Capacity Building for Industrial Physics in Developing and Emerging Economies

AIP ICTP Industrial Physics Forum

16-19 April 2012

Trieste, Italy

AIP American Institute of Physics

ICTP The Abdus Salam International Centre for Theoretical Physics

UNESCO IAEA

2012 Industrial Physics Forum

WELCOME

Capacity Building for Industrial Physics in Developing and Emerging Economies

On behalf of the International Center for Theoretical Physics (ICTP) and the American Institute of Physics (AIP) Corporate Associates, welcome the ICTP/AIP Industrial Physics Forum on "Capacity Building for Industrial Physics in Developing and Emerging Economies." This Industrial Physics Forum (IPF), is part of an annual series of IPFs run by AIP's Industrial Outreach Program, the goal of which is to build bridges between the industrial and academic physics communities in order to expose each to needs and capabilities of the other, but with particular focus on the technical and workforce needs of industry. Typically, AIP partners with one of its ten Member Societies, but this is the first IPF held outside of the US and is the first IPF since 2006 that is hosted by one of the member organizations of AIP's Corporate Associates.

The ICTP was founded in 1964, under the vision and leadership of Nobel Laureate Abdus Salam, becoming the world's first and leading global scientific institution for fundamental research and development. Functioning under the umbrella of a tripartite agreement between the Italian government, UNESCO and IAEA, the ICTP hosts leading international scientists doing basic and applied research in a broad range of areas. It runs more than 60 conferences, workshops and schools annually, and assists science policy makers and scientists from developing countries in the creation of regional centers of excellence and active scientific networks. By also providing excellent research conditions for developing country scientists through programmed long-term visits to its site, as well as offering advanced training programs aimed at younger generations of researchers, the ICTP has for over 47 years helped top scientists and their students from the poorest countries stay active in research at the highest levels, minimize their isolation, and contribute more efficiently to capacity building and development of their native land. Recognizing that science is a universal language that unites people across diverse cultures and political landscapes, the ICTP demonstrates a global approach to address the problems of our time.

The goal of the IPF is to increase the participants' ability to lead efforts that strengthen the role played by physics in economic development in their home countries, and in particular, at their home institutions. This is an ideal convergence of the missions of the AIP Industrial Outreach Program and the ICTP's initiative to increase industrial physics capacity in the regions within which it works. To advance the capacity building goal of this latest IPF, we have organized a four-day IPF within which will be interwoven three threads: technical, education, and policy. The technical sessions are built around topics in applied and industrial physics that address local and global economic development challenges, and which are appropriate for extending the excellent capacity building work already underway at ICTP. Specific technical themes include materials physics, solar energy and photovoltaics, renewable energy, nanotechnology, applications of microfluidics to applied problems, and optics.

The education sessions will focus on introducing participants to a range of new education pedagogies, technologies, and practices designed to make physics education more inquiry based and student focused. Indeed, a strong unifying philosophy underlying the IPF is that any successful capacity building effort will necessarily require institutions to assess the quality of their physics education at all grade levels and undertake reforms, where necessary, in order to ensure that the education is aligned with the expectations and needs of a growing technical economy.

The policy sessions will explore the policy implications of global and regional challenges, solutions to which depend, at least partially, on strategic applications of industrial physics in areas such as energy and economic development. A major part of the final day will be devoted to an extended session during which participants will network and develop capacity building action plans.

Finally, many participants will be presenting posters on their work. The poster session will certainly enliven the opportunities for networking and collaborations.

The program over the next four days would not have been possible without the hard work and dedication of IPF Program Planning Committee (listed on p. 3). We also acknowledge Rene Lopez, Liz McCormack, Sean Shaheen, and Richard Wiener for their extra efforts in planning and leading the capacity building workshop. Finally, Shirley Fairclogh of ICTP and Paula Gray of AIP have provided months of organizational and planning assistance that have laid the groundwork for an extremely successful Industrial Physics Forum.

Joe Niemela, *ICTP, IPF Co-director* www.ictp.it
Philip W. Hammer, *AIP, IPF Co-director* www.aip.org

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2012 Industrial Physics Forum

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Planning Committee

Amy Flatten, *American Physical Society*
William J. Gallagher, *IBM*
Katharine Gebbie, *National Institute of Standards and Technology*
Philip W. Hammer, *American Institute of Physics,* ***IPF Co-director***
Anthony Johnson, *University of Maryland, Baltimore County*
Vasudevan Lakshminarayanan, *University of Waterloo*
Rudy Ludeke, *American Institute of Physics Corporate Associates*
Romain Murenzi, *Academy of Sciences for the Developing World*
Joe Niemela, *International Centre for Theoretical Physics,* ***IPF Co-director***
Frederick Pinkerton, *General Motors*
Surya Raghu, *Advanced Fluidics LLC*
David Seiler, *National Institute of Standards and Technology*
Dean Zollman, *Kansas State University*

PROGRAM

Monday, April 16

9:30am – 10:40am: Welcoming & Introductory Remarks – Policy Session I

Welcome from ICTP
Fernando Quevedo, *International Centre for Theoretical Physics, Italy*
Welcome from AIP
Philip W. Hammer, *American Institute of Physics, USA*
Welcome Address
Speaker to be determined

10:40am – 12:00pm: Technical Session I – Alternative Energy

Session Chair: Rudy Ludeke, *AIP Corporate Associates, USA*

Photovoltaics Technology: No Longer an Outlier
Larry Kazmerski, *National Center for Photovoltaics (NREL), USA*
The Thermodynamic and Industrial Potentials of Organic Photovoltaics
Sean Shaheen, *University of Denver, USA*

12:00pm – 1:15pm: Lunch

1:15pm – 3:15pm: Technical Session II – Materials

Session Chair: Katharine Gebbie, *National Institute of Standards and Technology, USA*

Photonic Materials for Solar Energy Conversion at the Thermodynamic Limit
Harry Atwater, *California Institute of Technology, USA*
The Battery 500 Project: Towards the Ultimate Battery
Alessandro Curioni, *IBM Research, Zurich*
Graphene for Nanoelectronic Device Applications
Luigi Colombo, *Texas Instruments Inc., USA*

3:15pm – 3:30pm: Break

3:30pm – 6:10pm: Policy Session I – Energy Policy

Session Chair: David Seiler, *National Institute of Standards and Technology, USA*

Innovation, Science and Technology Policy, and the Public Good
Venky Narayanamurty, *Harvard University, USA*
Photovoltaics in Transition Towards a Mainstream Electricity Provider - in Developed and Emerging Economies
Winfried Hoffman, *European Photovoltaic Industry Association, Germany*
Bioenergy Innovation at Local, Regional and Global Levels - Addressing Needs for Emerging Technologies to Support Sustainable Growth and Development
Caroline Taylor, *University of California, Berkeley, USA*
Grid Access and Renewables in Developing Countries
Rob Stoner, *Massachusetts Institute of Technology, USA*

6:30pm – 8:00pm: Opening Reception & Poster Session

Posters listed on pages 8-9

Tuesday, April 17

9:20am – 10:00am: Policy Session II – Energy Policy

Session Chair: Joe Niemela, *ICTP, Italy*

Scaling up Access to Modern Energy Services in Africa
Ogunlade Davidson, *University of Sierra Leone, Sierra Leone*

10:00am – 12:00pm: Frontiers in Physics I

Session Chair: Joe Niemela, *ICTP, Italy*

Harnessing Light on a Silicon Chip for Optical Communications
Solomon Assefa, *IBM Watson Research Center, USA*

From Big Bang to Biosphere
Martin Rees, *Cambridge University, UK*

Quantum Nanotechology
Andrew Briggs, *Oxford University, UK*

12:00pm – 1:30pm: Lunch

1:30pm – 2:45pm: Education Session I

Philip W. Hammer, *American Institute of Physics, USA*

Introduction to the Education Sessions
Dean Zollman, *Kansas State University, USA*

Developing Teachers for Engaged Interactive Teaching
Ian Lawrence, *Institute of Physics, UK*

2:45pm – 3:00pm: Break

3:00pm – 5:00pm: Education Session II

Session Chair: Dean Zollman, *Kansas State University, USA*

Coach, An Integrated Learning Environment for Science Education
Ton Ellermeijer & Ewa Kedzierska, *CMA-Science, Amsterdam*

7:00pm – 10:00pm: IPF Banquet with Keynote Address

Science and Technology: Building Innovative Societies and 21st Century Diplomacy
William Colglazier, *Science Advisor to the United States Secretary of State, USA*

PROGRAM

Wednesday, April 18

8:30am – 10:30am: Technical Session III – Solar Energy

Session Chair: Rudy Ludeke, *AIP Corporate Associates, USA*

Insight into Organic Photovoltaics
K. S. Narayan, *Jawaharlal Nehru Centre for Advances Scientific Research, Bangalore, India*
Towards Affordable Clean Energy Solutions: The Nanoscience Route
Satishchandra B. Ogale, *National Chemical Laboratory, Pune, India*
Insight into Organic Photovoltaics
Rene Lopez, *University of North Carolina, Chapel Hill, USA*

10:30am – 10:45am: Break

10:45am – 12:45pm: Technical Session IV – Micro & Complex Fluidics I

Session Chair: Martin Poitzsch, *Schlumberger-Doll Research, USA*

Microfluidic System Technology in Chemical Analysis
Karsten Kraiczek, *Agilent, Germany*
Microfluidics and the Oil Industry
Patrick Tabeling, *ESPCI, France*
Explaining the Flow of Elastic Liquids
John Hinch, *Cambridge University, UK*

12:45pm – 2:00pm: Lunch

2:00pm – 3:20pm: Technical Session V – Optics

Session Chair: Vasudevan Lakshminarayanan, *University of Waterloo, Canada*

Photonics-based Telemedicine Technologies toward Smart Global Health Systems
Aydogan Ozcan, *UCLA, USA*
Realistic Applications of Optical Spectroscopy in the Environmental and Medical Fields, with Industrial Potential
Sune Svanberg, *Lund University, Sweden & South China Normal University, China*

3:20pm – 3:40pm: Break

3:40pm – 5:40pm: Education Session III

Session Chair: Dean Zollman, *Kansas State University, USA*

Experiences in Physics Education at the Open University
John Bolton, *British Open University, UK*
Inquiry Teaching Using Inexpensive Materials and Unexpected Results
Gorazd Planinsic, *University of Ljubljana, Slovenia*
Destinations and Inspirations: The Role of Undergraduate Research in Capacity Building For Industrial Physics
Elizabeth McCormack, *Bryn Mawr College, USA*

Thursday, April 19

8:30am – 9:30am: **Policy Session III – Capacity Building for Industrial Physics in Developing & Emerging Economies**

Session Chair: Philip W. Hammer, *American Institute of Physics, USA*

Scialog as a Model for Capacity Building Action Planning
Richard Weiner, *Research Corporation for Science Advancement, USA*

9:00am – 9:35am: **Capacity Building Action Planning I – Facilitated Breakout Session**

Facilitators:
Richard Wiener, *Research Corporation for Science Advancement, USA*
Rene Lopez, *University of North Carolina, Chapel Hill, USA*
Liz McCormack, *Bryn Mawr College, USA*
Sean Shaheen, *University of Denver, USA*

9:35am – 9:50am: **Break**

9:50am – 11:00am: **Capacity Building Action Planning II – Facilitated Breakout Session: Technical**

11:00am – 12:10pm: **Capacity Building Action Planning III – Facilitated Breakout Session: Regional**

12:10pm – 1:15pm: **Action Planning Lunch**

1:15pm – 1:45pm: **Capacity Building Action Planning IV – Plan Development**

1:45pm – 3:05pm: **Frontiers in Physics II**

Session Chair: Catharine O'Riordan, *American Institute of Physics, USA*

Time-Reversal, Waves and Innovation
Mathias Fink, *EPSI, France*
Diagnostics and Treatment of Tumours using Laser Techniques
Sune Svanberg, *Lund University, Sweden* & Katarina Svanberg, *Lund University, Sweden and South China Normal University, Guangzhou, China*

