

# New Frontiers of Ceramics for Sustainable Society

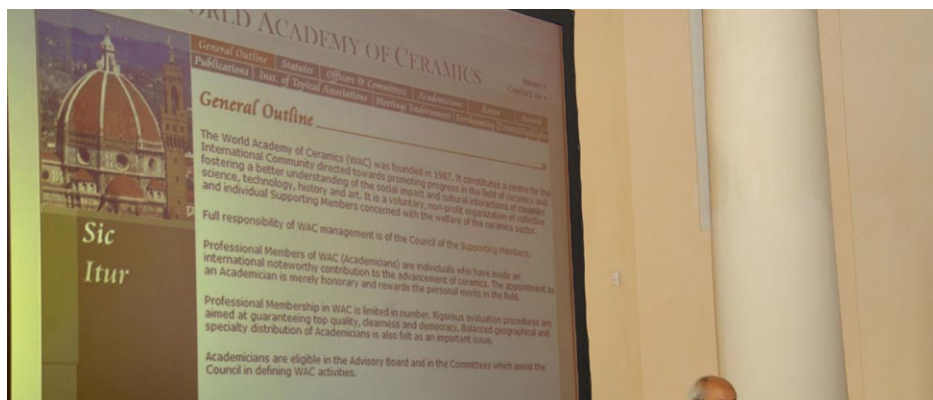
## World Academy of Ceramics FORUM 2012

### Dr. Mrityunjay Singh, President, WAC Forum

As increasing global population drives to improve their standards of living, the demand for energy, healthcare, housing, transportation, and industrial products also grows rapidly. However, the higher demand and production in all these areas leads to a dramatic increase in the overall energy consumption and rate of pollution leading to climate change that creates the risk of irreversible changes in ecosystem. New technologies and innovative solutions are required to address these needs. The WAC Forum 2012 in *Perugia, Italy* addressed global megatrends and the critical role of advanced ceramic materials and systems in solving grand societal challenges in this millennium. The WAC Forum 2012 was held in Sangallo Palace Hotel, Perugia, Italy from June 29 - July 3, 2012. About one hundred academicians, invited speakers, and their spouses attended the forum and social activities. The technical program of Forum 2012 covered wide ranging topics and identified key challenges and opportunities for various ceramic technologies in creating sustainable society. The Forum activities started with the arrival of the participants and registration as well as welcome dinner in Sangallo Palace Hotel on Friday, June 29. Some of the highlights of the Forum 2012 are given below.

#### Saturday, June 30, 2012 (morning)

On June 30<sup>th</sup>, opening ceremony was held in Sala S. Anna which included welcoming address from Prof. M. Yoshimura, WAC Advisory Board Chairman describing the activities and membership details of the Academy. His remarks were followed by Dr. Mrityunjay Singh, WAC Forum President, who gave a brief technical overview of the forum. Prof. Jose A. Varela, President of WAC Prize Committee discussed the WAC prize selection process and introduced both prize laureates Prof. Sossina M. Haile from USA and Prof. M. Endo from Japan. WAC Council President Dr. P. Vincenzini and Prof. Jose A. Varela awarded the prize to winners.







The award ceremony was followed by the much awaited induction of new Academicians from all over the world. Dr. Mrityunjay Singh, President of the WAC Nomination Committee explained the nomination and selection process and introduced new academicians. A total of 21 academicians were inducted from all over the world. Dr. Singh and Prof. Yoshimura gave the diplomas to new academicians. Prof. Gary Messing, WAC Advisory Board Vice Chairman Chaired the morning session.





After the induction ceremonies of new academicians, prize winners delivered their prize lectures. Prof. Sossina M. Haile from California Institute of Technology, USA discussed the applications of Ceria, both doped and undoped, in a range of energy technologies due to its high ionic conductivity, moderate electronic conductivity, chemical stability, mechanical robustness and exceptional chemical and electrochemical activity. This material has potential applications in fuel cells, as both electrolyte and anode component, catalytic converters, and thermochemical solar fuel production.



The second prize lecture on Carbon nanotubes was delivered by Prof. Morinobu Endo, Shinshu University, Japan. He discussed various nanotube growth techniques and applications ranging from multifunctional filler in matrices to electrochemical systems such as lithium ion batteries. He also described various issues and challenges related to biocompatibility and safety since the toxicological evaluation and the risk control are the essential issues for wide scale industrial applications of nanomaterials.

