussions not only during the session, but also at coffee/lunch breaks and the poster session period.

the other seven invited speakers were Dr. Jones Alami (INI Coatings Ltd., Germany), Prof. Jinn P. Chu (National Taiwan University of Science and Technology, Taiwan), Prof. Minoru Fujii (Kobe University, Japan), Dr. Tomas Kubiart (Uppsala University, Sweden), Dr. Shailesh Kumar (CSIRO, Australia), Dr. Gun Hwan Lee (Korea Institute of Materials Science, Korea) and Dr. Helena Oi Lun Li (Nagoya University, Japan). Their invited lectures, as well as presentations by several Manufacturers and by contributed authors contributed to the great success of this symposium.

For fundamental aspects of sputtering, reactive sputtering, HiPIMS and the combination of these seemed to be the hot topics. Novel process technologies, such
as sputtering with rotating spiral magnet configuration, plasma processes within solutions, were also reported. In addition, various applications were introduced, which included metallic glass films, flexible displays, nano-crystal Si, nanostructure carbons, hard coatings, photovoltaic film deposition, etc. Selected and peer-reviewed symposium papers are planned to be published in the Special Issue of JVST A next spring.

During the poster sessions, light meals, drinks and Japanese confectionery were served. At the beginning of the first day poster session, traditional Japanese Dance "Kyo-Mai" was presented and helped to promote the relaxing atmosphere. At the poster session room, 11 exhibitors displayed their booth and introduced their recent products and achievements.

Outstanding poster presentations were selected from all the papers (including oral contributors, judged base on their posters), and announced at the closing session of the final day. Winners were following three groups.

- Z. Kelgenbaeva, E. Omurzak, S. Sulaimankulova, M. Goto, T. Mashimo "Effect of temperature condition and surfactant on the formation of iron nanoparticle using pulsed plasma in liquid"
- T. Hanada, K. Yanachi, H. Ishizaki, Y. Otani, C. Yamamoto, J. Yamanaka, T. Sato, T. Takamatsu, Y. Fukuda "In situ formation of aluminum germanate interlayer for high-k/Ge metal-oxide-semiconductor structures by atomic layer deposition with trimethylaluminum and microwave-generated atomic oxygen"

The compete symposium program, statistics, comments from award winners, and more symposium pictures can be found at [http://issparchive.org/2013/](http://issparchive.org/2013/).

We appreciate all the participants, invited speakers and exhibitors for their great contribution to the symposium. We are also grateful to AVS for their cooperation in symposium announcements and post-symposium papers publication.