3:05pm – 3:30pm: **Break**

3:30pm – 5:30pm: **Technical Session VI – Micro & Complex Fluidics II**

Session Chair: Surya Raghu, *Advanced Fluidics LLC*

Reservoir Modeling and Simulation
Thomas Halsey, *ExxonMobil Upstream Research, USA*
Microfluidics for global health diagnostics
Samuel Sia, *Columbia University, USA*
Microfluidic principles and devices for analytical and synthetic purposes
Han Gardeniers, *University of Twente, Netherlands*

5:30pm – 6:10pm: **Policy Session IV**

Session Chair: Surya Raghu, *Advanced Fluidics LLC*

Photovoltaics and Renewable Electricity in Europe
Arnulf Jaeger-Waldau, *European Commission's Joint Research Center, Inspra, Italy*

6:30pm – 7:00pm: **Capacity Building Action Planning V - Reception & Poster Session of Action Plans**

7:00pm – 9:00pm: **Closing Banquet**

Posters

Advanced Absorbing Nanofilms for Sensitive Infrared Photodetectors
Viktor Lysiuk, Mykola Klyui, Vasyl Staschuk V. Lashkariov *Institute of Semiconductor Physics, National Academy of Sciences of Ukraine, and* Taras Shevchenko, *National University of Kyiv*

Biomass Gasification Technology: An Overlooked Alternative to Renewable Power Generation in Africa
Olayinka Babalola and Aderemi Alabi, *University of Ilorin, Nigeria*

Carbon Cages: Endohedral Fullerenes
Benjamin Farrington, *Trinity College, UK*

Carbon Nanotube Contacts in Organic Photovoltaics
Alex Dixon, *University of Denver, USA*

Conduction Mechanism and Photo-voltaic Characteristics of Zinc Oxide Thin Films
Mujtaba Ikram, Asghari Maqsood, Shehzad Salam, and Umer Farooq, *National University of Sciences and Technology, Islamabad-Pakistan*

Exergy Efficiency of Evaporative Coolers
Mohammad Hossein Pakravan, and Mohammad Reza Salimpour, *Isfahan University of Technology, Iran*

Exploring the rolling shutter effect using a computer scanner
Bor Gregorcic, *University of Ljubjana, Slovenia*

Fiber Bragg Gratings for Sensing Applications
Ioana R. Ivascu, *University "Politehnica" of Bucharest, Bucharest, Romania; and* Regina Gumenyuk, Samuli Kivistö and Oleg G. Okhotnikov, *Tampere University of Technology, Tampere, Finland*

Full Adiabatic to Non-adiabatic Quantum Pumping in Graphene Nanoribbons
[1]Tejinder Kaur, [2]Liliana Arrachea, and [1]Nancy Sandler

[1]Ohio University, Athens, Ohio, USA, [2]University of Buenos Aires, Argentina

Implementation of a Mandatory Capstone Project: Issues and Solutions
Linda S. Barton, Scott V. Franklin, and Michael Kotlarchyk, *Rochester Institute of Technology, USA*

Improvement of Arrangement to Collimator Sizes of Helmet in Gamma Knife using Artificial Neural Network
Leila Moghaddam-Banaem, Saeed Setayeshi, and M.G.Maragheh, *AmirKabir Technical University, Tehran, Iran*

Knowledge Sharing in Developing Scientific Organizations Process and Application
Seyed Kamal Vaezi, *University of Tehran, Iranian Ministry of Sciences, Research and Technology*

Nanostructured CdS:O Thin Films for Solar Cell Applications
E. Mammadov[1], A.Bayramov[1], E. Huseynov[1], I. Hasanov[1], Y. Shim[2], K. Wakita[3], and N. Mamedov[1]

[1] Azerbaijan National Academy of Sciences, Baku, Azerbaijan
[2] Osaka Prefecture University, Sakai, Japan
[3] Chiba Institute of Technology, Narashino, Japan

Nanotech Innovations Enterprise: Students Creating the Future- One Atom at a Time
John A. Jaszczak, Mary Raber, Paul Bergstrom, Nasser Alaraje, *Michigan Technological University, USA*; and Michael Bennett, *Northeastern University, USA*

Optical Characterization of Electrically Pumped Erbium-doped Slot-waveguide
Davide Gandolfi[1], Andrea Tengattini[1], Aleksei Anopchenko[1], Nikola Prtljaga[1], J.-M. Fedeli[2], P. Rivallin[2], K. Surana[2], and Lorenzo Pavesi[1]

[1]University of Trento, Trento, Italy
[2]CEA, Grenoble, France

Organic Photovoltaics: Lamination as a Fabrication Tool and it's Applications
Brian Bailey, *University of Denver, USA*

Photopletismography Transillumination Predictor
Camille Vazquez-Jaccaud, Gonzalo Paez, and Marija Strojnik, *Centro de Investigaciones en Óptica, Mexico*

Posters

Prism Foil in Active Learning Methods and Physics Education Research
Michael Gojkosek, *University of Ljubljana, Slovenia*

Scialog: Accelerating Scientific Breakthroughs with Small Teams and Dialog
Richard Wiener, *Research Corporation for Science Advancement, USA,* and Dean Malmgren and Michael Stringer, *Datascope Analytics, USA*

Self-cleaning Glass
M.R. Mohammadizadeh, M. Bagheri, M. Chekini, M. Kazemi, M. Mashhadbani, and A.A. Ashkarran, *University of Tehran, Iran*

Space Radiation Environment Modeling and Assessment of Damage to Electronics
P.B. Saganti and G.M. Erickson, *Prairie View A&M University, Prairie View, TX, USA*; and F.A. Cucinotta, *NASA Johnson Space Center, Houston, TX, USA*

Study of Some Binary and Ternary Chalcogenide Semiconductors as Materials for Solar Cells
Sunil H. Chaki and Mahesh D. Chaudhary, *Sardar Patel University, Gujarat, India*

Solar Cells: Renewable Energy Conversion Technologies
Seth Hubbard and Michael Kotlarchyk, *Rochester Institute of Technology, USA*

The Controlled Creation of Defects in Graphene by Electron Beam Irradiation
Alex W. Robertson, Christopher S. Allen, Yimin A. Wu, Angus I. Kirkland, and Jamie H. Warner, *University of Oxford, UK*

Abstracts

Monday, April 16

10:40am – 12:00pm

Photovoltaics Technology: No Longer an Outlier
Larry Kazmerski, *National Center for Photovoltaics (NREL), USA*
The prospects of current and coming solar-photovoltaic (PV) technologies are envisioned, arguing this solar-electricity source is beyond a *tipping point* in the complex worldwide energy outlook. Truly, a ***revolution*** in both the technological advancements of solar PV and the deployment of this energy technology is underway; PV is no longer an outlier. The birth of modern photovoltaics (PV) traces only to the mid-1950s, with the Bell Telephone Laboratories' development of an efficient, single-crystal Si solar cell. Since then, Si has dominated the technology and the markets, from space through terrestrial applications. Recently, some significant shifts toward technology diversity have taken place. Some focus of this presentation will be directed toward PV R&D and technology advances, with indications of the limitations and relative strengths of crystalline (Si and GaAs) and thin-film (a-Si:H, Si, Cu(In,Ga)$(Se,S)_2$, CdTe). Recent advances, contributions, industry growth, and technological pathways for transformational *now and near-term* technologies (Si and primarily thin films) and status and forecasts for *next-generation* PV (nanotechnologies and non-conventional and "new-physics" approaches) are evaluated. The need for R&D accelerating the now and imminent *(evolutionary)* technologies balanced with work in mid-term *(disruptive)* approaches is highlighted. The recent emergence of *"retro-photovoltaics"*, re-examining those earth-abundant technologies of the 1970s and 1980s with new understandings of materials and an arsenal of new characterization tools at the disposal of the researcher. Moreover, technology progress and ownership for next generation solar PV mandates a balanced investment in research on *longer-term* (the revolution needs *revolutionary* approaches to sustain itself) technologies (quantum dots, multi-multijunctions, intermediate-band concepts, nanotubes, bio-inspired, thermophotonics,. . .) having high-risk, but extremely high performance and cost returns for our next generations of energy consumers. This presentation provides insights to the reasons for PV technology emergence, how these technologies have to be developed (an appreciation of the history of solar PV), recent industry changes (consolidations, closures), bankability, the impact of incentives and the rise of Asian manufacturing—and where we can expect to be by this mid-21st century.

The Thermodynamic and Industrial Potentials of Organic Photovoltaics
Sean Shaheen, *University of Denver, USA*
The field of organic photovoltaics (OPV) has advanced rapidly over the last several years to the point now of initial commercialization of small scale products. Recent demonstration of efficiencies of 10% and beyond by several groups around the world continue to propel interest in OPV as a potential low-cost, large-scale solar energy technology. This talk will provide an overview of the materials and approaches commonly used in the field today. The operational mechanisms of the devices will be described, focusing on a kinetic description of the carrier generation, recombination, and transport processes, taking into account the impact of molecular morphology of the requisite electron donating and accepting molecules. Thermodynamic analysis of the losses in current devices will be presented, and several concepts for overcoming them will be outlined, in particular focusing on the role of the molecular reorganization energy in determining exciton dissociation rates and allowing for optimal band alignment in the devices. The result of these discussions will be several pathways to achieving significant gains in efficiencies beyond today[1]s values. Lastly, approaches to industrial upscaling that utilize the intrinsically rapid production that is possible with OPV will be presented, along with a discussion of what performance metrics and production rates will ultimately be needed to significantly impact the world[1]s energy portfolio.

1:15pm – 3:15pm

Photonic Materials for Solar Energy Conversion at the Thermodynamic Limit
Harry A. Atwater, *California Institute of Technology, USA*
Ever since serious scientific thinking went into improving the efficiency of photovoltaic energy conversion more than 50 years ago, thermodynamics has been used to assess the limits to performance, guiding advances in materials science and photovoltaic technology. Photovoltaics have advanced considerably, resulting in single-junction solar cells with a record efficiency of 28.3% and multi-junction cells with an efficiency of 43.5%. As impressive as these advances are, these record efficiencies and also today's manufactured cell efficiencies in the 10–18% range fall far short of the thermodynamic limits. Why such a large gap? There is no fundamental reason, and in this lecture, I will discuss photonic methods for systematically addressing the thermodynamic efficiency losses in current photovoltaics that can enable a next phase of photovoltaic science and engineering – ultrahigh efficiency photovoltaics. This development takes advantage of recent advances in the control of light at the nanometer and micron length scales, coupled with emerging materials fabrication approaches, and will allow the development of solar cells with efficiencies in the 50–70% range.

Web resources:
http://www.lmi.caltech.edu/
http://daedalus.caltech.edu/

The Battery 500 Project: Towards the Ultimate Battery
Alessandro Curioni, *IBM Research, Zurich*
In this presentation I will give an overview of the Battery 500 project, an interdisciplinary consortium lead by IBM

Research to develop a lithium air battery that aims to increase the range of electrovehicles to 500 miles. Particular emphasis will be given to some of the key issues that have hampered the development of lithium air technology so far, and how we are solving them via an integrated experimental and first principle-based simulation approach.