#### Saturday, June 30, 2012 (afternoon)

The afternoon session started with the presentation by Prof. Armin Reller from University of Augsburg, Germany. He discussed the emerging need for the management of critical material resources for energy and environmental technologies. He emphasized that many rare earth materials have limited supply and this could lead to restrictions of industrial productions. He demonstrated that geo-political, technical or even social criteria have to be taken in to consideration when the supply chain security is evaluated. Thus, resource management, resource efficiency and resource strategy are integrated concepts for the design and implementation of new functional materials.



His talk was followed by Prof. S. Mathur from University of Cologne, Germany who discussed the chemically engineered nanoparticles and nanowires for energy and health applications. Prof. Yu Zhou discussed the bioactive TiO<sub>2</sub>-based coatings on titanium alloy substrate fabricated by micro-arc oxidation for biomedical application. Prof. E. Yasuda from Tokyo Institute of Technology, Japan described the preparation of single domain oval carbon nanofiber from a polymer blend process. These fibers have potential applications in energy technologies.

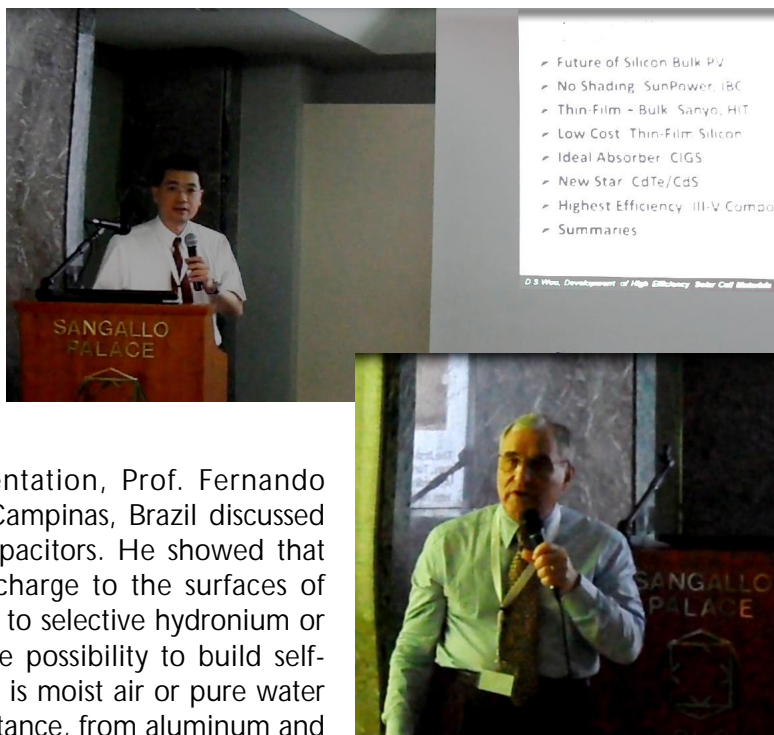
*From 5-7.30 pm, guided visit to Perugia Historical Center was organized. All the participants really enjoyed the guided tour with excellent tour guides.*

#### Sunday, July 1, 2012 (morning)

The second day of the Forum started with excellent presentation by Prof. Bruce Dunn from University of California-Los Angeles, USA who spoke on the ceramics for future energy storage devices and systems. He demonstrated why the design of the chemistry and nanostructure of ceramic materials could have a profound effect on the performance of electrodes and electrolytes in electrochemical energy storage systems. He discussed the development of mesoporous transition metal oxides who could be a significant contribution to the energy storage field.



The second talk of the morning session was delivered by Prof. Dong-Sing Wu, Da-Yeh & National Chung Hsing Universities, Taiwan who discussed the development of high efficiency solar cell materials. He gave an overview of major solar cell technologies and their efficiencies, cost, and global market situation. However, he emphasized that in order to meet the ever-increasing market demand, solar cells must to be pushed towards high conversion efficiency and low production cost. Following his presentation, Prof. Fernando Galembeck, Universidade Estadual de Campinas, Brazil discussed about the prospects of self-charging capacitors. He showed that atmospheric water vapor contributes charge to the surfaces of dielectric solids and isolated metals, due to selective hydronium or hydroxyl ion adsorption. This shows the possibility to build self-charging capacitors, where the dielectric is moist air or pure water and the two electrodes are made, for instance, from aluminum and stainless steel.



Continuing on the energy theme, Dr. Wolfgang Rossner from Siemens AG, Munich, Germany gave an overview of challenges for high-temperature ceramics for gas turbine applications. He showed that the growing need for cost efficient and environmentally sound power generation solutions causes a continuous push towards higher operation temperatures and reduced cooling air flows. There is urgent need for substantial improvement of the materials system used in hot gas path components such as heat shields, blades, vanes, and combustor liners.