Graphene for Nanoelectronic Device Applications

Luigi Colombo, *Texas Instruments Incorporated, USA*

In the past decade, the state of the art Si-based electronics has gone from devices at or above 100 nm to the realm of 30 nm and below, with a defined pathway to devices, logic and memory, of about 15 nm. In addition, as devices have scaled below a gate length of about 100nm performance per power density has not scaled, in fact it has decreased. In order to address the power issues the industry is facing as CMOS devices are scaled further, a program, Nanoelectronic Research Initiative, was created to develop new materials and devices that take advantage of new state variables with the objective of improving performance per power density. Graphene, a mono-layer of carbon atoms arranged in a honeycomb lattice, has recently been the subject of considerable theoretical and experimental interest because of its unique transport properties together with exceptional chemical and physical properties. New devices taking advantage of the theoretical prediction on the existence of a Bose-Einstein condensate (BEC) in bi-layer graphene films have been proposed. However, in order to demonstrate the existence of a BEC and new devices, high quality films will have to be developed and integrated with dielectrics and metal contacts.

High quality graphene has been formed by exfoliation from natural graphite with samples sizes of a few hundred square microns. Multilayered Graphene has also be grown on SiC substrates by a Si evaporation process from either the Si or C surfaces, but these films are limited to SiC and are difficult to integrate on Si wafers. The successful demonstration and implementation of graphene-based device technology will require synthesis of high quality graphene large- area films on substrates other than SiC or the exfoliation of graphene from graphite. The discovery of large-area and monolayer graphene growth on Cu substrates has opened many opportunities for the development of graphene-based devices including transparent conductive electrodes. Growth of graphene on Cu by chemical vapor deposition (CVD) is unlike growth on other substrates such as Ni, Co and other substrates with high C solubility in that a self-limited monolayer of graphite is grown by a surface mediated process. In order to take full advantage of the fundamental properties of graphene and the synthesis of large area films it is necessary to grow uniform and nearly defect-free films as the semiconductor industry has done with silicon substrates. In this presentation I will review the need for devices beyond CMOS, growth of large area graphene and integration of dielectrics with graphene and their effects on field effect transistors characteristics.

3:30pm – 6:10 pm

Innovation, Science and Technology Policy, and the Public Goo

Venky Narayanamurty, *Harvard University, USA*

In this talk I will review the role of Science and Technology in addressing some of the Societal Grand Challenges - such as energy technology, innovation, and sustainability. I will discuss the need to address the basic-applied dichotomy and role of technology in spurring both basic science and economic development as an inter-related ecosystem.

Photovoltaics in transition towards a mainstream electricity provider - in developed and emerging economies

Winfried Hoffman, *European PV Industry Association, Germany*

Until recently Photovoltaics (PV) has been seen as a useful and elegant provider of electricity to interesting markets like powering of satellites, industrial off-grid solutions and consumer applications. Only few could foresee the enormous growth over the last decade and even more surprising to many was the associated price decrease. The volume growth of the worldwide PV market was mainly influenced by market support programs like the Feed-in tariff (EEG) in Germany in 2001 and followed by more than 50 countries by now. Today we are with the Levelized Cost of Electricity (LCOE) equal or near to the retail price of electricity to households in most European countries ("dynamic grid parity") and will soon reach the generation cost for peak power production ("generation parity"). The price development of PV LCOE as function of cumulative PV installations will be described with the help of Price Experience Curves. Evidence is given that a further cost and price decrease will occur with PV in analogy to other industries like electronic and flat panel display products. Interestingly enough, as we transition towards a mainstream electricity supplier in developed countries, where we will also integrate storage to increase self consumption of the PV electricity produced locally, we have the necessary price structure available to provide cost effectively electricity to the many billions of people in emerging economies. It is the modularity of PV system components which makes it possible to benefit from the cost decrease of the technology driven development similarly for small solar home systems in rural areas, for kW up to MW roof systems in towns and villages and up to 100+MW systems for large scale use.

Bioenergy Innovation at Local, Regional and Global Levels - Addressing Needs for Emerging Technologies to Support Sustainable Growth and Development

Caroline Taylor, *UC Berkeley, USA*

There is no "silver bullet" solution to climate stress and development needs, but biofuels and bioenergy will be a necessary and substantial portion of the global energy portfolio. Biomass is the original 'alternative' energy. From a primary source of fuel, it has evolved to supply renewable energy services at levels spanning the very simple to the highly complex. As localized energy carriers with localized benefits that can smooth some of the heterogeneity in resource allocation, biofuels and bioenergy can be a means of advancement and sustainable development. This talk will discuss the state of technology and emerging research in biofuels, and the human and technical capacity and infrastructure needs to support its development. The role, deployment, and impact of bioenergy technologies will be evaluated as a support for growth in developing and underdeveloped regions, in the context of domestic and international biofuels policies in developed economies that effect developing and underdeveloped nations. This talk will also address the potential for public/private partnerships to contribute to capacity building for bioenergy and biofuels development.

Grid Access and Renewables in Developing Countries

Rob Stoner, *MIT, USA*

In the early 1990's, South Africa embarked on a program to massively expand grid access. After almost two decades, the story continues to unfold, and it is filled with lessons and examples that inform current thinking about energy policy and technology in other developing economies. South Africa is now in the early stages of a new effort to integrate renewables onto its grid system on an unprecedented scale. In this talk I will describe recent developments there, and relate them to equally important developments in other countries in Africa, and elsewhere where unreliable access to modern energy remains a serious daily concern, and an impediment to economic progress.

Tuesday, April 17

9:20am – 10:00am

Scaling up Access to Modern Energy Services in Africa

Ogunlade Davidson, *University of Sierra Leone, Sierra Leone*

Modern energy is essential for socio-economic development and crucial in alleviating poverty. The provision of reliable and affordable energy services in the continent for majority of its inhabitants is not only a huge task but is very urgent. Achieving this task will involve establishing optimum strategies between national efforts and international community while realising that the continent is extremely rich in most energy resources. This paper will aim at providing a robust analytical information that will help to develop optimum solutions.

10:00am – 12:00pm

Harnessing Light on a Silicon Chip for Optical Communications

Solomon Assefa, *IBM Watson Research Center, USA*

Supercomputers capable of delivering Exaflops performance are envisioned to become a reality by the end of this decade. In order to provide the enormous communication bandwidth that is necessary, millions of optical interconnects will have to be deployed to connect together racks, modules and chips. Such massive level of parallelism will require monolithic integration of deeply scaled silicon nanophotonics devices in close proximity with transistors by utilizing the latest CMOS technology. This talk will discuss the physics and practical application of silicon nanophotonic devices, challenges in integration, and the frontiers of optical physics enabled by nanoscale engineering.

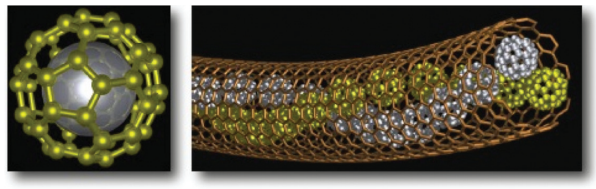
From Big Bang to Biosphere

Martin Rees, *Cambridge University, UK*

Astronomers and space scientists have made astonishing progress in probing our cosmic environment, thanks to advanced technology. We can trace cosmic history from some mysterious 'beginning' nearly 14 billion years ago, and understand in outline the emergence of atoms, galaxies, stars and planets -- and how, on at least one planet, life emerged and developed a complex biosphere of which we are part. But these advances pose new questions: What does the long-range future hold? How widespread is life in our cosmos? Is physical reality even more extensive than the domain that our telescopes can probe? This illustrated lecture will attempt to address such issues

Quantum Nanotechology

Andrew Briggs, *Oxford University, UK*



Images courtesy of Dr. Simon Benjamin

Quantum superposition and entanglement offer deep resources which are ripe for harnessing in practical devices. Superposition incorporates a phase with information content surpassing any classical mixture. Entanglement offers correlations stronger than any which would be possible classically. Together these give quantum computing its spectacular potential, but earlier applications may be found in metrology and sensing. Fundamental progress is being made in the development of quantum devices incorporating electron and nuclear spins which can be controlled with high precision.

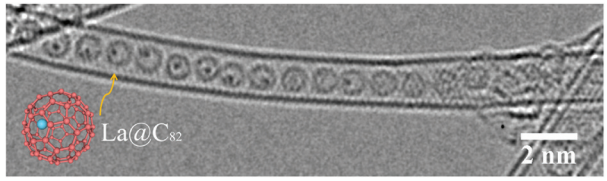


Image courtesy of Dr. Jamie Warner

Fullerene molecules offer remarkable electron spin properties. They can be assembled in single walled carbon nanotubes, and the resulting atomic structures can be imaged using low voltage aberration corrected transmission electron microscopy.N@C_{60} contains a single nitrogen atom in a cage of sixty carbon atoms, whose spin superposition states are coherent for hundreds of microseconds,and other endohedral fullerenes can be almost as good. Information can be transferred from electron to nuclear spins and back again to give even longer memory times,and can be stored and retrieved holographically in collective spin states. Small tip-angle excitations can be used to demonstrate many of the fundamental principles. Correlated spins can be used for magnetic field sensors that surpass the standard quantum limit. Devices can be made in which the active materials can be imaged with atomic resolution, and whose transport properties can detect a single electron spin. These results open the way for new technologies using the remarkable resources of quantum superposition and entanglement. This kind of quantum nanotechnology also enables fundamental concepts such as reality to be tested experimentally, stimulating new philosophical insights. Somewhat remarkably, these basic studies serve in turn to push the limits of technology, by extending the range of 'quantumness' which can be embodied in practical systems.

1:30pm – 2:45pm

Introduction to the Education Strand

Dean Zollman, *Kansas State University, USA*

Capacity building requires that university students learn

physics efficiently and effectively, and that pre-university physics teachers understand how to teach their students well. Over the past 20 years university education in physics has made major changes as a result of two related phenomena. First, through careful investigation of the teaching and learning of physics (Physics Education Research) we learned much about the difficulties that students have when learning physics and have developed approaches to address these difficulties. The results show that we can increase the number of students who learn physics well by increasing significantly the amount of student interactivity in our physics courses. Second, technology has provided new ways to help students learn physics. The technology includes general purpose items such as the Internet and productivity software, but also specialized equipment to enable laboratory measurements at all levels via computer interfaces. The education strand at the Forum will briefly explore these areas as well as the development of teachers who are aware of the news ways of teaching.

Developing Teachers for Engaged Interactive Teaching
Ian Lawrence, *Institute of Physics, UK*
To teach physics is to make connections between different physical theories, phenomenal experiences, and the minds of students. To do this effectively requires a broad range of interpersonal skills and, crucially, effectively developed pedagogic content knowledge—how this has been done will be the focus of the workshop.

Experience and research have shown that to learn effectively is not simply to sit at the feet of someone who has suitable qualifications and listen to them restate their understanding. Rather a reworking must take place that connects the learner to what is learned: to learn to reason in this subject is most fruitfully thought of as a kind of apprenticeship, and therefore requires interactive exemplification by a skilled practitioner. To begin to reason with physics, one must be able to use predictive models: so one needs to acquire a conceptual kitset with which to make connections appropriate to existing understandings. The exemplifying practitioner (a teacher) needs to have this kitset to hand, ready to deploy flexibly in response to the learner's reasoning.

The Supporting Physics Teaching (SPT) materials and the TalkPhysics website both provide environments in which teachers can develop these conceptual kitsets: SPT contains many useful pre-formed parts but these cannot be absorbed passively. Teachers (whether physics graduates or graduates of other sciences) must re-work their own understanding in order to prepare the kitset for use in their own classroom. No amount of documentation seems to provide an alternative to this mentoring/coaching approach to developing teachers.

It is that this reason that the SPT project developed the materials to support in-service training and that the TalkPhysics website is designed from the ground up to support a growing community of practice.
During the hour I will introduce you to both resources, focussing on SPT.

Web resources:
http://www.iop.org/spt
http://www.Talkphysics.org

3:00pm – 5:00pm

Coach, An Integrated Learning Environment for Science Education
Ton Ellermeijer & Ewa Kedzierska, *CMA-Science, Amsterdam*
The integration of ICT in physics education has proved to be very effective to enable inquiry-based education and also to make links to more professional and industrial activities.

Teachers and students are provided with powerful tools for a.o. data-acquisition with sensors and from videos, for analyzing data and modeling. This helps them to perform more realistic research-kinds of projects.

In the EC-funded ESTABLISH project (see www.establish-fp7.eu) science teachers are prepared for delivering IBSE lessons with a clear link to the professional world. Learning units have been developed (and more are under development) in which the ICT environment Coach for Mathematics and Science Education (see www.cma-science.nl) is applied.

In the workshop, participants will be introduced to Coach and Establish applications, and will have hands-on experience.

Banquet Keynote Address

Science and Technology: Building Innovative Societies and 21st Century Diplomacy
William Colglazier, *Science Advisor to the United States Secretary of State, United States Department of State, USA*
Because of the accelerating pace of technological change—due in part to the information and computer revolution and the global spread of expertise and knowledge—and its unquestioned impact on economic development, science and technology have become even more important assets for diplomacy. Nearly every country has been convinced that it must engage on a world-class level in science and technology and become more innovative in this highly competitive and interconnected world. As a consequence, science diplomacy becomes an important mechanism to help build more knowledge- and innovation-based societies and to help spread scientific values, including meritocracy and transparency, that support democracy. Making progress will require energetic international engagement by scientists and engineers everywhere, which can help to ensure a more peaceful, secure, and prosperous world.

Wednesday, April 18

8:30am – 10:30am

Insight into Organic Photovoltaics
K. S. Narayan, *Jawaharlal Nehru Centre for Advanced Scientific Research, Bangalore, India*
Issues related to morphology, crystallinity, and phase separation which are important in the development of efficient polymer based solar cells will be introduced and discussed. A versatile method to examine the donor-acceptor based bulk hetrojunction structures developed in our laboratory will be discussed. The method was used to follow changes with annealing and different donor:acceptor ratios, where the correlation between the

changes in the morphology and charge carrier generation was clearly established. The general viewpoint of increasing heterogeneity between two components and continuous pathways in the entire photovoltaic layer upon thermal annealing are clearly evident from the high resolution optical and current contrast images. Implications from recent observations and analysis of current fluctuations in solar cells will also be presented. Recent trends in low cost manufacturing methods and stability of organic solar cells will also be discussed.

Towards Affordable Clean Energy Solutions: The Nanoscience Route

Satishchandra B. Ogale, *National Chemical Laboratory, Pune, India*

Energy, environment, health, food and water are the sectors of critical significance and concern to the world, especially to the rapidly developing countries. These fields are intertwined in many complex ways and our excessive dependence on polluting fuels has had extremely serious and progressively deleterious influence on the quality of our lives. Since energy drives the engines of growth, our increasing demand for energy is unavoidable in the face of development, but in the light of the issues mentioned above we must necessarily seek clean forms of energy. Amongst the various forms of renewable energy, solar energy is the most abundant and clean source, and it can be harnessed in various interesting and effective ways. For a long time it was considered to be uneconomic, but with improvements in technologies, new inventions during the past decades, and novel possibilities generated by the emergence of nanoscience and nanotechnology, the solar economics are gyrating towards favourable domains of utilization.

In this talk I will discuss this scenario taking some examples from our own research on Dye and Quantum Dot Sensitized Solar Cells, photo-electrochemical (PEC) water splitting and visible light photocatalysis. The materials, electrodes, and systems required to be developed in this effort are synergistically similar to the requirements of other related fields such as energy storage (batteries and supercapacitors), and fuel cells, if functional carbon is included innovatively. We have thus ventured into the domain of synthesis and science of novel forms of carbon for such energy applications. I will discuss a few examples of this research as well. Interestingly, such suitably engineered high surface area carbon based systems are also useful for pollution control.

Bio-Inspired electro-photonic structure for organic and dye sensitized solar cells

Rene Lopez, *University of North Carolina at Chapel Hill, USA*

A major challenge in solar cell technology dwells in achieving an efficient absorption of photons with an effective carrier extraction. In all cases, light absorption considerations call for thicker modules while carrier transport would benefit from thinner ones. This dichotomy is a fundamental problem limiting the efficiencies of most photovoltaics. Light absorption in silicon cells, for example, is very weak, especially at the red side of the absorption band, requiring a thick active layer to capture enough photons. This active layer needs to be of high quality (and expensive!) crystalline material to transport the excitons over tens of microns. One pathway to overcome this problem is to decouple light absorption from carrier collection. We present solutions to this problem applying bio-inspired nanostructures to two different types of systems: organic photovoltaic (OPV) and dye sensitized solar cells (DSSC).

10:45am – 12:45pm

Microfluidic System Technology in Chemical Analysis

Karsten Kraiczek and Gerard P. Rozing, *Agilent, Walbron, Germany;* Kevin Killeen, *Agilent Technologies, Santa Clara, USA*

Chemical Analysis is facing nowadays rapidly changing requirements on performance. Resolution of sample components over a very wide range of concentration, analysis time, selectivity and specificity are expected to improve continuously. At the same time acquisition of samples for analysis is getting more difficult since samples are much smaller and must remain representative for a chemical, biological or environmental system in time and space. In addition, analysis methods must remain affordable, easy to use, and robust and applied by professional staffs, who are not trained lab technicians. These requirements and challenges can only be met by advances of the measurement technology itself. The vision of integrating largely manual steps in chemical analysis workflow from sample handling to data analysis in one device has lead to a rigorous reduction in scale (miniaturization) and to the concept of "Lab-on-a-Chip".

Microfluidics and the Oil Industry

Patrick Tabeling, *ESPCI, France*

Microfluidics is about the manipulation of fluids at the micrometric scale. This technology is impacting established fields—physics, chemistry, biology—by offering new methodologies. The oil industry recently realized the full potentiality of this technology. I will show a few examples in which microfluidic technology has generated new knowledge in the domains of reservoir characterisation. I will also show examples of new microfludic devices that are simple, portable, accurate and fast, able to acquire new information in the field, or that have the potential to challenge well-established instruments for surface testing.

Explaining the Flow of Elastic Liquids

John Hinch, *Cambridge University, UK*

One finds elastic liquids in the processing of plastics, processing of food, and in flowing biological fluids. They are in principle materials somewhere between viscous liquids and elastic solids. But their behaviour is not between that of a simple liquid or a simple solid. An example in the kitchen: water is ejected to the side walls of a bowl by a rotating whisk, while egg-whites climb the whisk. Further strange examples will be given. We seek an understanding of their behaviour.

2:00pm – 3:20pm

Photonics-based Telemedicine Technologies toward Smart Global Health Systems

Aydogan Ozcan, *UCLA, USA*

Today there are more than 5 billion cell-phone users in the world, and the majority of these cellphones are being used in the developing parts of the world. This massive volume of wireless phone communication brings an enormous cost-reduction to cellphones despite their sophisticated

hardware and software capabilities. Utilizing this advanced state-of-the-art of cell phone technology towards point-of-care diagnostics and/or microscopic imaging applications can offer numerous opportunities to improve health care especially in the developing world where medical facilities and infrastructure are extremely limited or even do not exist.

Centered on this vision, in this talk I will introduce fundamentally new imaging and detection architectures that can compensate in the digital domain for the lack of complexity of optical components by use of novel theories and numerical algorithms to address the immediate needs and requirements of Telemedicine for Global Health Problems. Specifically, I will present an on-chip cytometry and microscopy platform that utilizes cost-effective and compact components to enable digital recognition and 3D microscopic imaging of cells with sub-cellular resolution over a large field of view without the need for any lenses, bulky optical components or coherent sources such as lasers. This incoherent holographic imaging and diagnostic modality has orders of magnitude improved light collection efficiency and is robust to misalignments which eliminates potential imaging artifacts or the need for realignment, making it highly suitable for field use. Applications of this lensfree, on-chip microscopy platform to high-throughput imaging and automated counting of whole blood cells, monitoring of HIV+ patients (through CD4 and CD8 T cell counting), and detection of waterborne parasites towards rapid screening of water quality will also be demonstrated. Further, I will discuss lensfree implementations of various other computational imaging modalities on the same platform such as pixel super-resolution imaging, lensfree on-chip tomography, holographic opto-fluidic microscopy/tomography. Finally, I will demonstrate lensfree on-chip imaging of fluorescently labeled cells over an ultra wide field of view of >8 cm^2, which could be especially important for rare cell analysis (e.g., detection of circulating tumor cells), as well as for high-throughput screening of DNA/protein micro-arrays.

Realistic Applications of Optical Spectroscopy in the Environmental and Medical Fields, with Industrial Potential

Sune Svanberg, *Lund University, Sweden & South China Normal University, China*
Examples of realistic diagnostic optical equipment based on diode lasers, light- emitting diodes, optical fibres, compact spectrometers and lap-top computers are given. Experience from implementation in Africa, South America and China will be presented.

3:40pm – 5:40pm

Experiences in Physics Education at the Open University

John Bolton, *British Open University, UK*
While being truly open access, the Open University provides a set of modules that can take students from a very basic level up to advanced concepts and techniques. It also allows mature students with some background in physics and/or maths to top up their knowledge in specific subject areas. Over many years, our aim has been to develop inspiring and effective learning materials specifically designed for study at a distance. Typically, much effort is invested in the creation of new materials, but delivery can be easily scaled to large student populations.

In this talk I will describe some of the techniques we use, ranging from custom-designed books to simulations, interactive assessments and remote experiments. I will also present statistical evidence from student surveys, and show the results of investigations that link student success to a variety of factors, including the use of formative continuous assessment.

Inquiry Teaching Using Inexpensive Materials and Unexpected Results

Gorazd Planinsic, *University of Ljubljana, Slovenia*
In my presentation I will illustrate the following ideas that were found to be among most important in achieving effective physics teaching:

1. Effective teaching should engage students in active construction and testing of ideas. Traditional teaching in most cases does not create opportunities for the students to actively construct and test their own ideas. Active construction and testing are important steps in achieving understanding.

2. Teaching in context can significantly increase the motivation for learning. Creating meaningful context that is perceived as relevant by the learner will help students connect new ideas to existing knowledge. Creating stories is a key part of learning.

3. Multiple representations enhance student learning. Helping students represent ideas in multiple ways is an effective teaching technique. Those representations include words, real experiments, images, diagrams, graphs, videos, simulations, humor, etc. Here, modern technology opens new possibilities. I will not share these ideas as a dry theory, but will rather present them through examples and simple experiments.

Destinations and Inspirations: The Role of Undergraduate Research in Capacity Building for Industrial Physics

Liz McCormack, *Bryn Mawr College, USA*
In the USA there have been multiple reports calling for renewed efforts to increase the number of young people choosing to pursue careers in the sciences, engineering and mathematics. Alongside there have also been numerous reports from the private sector outlining the kinds of knowledge, skills and habits of mind that are of value to employers seeking to recruit new graduates. Educators at all levels have a critical role to play in meeting these demands, chiefly through the learning experiences we create for students. The Association of American Colleges and Universities, through the Liberal Education and America's Promise (LEAP) initiative, has articulated and promoted a set of essential learning outcomes intended to highlight and address what arguably matters most in college, in the context of a global economy and citizenship in the diverse USA democracy. We will use their rubric to explore the question, "How and to what degree do research experiences prepare undergraduates for the working world?" We'll look at the available evidence and consider ways to increase the efficacy of undergraduate research in preparing students to meet the challenges of 21st century work environments around the globe.

Thursday, April 19

8:30am – 9:30am

Scialog as a Model for Capacity Building Action Planning

Richard Wiener, *Research Corporation for Science Advancement, USA*

Research Corporation for Science Advancement's Scialog program is designed to accelerate the work of 21st-century transformational science through funding research, intensive dialog and community building. Each multi-year initiative seeks to support highly innovative early career scientists in response to a complex research challenge that serves as a driver in contemporary science. The first initiative under this program is Scialog: Solar Energy Conversion, and it is focused on fundamental research at the molecular and nanoscale levels that shows high potential to impact advanced energy technologies. Scialog is a research grant program emphasizing annual conferences with authentic dialog and competitive proposal writing. The process creates new cross-disciplinary collaborative teams based on novel ideas which emerge at conferences. Rigorous scientific assessment has been an integral component of the Scialog initiative from inception. This talk will describe the Scialog process and present intriguing initial assessment results suggesting that Scialog has so far been successful in creating new small cross-disciplinary teams organized around highly innovative research projects. The talk will provide the background for participants at this conference to engage in a Scialog process of dialog and community building leading to concrete action plans for capacity building after participants leave the conference.

1:45pm – 3:05pm

Time-Reversal, Waves and Innovation

Mathias Fink, *EPSI, France*

Time-reversal invariance is a very fundamental concept in classical and quantum physics. The objective of this talk is to show how this concept can be turned into a huge source of innovations and successful start-up companies.

It was first in the field of acoustics and later for microwaves, where antenna array technology was available, that "time-reversal mirrors" have been built. Such mirrors allow us to refocuses in space and time an incident wave field at the original source location regardless of the complexity of the propagation medium. Contrary to intuition, a remarkable property was shown: the more complex the propagation medium, the sharper the focus. Such results have been recently extended to focus on spots much smaller than the wavelength using new sub-wavelength structured media, opening new avenues toward super-resolution imaging and high rate telecommunications.

Time reversal mirrors are not only unique research tools in the field of fundamentals physics but they have plenty applications including therapy, medical imaging, telecommunications, underwater acoustics, seismology, and human-machine interface.

Recently, new tools available in optics, such as sensitive and fast megapixel digital sensors and modulators, are opening new perspectives toward time reversal of light.

Diagnostics and Treatment of Tumours using Laser Techniques

Katarina Svanberg, *Lund University Hospital, Lund University, Lund, Sweden* and Sune Svanberg, *Lund University, Sweden*

There are numerous challenges to be solved within clinical and preclinical medicine ranging from microbiology, surgery, oncology, anaesthesiology and intense care, all the way to pediatrics. The ongoing effort to develope new methods utilising optics and photonics has resulted in some promising results and in a translational process, also brought over to clinical early phase studies.

Applications of optical and laser spectroscopy to the medical field, including photodynamic therapy (PDT) and laser-induced fluorescence diagnostics (LIF) for cancer treatment and diagnostics, respectively, will be presented. Photodynamic therapy in conjunction with LIF for demarcation of the treatment target area will be discussed. To overcome the limited light penetration in superficial illumination interstitial delivery (IPDT) with the light transmitted to the tumour via optical fibres has been developed. Interactive feed-back dosimetry is of importance for optimising this modality and such a concept has been developed and will be presented. Special emphasis will be on prostate cancer therapy with interstitial PDT.

The most important prognostic factor for cancer patients is early tumour discovery. If malignant tumours are detected during the non-invasive stage, most tumours show a high cure rate of more than 90%. There is a variety of conventional diagnostic procedures, such as X-ray imaging. More advanced results are given in computerised investigations, such as CT-, MRI- or PET-scanning. Laser-induced fluorescence (LIF) for tissue characterisation is a technique that can be used for monitoring the biomolecular changes in tissue under transformation from normal to dysplastic and cancer tissue before structural tissue changes are seen at a later stage. The technique is based on UV or near-UV illumination for fluorescence excitation. The fluorescence from endogenous chromophores in the tissue alone, or enhanced by exogenously administered tumour seeking substances, can be utilised. Conventionally, the diagnosis of e.g., skin cancer is performed by taking a biopsy, which may cause scarring and also pain besides leaving the patient with anxiety during the time for histopathological examination. The LIF technique is non-invasive and gives the results in real-time. It can be applied for point monitoring or in an imaging mode for larger areas, such as the vocal cords or the portio of the cervical area. The possibility to combine LIF and PDT will be discussed and illustrated with clinical examples from many specialities, such as dermatology, gynaecology and laryngology.

A new method where free gas, such as oxygen or water vapour, can be detected will also be presented. The technique is called GASMAS, gas absorption spectroscopy in scattering media. In clinical studies it was shown that it can be used for monitoring the para nasal sinus cavities in the facial skeleton. This is of importance for patients with sinusitis, in particular these with recurrent problems, as the GASMAS technique relies only on light and not on ionizing radiation. The method can also be used to study the gas exchange between the nasal cavity and the different sinuses in the facial region. Another application of the GASMAS technique is for the preterm infants who suffer from insufficient lung function. Due to this, the oxygenation is low and there is a risk of brain damage. With this technique the lung function can be monitored. The standard methods used in the clinic

now are either x-ray based methods or blood tests. With this non-invasive optical technique the monitoring can be performed in vivo with 24 hour surveillance. This opens up an opportunity to follow-up the treatments the small infants are given to improve their lung function.

3:30pm – 5:30pm

Reservoir Modeling and Simulation
Thomas Halsey, *ExxonMobil Upstream Research, USA*
Understanding the flow of fluids in the subsurface is key to the economical production of oil and gas, the effective management of water resources, and potentially to the geological storage of carbon dioxide emissions from industrial and power generation processes. While the fundamental physics of single-phase flow in simple porous media is well understood and can be comprehensively modeled, real fluids and geological media add complex phase behavior, wetting behavior, multi-phase flow, and multi-scale porosity and fracture transport to the list of physical effects to be modeled. If fluids are to be produced or injected at the surface, then the interaction of the subsurface flows with flows through engineered systems and wellbores must also be included to achieve satisfactory models. Finally, an overarching complexity is that the exact nature of subsurface heterogeneity can never be determined from surface measurements; in the real world, subsurface models must be continually updated as more information is gleaned from flow histories. I will review these different levels of sophistication in reservoir modeling and simulation, with particular attention to those aspects key to global society's needs for energy, water management, and reduction in greenhouse gas emissions reaching the atmosphere.

Microfluidics for Global Health Diagnostics
Samuel Sia, *Columbia University, USA*
Lab-on-a-chip (LOC) devices have a tremendous potential for improving the health of people in developing countries by providing immediate diagnosis in the field. The development of diagnostics for global health, however, presents unique and challenging design criteria. We will discuss our lab's current efforts, in conjunction with partners in industry, public health, and local governments, to develop new rapid diagnostic tests. Our tests span a variety of technologies, and target HIV, sexually transmitted diseases, and other infectious diseases.

Microfluidic Principles and Devices for Analytical and Synthetic Purposes
Hans Gardeniers, *University of Twente, Netherlands*
Current developments in the field of microfluidic technology allow accurate handling of liquid volumes in the nl to µl range, in miniaturized systems in which sensing elements to monitor chemical processes on-line can be integrated. This development is especially relevant for the field of chemical analysis in the life sciences where only limited sample volumes are available. This contribution will give a number of examples of integrated microfluidic devices which use sample volumes of 1 microliter or less, including devices which emply NMR, IR, or MS. A second class of topics that will be discussed is that of microreaction systems in which physical principles are used to stimulate chemical activity. In the discussion of the latter topic the focus will be on the use of ultrasound.

5:30pm – 6:10pm

Photovoltaics and Renewable Electricity in Europe
Arnulf Jaeger-Waldau, *European Commission's Joint Research Center, Inspra, Italy*
Renewable energy use is growing at a much faster pace than the rest of the economy in Europe and world-wide. This and the dramatic oil price increases since 2005 have lead to a remarkable re-evaluation of the renewable energy sector by politics and financing institutions. Despite the fact that there are still discrepancies between the European Union and the USA how to deal with climate change, renewable energies will play an important role for the implementation of the Kyoto Protocol and the world wide introduction of tradable Green Certificates. Apart from the electricity sector, renewable energy sources for the generation of heat and the use of environmental friendly bio-fuels for the transport sector will become more and more important in the future.

Photovoltaics is one of the fastest growing industries at present. In the last ten years, the production of photovoltaic cells has increased exponentionally by more than 50% per year, driven not only by the progress in materials and processing technology, but by market introduction programmes in many countries around the world. This growth is realised mainly by an increase of manufacturing capacities based on the technology of crystalline, single junction devices, but thin film technologies could increase their market share over the last five years to about 20%. Consistent with the time needed for any major change in the energy infrastructure, another 20 to 30 years of sustained and aggressive growth will be required for photovoltaics to substitute a significant share of the conventional energy sources. Despite the fact that globally the share of electricity from photovltaic systems is still small, the share of PV electricity at local level can already now be above 30% of the demand at certain times of the year. Future research in PV has to provide intelligent solutions not only on the cell, but also on the module and the system level in order to permit the future rapid growth of photovoltaics in order to become one of the major electricity sources in 2020.

Speaker Biographies

Solomon Assefa is a Research Staff Member at the IBM T.J. Watson Research Center. His research interests include CMOS-integrated silicon nanophotonics for optical interconnect, ultra-fast photodetectors, silicon-platform for quantum communication, and photonic-crystals for biosensing. Solomon is a member of IEEE, OSA, and APS. He has filed 30 patents, published over 30 articles in technical journals and 80 conference proceedings, and delivered over 30 invited presentations. He has received a Technical Accomplishment Award and several Invention Achievement Awards from IBM. He was also recognized by MIT Technology Review's TR35, a list of the World's Top Young Innovators for 2011. Solomon received B.S. in physics, B.S. in EECS, and M.S. in EECS in 2001 from MIT. He joined IBM in 2004 after receiving a Ph.D. from MIT for his research on photonic-crystals. He was born in Addis Ababa, Ethiopia.

Harry Atwater is the Howard Hughes Professor and Professor of Applied Physics and Materials Science at the California Institute of Technology. His research interests center around two interwoven research themes: plasmonics & optical metamaterials, and photovoltaics & solar energy. He is an early pioneer in surface plasmon photonics; he gave the name to the field of plasmonics in 2001. He has authored or co-authored over 200 publications, and his group's developments in the solar and plasmonics field have been featured in *Scientific American* and in research papers in *Science, Nature Materials, Nature Photonics* and *Advanced Materials.* Atwater and his group have been active in photovoltaics research for more than 20 years. Recently they have created new photovoltaic devices, including silicon wire array solar cells, and transferred-layer designs for III-V semiconductor and multijunction cells, as well as making advances in plasmonic light absorber structures for III-V compound and silicon thin films.

John Bolton is a Senior Lecturer and past Director of Teaching in the Physics Discipline of the Open University, where he has developed many distance learning materials on quantum mechanics, electromagnetism, relativity, the physics of matter, introductory physics and applied mathematics. He has received a teaching award at the Open University, a national teaching award for a videodisc on the physics of water and has been a Visiting Scholar with Wolfram Research. He has particular interests in helping distance education students develop good problem-solving techniques and has recently investigated factors that lead to success in higher-level physics and astronomy modules, including the effectiveness of formative assessment.

Andrew Briggs is Professor of Nanomaterials at the University of Oxford. He is Fellow of St Anne's College, Fellow of Wolfson College, Fellow of the Institute of Physics, Honorary Fellow of the Royal Microscopical Society, Member of Academia Europaea, and Liveryman of the Worshipful Company of Clothworkers. He has a degree in Physics from Oxford, and a PhD in Physics and a degree in Theology from Cambridge. He received the Holliday Prize, Institute of Materials, 1984, and the Metrology award for World Class Manufacturing, 1999. He holds a Private Pilot Licence. From 2002 – 2009 he was Director of the UK Quantum Information Processing Interdisciplinary Research Collaboration. He serves on the EPSRC Peer Review College, the Science & Engineering Fellowships Committee of the Royal Commission for the Exhibition of 1851, the Engineering Panel of the Newton International Fellowships, and the Advisory Council of the McDonald Centre for Theology, Ethics, and Public Life. He is a member of the International Board of Advisors of the John Templeton Foundation, and is responsible for proposals to the Templeton World Charity Foundation. He has over 575 publications, with more than 9,000 citations. His research interests focus on nanomaterials in which the electron and nuclear spin states can be harnessed for quantum technologies.

E. William Colglazier was appointed in July 2011 as the fourth Science and Technology Adviser to the Secretary of State. His office provides scientific and technical expertise and advice in support of the development and implementation of U.S. foreign policy. From 1994 to 2011, Dr. Colglazier was Executive Officer of the National Academy of Sciences (NAS) and the National Research Council (NRC) where he helped to oversee the studies conducted by the NRC, which is the operating arm of the NAS, the National Academy of Engineering, and Institute of Medicine. From 1983 to 1991, he was Professor of Physics and Director of the Energy, Environment, and Resources Center at the University of Tennessee. He received his Ph.D. in theoretical physics from the California Institute of Technology in 1971, and prior to 1983 worked at the Stanford Linear Accelerator Center, the Institute for Advanced Study in Princeton, and the Center for Science and International Affairs at Harvard's Kennedy School of Government. In 1976-77, he was an AAAS Congressional Science Fellow working for Congressman George Brown.

Luigi Colombo is a TI Fellow in the External Research and Development group at Texas Instruments. He joined TI in 1981 to work on infrared detector materials where among other materials he developed a HgCdZnTe liquid phase epitaxy process which he also put in production in 1991 and it is still in production. Since then he has been responsible for the development of high-k capacitor MIM structures for DRAMs, development of high-k gate/metal gate transistor gate stack using Hf-based dielectrics, and low leakage SiON based 45 nm transistor gate stack development. He is currently responsible for the development of new materials development such as graphene and its integration in new device flows for beyond CMOS device technology as part of

the Nanoelectronics Research Initiative. Luigi has authored and co-authored over 130 refereed papers, made over 150 invited and contributed presentations, has written 3 chapters in edited books, and holds 73 US and 18 international patents. He was elected to IEEE Fellow in 2011 and is an Adjunct Professor in the Dept. of Materials Science & Engineering at the University of Texas at Dallas.

Alessandro Curioni received his diploma in Theoretical Chemistry and PhD in Computational Materials Science at Scuola Normale Superiore, Pisa, Italy. He joined IBM Zurich Research Laboratory in 1998 as Research Staff Member in the Computational Biochemistry and Materials Science Group. In 2007 he has been appointed Manager of the Computational Science Group and in 2012 Head of the Mathematical and Computational Sciences Department. Since 2011 he has been a member of the IBM Academy of Technology. His main research interest is the development of atomistic simulation methods and their application to frontier problems of materials science and life science, with particular interest in the design of materials with tailored properties. He is also a world expert in high performance computing and is involved in the scaleout of Deep Computing applications on massively parallel supercomputers such as Blue Gene.

Ogunlade R. Davidson was Minister of Energy and Water Resources for two and a half years in the Sierra Leone Government, and Co-Chair of the Steering Committee of the Global Network on Energy for Sustainable Development (GNESD). He is Professor of Mechanical Engineering and was Dean of Post-Graduate Studies, Director of Research. Also, he was Head of Department of Mechanical and Maintenance Engineering, and Dean of the Faculty of Engineering at the same university. He was also the Chairman of the Board of the Sierra Leone Environmental Protection Agency (SLEPA), and was Director of the Board of National Power Authority and member of the Transitional Management Committee of the Sierra Leone Broadcasting Services. Internationally, he was Vice-Chair of the Intergovernmental Panel on Climate Change (IPCC). Also, he was Professor and Director of the Energy and Development Research Centre (EDRC) of University of Cape Town, South Africa. Before then, he was a Senior Fulbright Scholar at University of California, Berkeley and a MacArthur Scholar at Princeton University and Lawrence Berkeley Laboratory in the USA. He has worked as a visiting Professor at the University of Gothenburg, Sweden, ENDA-TM in Senegal, and National Technical University of Denmark. He has published extensively in African energy systems and policies, power sector reform, renewable energy policy, mitigation of climate change and on national climate change strategy. He has worked as a Consultant for UNESCO, UNIDO, ILO, ABD, UNECA, UNDP, UNEP, GEF, UNFCCC, NEPAD, ADB, and the World Bank. Professionally, he is a Registered Chartered Engineer of United Kingdom and Fellow of the African Academy of Sciences and of the Sierra Leone Institution of Engineers, and a Chartered Member of the Nigerian Society of Engineers.

Ton Ellermeijer is Director of CMA and current President of GIREP (the International Group of Physics Education Researchers, Teacher Trainers and Teachers). Ton Ellermeijer is an experienced researcher in science education, curriculum developer and teacher trainer. He is specialized in the application of ICT in Science Education. He has been Director of the AMSTEL Institute of the University of Amsterdam from 1997 up to 2010. Ton Ellermeijer received the Minnaert Prize for his contributions to Dutch Physics Education (1999) and the ICPE Medal (International Commission of Physics Education of the IUPAP, 2009) for his contribution to physics education worldwide.

Mathias Fink received the M.S. degree in mathematics from Paris University, France, in 1967, and the Ph.D. degree in solid state physics in 1970. Then he moved to medical imaging and received the Doctorat es-Sciences degree in 1978 from Paris University. His Doctorat es-Sciences research was in the area of ultrasonic focusing with transducer arrays for real-time medical imaging.
Mathias Fink is a professor of physics at the Ecole Superieure de Physique et de Chimie Industrielles de la Ville de Paris (ESPCI ParisTech), Paris, France. In 1990 he founded the Laboratory Ondes et Acoustique at ESPCI that became in 2009 the Langevin Institute. In 2002, he was elected at the French Academy of Engineering, in 2003 at the French Academy of Science and in 2008 at the College de France on the Chair of Technological Innovation.

Mathias Fink's area of research is concerned with the propagation of waves in complex media and the development of numerous instruments based on this basic research. His current research interests include time-reversal in physics, super-resolution, metamaterials, medical ultrasonic imaging, ultrasonic therapy, multiwave imaging, acoustic smart objects, acoustic tactile screens, underwater acoustics, geophysics and telecommunications. He has developed different techniques in medical imaging (ultrafast ultrasonic imaging, transient elastography, supersonic shear imaging), wave control and focusing in complex media with time-reversal mirrors. He holds more than 55 patents, and he has published more than 350 peer reviewed papers and book chapters. 4 start-up companies have been created from his research (Echosens, Sensitive Object, Supersonic Imagine and Time Reversal Communications)

Han Gardeniers started as an assistant professor in the field of Micromechanical Tranducers at the University of Twente in 1990. From 2001 until 2003 he was active as a senior scientist in industry, first at Kymata Ltd./Alcatel Optronics, and later at Micronit Microfluidics. In 2003 he rejoined the University of Twente, with the Biosensors/ Lab-on-a-Chip Group. Since January 2007 he leads the Mesoscale Chemical Systems group, which is also associated with the MESA+ Institute for Nanotechnology. His research interest and expertise is in microfluidics, microreactors, and miniaturized analysis systems. He has published 170 reviewed journal papers in the field of microfabrication, MEMS, lab-on-a-chip and microfluidics and is the inventor on six patents.

Thomas C. Halsey is currently Manager for Computational Sciences and Upstream Breakthrough Research at ExxonMobil Upstream Research Company in Houston, TX. In this role he is responsible for research and development for all computational sciences and technical software used by ExxonMobil's global exploration and production (upstream) businesses. In addition, he is charged with leading the

innovation underlying the most high-risk / high-reward component of ExxonMobil's upstream research. He joined ExxonMobil (then Exxon) in 1994, and has worked in a variety of research, staff, and management positions in New Jersey and in Texas. He was on the faculty of the Department of Physics and the James Franck Institute at the University of Chicago from 1987 to 1994, and held postdoctoral fellowships at the University of Chicago and the Centre d'Etudes Nucléaires de Saclay, France. He received a Ph.D. in Physics from Harvard University in 1984. He is a Fellow of the American Physical Society, and was a Presidential Young Investigator as well as an A.P. Sloan Foundation Fellow.

Philip (Bo) W. Hammer is the Associate Vice President for the Physics Resources Center at the American Institute of Physics. He shares responsibility for overall management of AIP's outreach programs and has specific responsibility for government relations and industrial outreach.

Prior to arriving at AIP, Hammer was Associate Executive Officer of the American Association of Physics Teachers. Prior to AAPT, Hammer was vice president for The Franklin Center at The Franklin Institute Science Museum in Philadelphia.

Hammer received his PhD in Physics from the University of Oregon in 1991. From 1991-93, Hammer was an Office of Naval Research Postdoctoral Fellow at the Naval Surface Warfare Center in Silver Spring, MD, doing experimental nonlinear dynamics research. His research resulted in the first experimental verification of On-Off Intermittency. Hammer spent the '93-'94 academic year as an APS Congressional Science Fellow working on the staff of the Subcommittee on Science in the US House of Representatives. In 1994, Hammer was appointed Assistant to the Executive Director at the American Institute of Physics. In the AIP Director's office, Hammer ran the Corporate Associates Program. In 1996, Hammer moved to the AIP Education Division, where he was Director of the Society of Physics Students and Sigma Pi Sigma until 2000.

Hammer has published research in Physical Review Letters, Physical Review E, and the Journal of Statistical Physics; he has written for Physics Today, The Industrial Physicist, APS News, Radiations magazine, Physics and Society, and for a number of books and proceedings on topics ranging from basic research, to the role of physics in society, to career advice for scientists.

Hammer was a participant in President Clinton's Forum on Science in the Public Interest in 1994, served on the APS Panel on Public Affairs from 1995-1996, and was a panelist on the US House of Representatives Early Career Scientists Roundtable in 1997. He is past-Chair of the APS Forum on Physics and Society. Hammer also recently completed six years on the Haddon Heights, NJ Board of Education, the last two of which he served as Board President. He served APS as a member of the Council and is a past member of the APS Executive Board, past-Chair of the APS Committee on Informing the Public, and past-Chair of the APS Prizes and Awards Committee. Hammer also recently ended his term on the Executive Committee of the APS Forum on Physics and Society and served on the organizing committee of the new APS Forum on Outreach and Engaging the Public. Hammer is a Fellow of the American Physical Society.

John Hinch received his education at Cambridge University, graduating with a B.A. in mathematics in 1968 and a Ph.D. in 1972 supervised by George Batchelor on the "Mechanics of suspensions of particles in fluids, with an additional section on the convection due to a moving heat source". After a post-doc at Caltech under the then young Gary Leal, he returned to a faculty position at Cambridge University and since 1998 has been there a Professor of Fluid Mechanics. He has benefited greatly from many collaborations, first with Andreas Acrivos and his students, and later with experimental groups in France following introductions by Etienne Guyon. He is a Fellow of the APS and the Royal Society of London. His research interests include suspensions of particles and other mobile particulate systems, the flow of non-Newtonian fluids and applications of mathematics to industrial problems.

Winfried Hoffmann graduated in physics and did his PhD-thesis in biophysics. He joined the just formed photovoltaic R & D group for thin film solar cells of NUKEM in 1979 and took over its leadership in 1985.

He initiated the Joint-Venture in the photovoltaic field between NUKEM and Daimler-Benz Aerospace to form "Angewandte Solarenergie - ASE GmbH" in 1994, where he served as Managing Director. In the same year the acquisition of 100 % shares of Mobil Solar as a subsidiary company was done. In October 2002 the Joint Venture between RWE Solutions and SCHOTT Glas, the RWE SCHOTT Solar GmbH, was formed, where he served as Chairman of the Board. Effective in 2005 SCHOTT acquired the shares of RWE Solutions and the company was renamed SCHOTT Solar GmbH where he was Member of the Management Committee.

In 2007 he joined Applied Materials to become Chief Technology Officer and Vice President of the Solar Business Group and member of the Management Board of the German based Applied Materials GmbH. From November 2010 he serves as consultant (ASE – Applied Solar Expertise) to the solar business of Applied Materials.

He is currently Vice President of the European Photovoltaic Industry Association (EPIA) and member of the Scientific Board of the Fraunhofer Institute for Solar Energy (FhG-ISE) and member of the Supervisory Board of the institute for solar energy research in Hameln (ISFH), the Helmholtz Centre Berlin and the company SMA Solar Technology AG.

Arnulf Jäger–Waldau is a Scientific Officer and Senior Scientist at the Renewable Energy Unit, Institute for Energy and Transport of the European Commission's Joint Research Centre since 2001. He works on the assessment of renewable energy technologies, the effectiveness of their implementation and their integration into energy infrastructures.

Since 1987 he has worked in the field of material research for solar cells and holds patents on semiconductor material deposition for thin film solar cells and solar module design.

He has more than 150 publications in peer reviewed journals and conference proceedings ranging from materials research for PV and solar cell development to market studies and policy evaluations for renewable energies. He is the author of the European Commission's annual "Photovoltaic Status Report", which has been published annually since 2002.

Dr. Jäger-Waldau was a Lead Author for Solar Energy of the 2011 Special Report of the IPCC on Renewable Energy and Climate Change Mitigation.

He serves as a member of the Executive Committee of the European Materials Research society (E-MRS), member of the Academic Advisory Board of the Chinese Trina State Key Laboratory for Photovoltaics, Academic Committee Vice Chairman of the Asian Photovoltaic Industry Association (APVIA), member of the International Advisory Board of the Warsaw University Photovoltaic Centre and member of the Scientific Advisory Board of the Solar Research Centre of the Bulgarian Academy of Science.

He is the Technical Chairperson of the 27th European Photovoltaic Solar Energy Conference and Exhibition (EU PVSEC) in Frankfurt 2012 and is the designated Chairman of the 2013 E-MRS Spring Meeting in Strasbourg.

Lawrence L. Kazmerski is Executive Director, Science and Technology Partnerships at the *National Renewable Energy Laboratory*, Golden, Colorado—having served as Director of the National Center for Photovoltaics for the period 1999-2008. He received his B.S.E.E. in 1967, M.S.E.E. in 1968, and his Ph.D. degree in electrical engineering in 1970—all from the University of Notre Dame. He served in a postdoctoral position with the Atomic Energy Commission at the Notre Dame Radiation Research Laboratory, January through August 1971. He was on the electrical engineering faculty of the University of Maine before coming to SERI (NREL) in 1977. His research at Maine included NSF- and ERDA-funded work in thin-film photovoltaics and the report of the *first* thin-film copper-indium-diselenide (CIS) solar cell. While at UMaine, Kazmerski inaugurated a graduate program with Fairchild Semiconductor in South Portland, combining classes taught over the Maine Public Broadcasting microwave transmission system, faculty visits to the South Portland facility, and "semester sabbaticals" for Fairchild engineers and scientists to the Orono campus. He was SERI's (NREL's) first staff member in photovoltaics, hired specifically to establish efforts in the characterization of photovoltaic materials and devices; he led NREL efforts in measurements and characterization for more than 20 years. Kazmerski has more than 320 publications and some 200 invited talks. His current research interests include the DOE Office of Science Energy Frontiers Research Center (EFRC) at NREL dealing with "materials by design" (www.centerforinversedesign.org), for which he serves as Co-Director and Project Integrator, and solar projects ranging from the rebuilding of the electricity infrastructure in Iraq through mitigating dust problems for PV collectors. He has been recognized with several national and international awards, including the World PV Prize, the IEEE William R. Cherry Award, the AVS Peter Mark Memorial Award, and the ASES Charles Greeley Abbot Award. He is a Fellow of the IEEE, a Fellow of the APS, a Fellow of the AVS, and a Fellow of the American Solar Energy Society (ASES). Kazmerski is a member of the *National Academy of Engineering*.

Ewa Kedzierska is a senior staff member of CMA, an ICT in Science specialist and Science educator. Experienced in the development of the Coach learning environment and in international projects. Involvement in curriculum development, teacher training materials and dissemination.

Karsten Kraiczek received his Diploma in precision mechanics at the University of Applied Science in Furtwangen / Germany. He joined Hewlett Packard's Analytical Product Group Germany in 1985 as R+D Engineer in Optical Detection and then HP's Integrated Circuit Division in Colorado as R+D Scientist and Project Manager for Photodiode Array Technology. Today he is working as R+D Project Manager and Senior Scientist in Agilent's Life Science and Chemical Analysis Group in the field of Micro-Fluidics System Technology. In parallel he is writing his PhD Thesis at the University of Freiburg/ Germany on Optical Detection in low flow HPLC.

Rene Lopez obtained his Bachelor degree from the Monterrey Institute of Technology (Mexico), and his Master and Doctoral degrees from Vanderbilt University (USA). He worked at the Oak Ridge National Laboratory and Vanderbilt University before joining the Faculty of the University of North Carolina at Chapel Hill (USA). He currently heads a group that does research in optical materials. In particular, photonic structures for organic photovoltaics, dye sensitized solar cells, surface raman enhancement spectroscopy, and evanescent wave amplification.

Ian Lawrence: After a degree in Physics and Philosophy from the University of Bristol and a PGCE at Cambridge, Ian Lawrence taught physics in schools in England and New Zealand for nearly 20 years before moving to Birmingham University where he was a lecturer in physics education for 7 years. Along the way he became involved in multimedia authoring and computer modelling tools, contributed to the Nuffield science courses, played a significant part in developing the Advancing Physics course for post-16 students, and co-led the Supporting Physics Teaching 11-14 project. He is currently the national co-ordinator for the Supporting Physics Teaching project at the Insitute of Physics. He was awarded the Bragg medal for innovative contributions to physics education in 2002.

Elizabeth F. McCormack is Professor of Physics at Bryn Mawr College. She received her bachelor's degree in astronomy and physics from Wellesley College (1983) and her Ph.D. in physics from Yale University (1989). She was an Alexander Hollaender Distinguished Postdoctoral Fellow (1990) and a staff physicist at Argonne National Laboratory (1991-1995). In 1995 she joined the faculty at Bryn Mawr College. Her research interests include fundamental aspects of molecular excited state-structure and dynamics using a variety of laser spectroscopy techniques: Rydberg and ion-pair state dynamics, photoionization, autoionization, predissociation, and photodissociation; resonant multiphoton excitation and detection, time-of-flight mass spectroscopy, and resonant, four-wave mixing in the frequency and time domains. She has published over 30 peer-reviewed journal articles. She was a Fulbright Senior Research Scholar and Visiting Professor at the University of Paris XI in Orsay, France (1998) and an ERCOFTAC Guest Scientist at the Paul Scherrer Institute in Switzerland (1999). She is a Fellow of the APS and has been a member of the APS Committee on Education (2004-2007), the DAMOP Thesis Prize Committee (2008-2010), the DAMOP Executive Committee (2007-2010); the DLS Fellowship Committee (2005, 2008), the APS, AIP, and AAPT National Task Force

on Undergraduate Physics (2003-2007), the DLS Nominating Committee (2003), and since 2003, the DLS Distinguished Traveling Lecturer Committee. At Bryn Mawr College she has been Chair of the Faculty (2006-2007), Director of the Center for Science in Society (2006-2008), and Dean of Graduate Studies (2008-2011). She received the College's McPherson Prize for Faculty in 2007. She has served as a curriculum consultant for Effat College in Saudi Arabia (2001) and was a Fellow of the American Council on Education at Lesley University (2005). She also currently serves on the Board of Directors of The Research Corporation for Science Advancement, and chairs the Board of Advisors to Project Kaleidoscope at the Association of American Colleges and Universities.

K. S. Narayan (KSN) obtained MSc. Physics from IIT (Bombay), and Ph.D. from The Ohio State University in the area of Low dimensional Molecular Magnetism in 1991. Subsequently he was a Scientist at Wright Patterson Air Force Base, Dayton. Since 1994 he is at JNCASR, Bangalore where he is a professor and heads the molecular electronics laboratory. KSN has been actively involved in studying electronic, optical, and magnetic phenomena and exploring device structures in synthetic polymeric/organic/nanoparticle based systems. His current research activities is focused on: (i) Device physics of soft-electronic materials which involves fabrication of FETs, solar cells, large area imaging structures (ii) Photophysical and transport studies of conjugated polymers using quasi-near field scanning and spectroscopic techniques (iii) Electric field induced patterning methods of soft elastic films (iv) Developing components for artificial retina. He has held visiting positions - Univ. of Illinois, Univ. of Michigan and Motorola Labs. He has over 80 publications and couple of international patents. He is an Editorial Board Member of Pramana Journal of Physics, Journal of Sensors, Synthetic Metals and a Senior IEEE member. He is a Fellow of National Academy of Sciences, India and Fellow of the Indian Academy of Sciences. He is also actively involved in community efforts related to usage, implementation and information dissemination of alternative energy resources.

Venkatesh Narayanamurti is the Benjamin Peirce Professor of Technology and Public Policy, and a Professor of Physics at Harvard. He is also the Director of the Science, Technology and Public Policy Program at the Belfer Center for Science and International Affairs at the Harvard Kennedy School (HKS). He was formerly the John L. Armstrong Professor and Dean of the School of Engineering and Applied Sciences, and Dean of Physical Sciences at Harvard. Previously he served as the Richard A. Auhll Professor and Dean of Engineering at the University of California at Santa Barbara. Prior to that he was Vice President of Research at Sandia National Laboratories and Director of Solid State Electronics Research at Bell Labs. He obtained his PhD in Physics from Cornell University and has an Honorary Doctorate from Tohoku University. He is an elected member of the American Academy of Arts and Sciences, the National Academy of Engineering and the Royal Swedish Academy of Engineering Sciences, and a Fellow of the American Physical Society, the American Association for the Advancement of Science, the IEEE, and the Indian Academy of Sciences. He has served on numerous advisory boards of the federal government, research universities, and industry. He is the author of more than 200 scientific papers in different areas of condensed matter and applied physics. He lectures widely on solid state, computer, and communication technologies, and on the management of science, technology and public policy.

Satishchandra Ogale did his Ph.D. in Physics from Pune University (India) in 1980. Currently he is Chief Scientist and Coordinator of the Centre of Excellence in Solar Energy at CSIR's National Chemical Laboratory (NCL) in Pune. From 1980 to 1996, he worked as Faculty at the Physics Department of Pune University; he was also the Head of the Physics Department (1992-95). Subsequently he worked as Senior Scientist at University of Maryland at College Park for about 10 years (1996-2006) before returning to CSIR-NCL, India. Over the past 25 years has worked as a Visiting Professor or Scientist at several Universities/ Laboratories such as University of Southern California, Bell Communications Research, University of Maryland, University of Rouen, France, FOM Institute, Amsterdam, Hanyang University, Korea, National University of Singapore etc. He has published over 340 research papers in peer reviewed international journals including Nature, Science, Nature Materials, Advanced Materials, Physical Review Letters, Applied Physics Letters, Energy and Environmental Science, etc. He has supervised over 40 PhD students in India and abroad. He is the recipient of eight national level prizes in India and is an elected fellow of two science academies of India. His current research focus is on engineered nanomaterials for applications in the fields of energy and environment.

Aydogan Ozcan joined UCLA in the summer of 2007, where he is currently an Associate Professor leading the Bio-Photonics Laboratory at the Electrical Engineering Department. Dr. Ozcan holds 18 issued patents and another 10 pending patent applications, and is also the author of one book and the co-author of more than 200 peer reviewed research articles in major scientific journals and conferences. Dr. Ozcan received several awards including the Presidential Early Career Award for Scientists and Engineers (PECASE), Army Research Office Young Investigator Award, NSF CAREER Award, NIH Director's New Innovator Award, Office of Naval Research Young Investigator Award, IEEE Photonics Society Young Investigator Award, and MIT's TR35 Award for his seminal contributions to near-field and on-chip imaging, and telemedicine based diagnostics. Dr. Ozcan is also the recipient of the National Geographic Emerging Explorer Award, Gates Foundation Grand Challenges Award, Popular Mechanics Breakthrough Award, Netexplorateur Award, and the Wireless Innovation Award organized by the Vodafone Americas Foundation, as well as the Okawa Foundation Award.

Gorazd Planinsic is a professor of physics at Faculty of mathematics and physics, University of Ljubljana, Slovenia. He is leading the undergraduate and post-graduate Physics Education program. He is also leading the Continuing Education program for in-service secondary school physics teachers in Slovenia. His research background is in MRI but his current interest is in development and didactical use of experiments. GP is author of many articles in physics education journals and author of a book, "Active learning with experiments, mechanics and thermodynamics" (in Slovene).

He is chair of Physics Education Division at European Physical Society and co-founder and collaborator of Slovenian hands-on science centre The House of Experiments.

Fernando Quevedo obtained his early education in Guatemala. His Ph.D. in theoretical physics was obtained at the University of Texas at Austin under the supervision of Nobel Laureate Steven Weinberg. He had research appointments at CERN, Switzerland, McGill University in Canada, Institut de Physique in Neuchatel, Switzerland, and the Los Alamos National Laboratory, USA, as well as a brief term as professor of physics at the UNAM (Mexican National Autonomous University), Mexico.
He joined the Department of Applied Mathematics and Theoretical Physics at the University of Cambridge, UK, in 1998, where he is Professor of Theoretical Physics and Fellow of Gonville and Caius College.

He has received various honours including Doctorates Honoris Causa from the Universidad del Valle de Guatemala and the Universidad de San Carlos de Guatemala, the Royal Society Wolfson Merit Award and the John Simon Guggenheim Foundation Fellowship. He is the founder and coordinator of the International Network of Guatemalan Scientists. He is also a Fellow of the Academy of Sciences for the Developing World. Quevedo was also awarded the 1998 ICTP Prize in recognition of his important contributions to superstring theory.

Martin Rees has been Master of Trinity College, Cambridge since 2004. He holds the honorary title of Astronomer Royal and also Visiting Professor at Imperial College London. After studying at Cambridge, he held post-doctoral positions in the UK and the USA, before becoming a professor at Sussex University, and subsequently Plumian Professor of Astronomy and Experimental Philosophy at Cambridge, where he also served for ten years as director of the Institute of Astronomy. From 1992 to 2003 he was a Royal Society Research Professor. He is the author or co-author of more than 500 research papers, mainly on astrophysics and cosmology, as well as seven books (most recently, 'From here to Infinity: Scientific Horizons', and numerous articles on scientific and general subjects. He has lectured widely, been on many advisory groups, and received numerous international awards including the Balzan Prize and the Crafoord Prize. He is a foreign associate of the US National Academy of Sciences, the Russian Academy of Sciences, the Pontifical Academy, and several other foreign academies. He served during 2005-2010 as President of the Royal Society, and in 2005 he was appointed to the House of Lords.

Sean Shaheen is an Associate Professor in the Department of Physics and Astronomy at the University Denver and a contractor to the National Renewable Energy Laboratory (NREL). He obtained his B.S. in physics from Carnegie Mellon University and Ph.D. in physics from the University of Arizona. He then did a postdoc at the University of Linz, Austria as a Lise Meitner Postdoctoral Fellow. Prior to joining the faculty at the University of Denver, he worked full time in the National Center for Photovoltaics at NREL for 5 years. He has worked in the field of organic electronics for over 15 years and made early contributions to the advancement of their device efficiencies. He was recently named a Research Corporation Scialog Fellow and is Principle Investigator on an NSF Solar project aimed at developing novel mechanisms for controlling and harnessing excitons in organic photovoltaic devices. He frequently gives tutorials on organic photovoltaics at conferences such the Materials Research Society Meetings, the IEEE Photovoltaic Specialists Conference, and the Inter-Continental Advanced Materials for Photonics(I-CAMP) summer school. In 2011, he gave a plenary talk at the SPIE Optics + Photonics Solar Energy Technologies session. Beyond organic photovoltaics, he is also interested in topics of complex systems in science and society.

Samuel Sia is an Associate Professor in the Department of Biomedical Engineering at Columbia University. His lab focuses on using microfluidics for global health diagnostics and for 3D tissue biology.

He obtained his B.S. in Biochemistry at the University of Alberta, Ph.D. in Biophysics at Harvard University, and postdoctoral fellowship in Chemistry at Harvard University. He was a Howard Hughes Medical Institute Predoctoral Fellow, National Science and Engineering Council of Canada Predoctoral Fellow, and Canadian Institute of Health Postdoctoral Fellow. Since 2005, he has been a faculty member of Columbia University's Biomedical Engineering department. His lab's work has been supported by the NIH (NHLBI and NINR), NSF, Wallace H. Coulter Foundation, American Heart Assoc., and the World Health Organization. He has been named one of the world's top young innovators by MIT Technology Review, and one of 10 innovators in human health and sustainability by NASA. His research has been covered by NPR, Washington Post, CBS, NBC, BBC, CBC, Voice of America, and Agence France Presse. He is a founder of Claros Diagnostics, a venture capital-backed company that is developing novel point-of-care diagnostics products; the company's first microfluidics product for monitoring prostate cancer growth received European Union regulatory approval in 2010.

Katarina Svanberg Katarina Svanberg is an M.D. and started her research career by studying laser light interaction in biological tissue. Her PhD thesis in Medical Science presented pre-clinical research work within experimental photodynamic therapy and tissue spectroscopy. Her post doc research activity has been focussed on clinical application of the pre clinical achievements. Katarina Svanberg has combined her clinical activity with research work and thus been able to introduce a new cancer treatment modality in oncology (Photodynamic Therapy) at the Lund University Hospital. She has been a key person in the collaboration in between several clinics and departments at Lund University in introducing and applying laser-induced fluorescence spectroscopy for early tumour detection. K.S. is a board member of Lund Laser Centre and since 1993. She is the director of the Lund University Medical Laser Centre. She has organized many international conferences in biomedical optics. During 2011 she served as the president of the International Society for Optics and Photonics (SPIE).

Sune Svanberg is a senior professor at the Physics Department, Lund University, Sweden, and a professor at the Centre of Optics and Electromagnetic Research, South China Normal University, Guangzhou. He has directed the Lund Atomic Physics Division and the Lund Laser

Centre until recently. His research interests have lately been environmental and medical applications of laser spectroscopy. He has collaborated with large industries and helped form spin-off companies based on his inventions. He has extensive experience from research collaboration with developing countries.

Rob Stoner is Associate Director of the MIT Energy Initiative. He is also the Executive Director of the MIT-Tsinghua-Cambridge Low Carbon Energy University Alliance, and a member of the MIT Future of Solar Energy Study Group.

He has worked extensively in academia and industry throughout his career, and formed several successful startups. From 2007 through 2009 he worked in African and India with the Clinton Foundation.

Dr. Stoner earned his Bachelor's degree in engineering physics from Queen's University, and his Ph.D. from Brown University in condensed matter physics. His current interests include energy technology and policy for developing countries.

Patrick Tabeling is directeur de Recherches CNRS, Professor ESPCI, and director of the Institut Pierre-Gilles de Gennes. Since 2001, he is leader of the group MMN (Microfluidics MEMS and Nanostructures) composed of 20 researchers (permanents, PhDs and Postdoctoral students). He occupied various positions in different laboratories: Visiting researcher in University of Chicago (1984-1985), Chargé/Directeur de Recherches CNRS in the Department of Physics in ENS (1985-2001), visiting professor to UCLA, now Directeur de Recherches/Professor at ESPCI. He was professor chargé de cours at the Ecole Polytechnique (1996-2008) He is the author of 200 papers (120 in refereed journals), 9 patents (4500 citations, h factor 40), 75 invited talks in international conferences; he is divisionnal editor of Physical Review Letters, Associate Editor of Physics of Fluids and Biomicrofluidics, guest editor ofCRAS and PNAS. He is member of Academia Europae, and was recipient of Slichting Award in 1995. He published the book entitled "An introduction to microfluidics" (Oxford University Press - a French version being edited by Belin) in 2005.

Caroline Taylor is currently serving as a Senior Bioenergy Analysis Fellow at the Energy Biosciences Institute at the University of California, Berkeley and an adjunct professor of Physics at Michigan Technological University. She holds Bachelor's degrees in Classics and Chemistry from the University of California at Irvine, and she did her graduate work in Chemical Physics at the University of Chicago, followed by post-doctoral work in fluids at Cornell University. Dr. Taylor has also held visiting appointments at the Forschungszentrum Julich's von Neumann Institute (now the Julich Supercomputing Center) and the James Franck Institute of the University of Chicago. Her research has focused on interfacial behaviour in environmental and biological systems, using analytical theory and computational methods. In 2009, Dr. Taylor joined the EBI from the faculty of the College of Sciences and Arts at MTU. In her role as founding member and co-lead of the EBI's integrative Bioenergy Analysis Team she assesses the viability of various emerging plant-based solutions for addressing global energy needs sustainably, provides strategic insight and engages with a range of stakeholders that includes engineers and policy makers, and participates in international efforts to build regionally-specific global bioenergy/biofuels scenarios.

Richard Wiener is a Program Director at Research Corporation for Science Advancement, a private foundation that has been funding research by academic scientists for 100 years. Wiener completed a Bachelor of Arts degree in philosophy at the University of California, Berkeley and a Ph.D. in physics at the University of Oregon under the direction of London Prize recipient Russell Donnelly. His research previously focused on nonlinear pattern formation, with an emphasis on controlling chaotic patterns in fluid flows. Recently, he has been working on the application of nonlinear dynamical models to the production of energy resources, social group competition, and conference-mediated growth of collaboration networks. From 1995-2006 Wiener was a physics professor at Pacific University Oregon and Chair of the Division of Natural Sciences from 2004-2006. He has been a National Corporation for Atmospheric Research Postdoctoral Fellow in Ocean Modeling at Oregon State University, a Visiting Professor at Lewis & Clark College, and a Visiting Scientist and Visiting Professor in Eberhard Bodenschatz' research group at Cornell University. Wiener currently holds an appointment as an adjunct Professor of Physics at the University of Arizona and he is a member of the Executive Committee of the Forum on Physics and Society of the American Physical Society.

Dean Zollman is University Distinguished Professor of Physics at Kansas State University. From 2001 to 2011 he was the William & Joan Porter University Distinguished Professor, and Head of the Physics Department He also holds the title of Distinguished University Teaching Scholar. He has focused his scholarly activities on research and development in physics education since 1972. He has received three major awards – the National Science Foundation's Director's Award for Distinguished Teacher Scholars (2004), the Carnegie Foundation for the Advancement of Teaching Doctoral University Professor of the Year (1996), and American Association of Physics Teachers' Robert A. Millikan Medal (1995). His present research concentrates on investigating the mental models and operations that students develop as they learn physics and how students transfer knowledge in the learning process. He also applies cutting edge technology to the teaching physics and to providing instructional and pedagogical materials to physics teachers, particularly those teachers whose background does not include a significant amount of physics.

NOTES

Countries represented at the 2012 AIP/ICTP Industrial Physics Forum