### Sunday, July 1, 2012 (afternoon)

The afternoon session started with a talk by Prof. Tatiana Prikhna, V.N. Bakul Institute for Superhard Materials (ISM), National Academy of Sciences, Ukraine related to superconducting ceramics for fault current limitation. She emphasized that the fault currents should be managed with a fast protection system, preferably with a dead time well below a second. His presentation was followed by Dr. Yanchun Zhou from Aerospace Research Institute of Materials and Processing Technology, Beijing, China who discussed the development of Nd Doped  $Ti_3SiC_2$  for interconnect material for solid oxide fuel cells. Dr. Hua-Tay Lin, Oak Ridge National Laboratory, Oak Ridge, TN, USA discussed the role of advanced SiC ceramics for next generation nuclear technologies. He emphasized that the application of SiC and SiC/SiC CMC could mitigate the long-term waste disposal issue due to its inherent low induced activation nuclear properties and excellent tolerance against neutron irradiation at high temperatures. He reviewed the recent research and development of the advanced radiation-resistant SiC and SiC/SiC CMC for next generation nuclear technologies applications. Dr. Tatsuki Ohji from AIST, Nagoya, Japan described the development of high conductivity silicon nitride ceramics for thermal management applications. He described various processing routes to make the high conductivity silicon nitride materials and showed their excellent thermomechanical properties.





*At 4.15 pm all the attendees boarded two buses for guided tour to Gubbio which is a town in the far northeastern part of the province of Perugia (Umbria). It is located on the lowest slope of Mt. Ingino, a small mountain of the Apennines. The tour buses came back to hotel at 8.00 pm.*

### **Monday, July 2, 2012 (morning)**

Third day of the forum started with the excellent presentation by Prof. Larry L. Hench, University of Florida, USA. He described the use of bioceramics for implants, tissue regeneration and therapy. He mentioned that millions of patients have benefited from pain relief and improved mobility; however, survivability analyses of most skeletal prostheses show that a third to half of prostheses fail within 15-25 years and patients require revision surgery. He emphasized that a major shift is needed from replacement to stimulating the body to regenerate tissues and it is time for a revolution to emphasize a more biologically based method of repair- regeneration of tissues.



Prof. Danilo De Rossi, University of Pisa, Italy gave very interesting presentation on the wearable wireless body sensor networks for healthcare applications. He described many body worn systems, endowed with autonomous sensing, processing, actuation, communication and energy harvesting and storage. These systems are emerging as a solution to the challenges of monitoring people anywhere and at anytime in applications such as healthcare, well-being and lifestyle, protection and safety. He illustrated some e-textile based wearable platforms and its reliance on integration at various levels of conventional off-the-shelf microelectronics components with fabrics.



After the coffee break, Prof. Min Wang from University of Hongkong gave an interesting talk on ceramics for biomedical applications. He overviewed the ground-breaking research on bioceramics, performed in the 1970s and early 1980s, which has resulted in the phenomenal growth of bioceramics as viable materials for the repair and reconstruction of human body tissues, especially hard tissues, in the subsequent decades. He showed that bioactive bioceramics, in the form of non-porous structures, porous scaffolds or coatings, can be loaded with anti-bacteria drugs for the prevention of bacterial infections. His talk was followed by presentation by Prof. Robin Drew from Concordia University who presented a processing route to make nitrate-



free sol-gel route for the synthesis of bioactive glasses. He was followed by Prof. Pavol Sajgalik from Slovak Academy of Sciences who discussed a number of ternary nitrides and their applications. The last talk before the lunch was delivered by Prof. Vladimir Ya. Shevchenko, Institute of Silicate Chemistry, Russian Academy of Sciences, Russia who discussed the Nanoworld – the space of formation of chemical substance. He emphasized that the nanoworld is a region of space in which matter (individual, chemical), living or nonliving, is self-organized from atoms.

### Monday, July 2, 2012 (afternoon)

*At 3.30 pm, all the participants boarded two buses for a guided tour to Assisi which is a town in the province of Perugia in the Umbria region, on the western flank of Monte Subasio. It was the birthplace of St. Francis, who founded the Franciscan religious order in the town in 1208, and St. Clare (Chiara d'Offreducci), the founder of the Poor Sisters, which later became the Order of Poor Clares after her death. The 19th-century Saint Gabriel of Our Lady of Sorrows was also born in Assisi.*

### Tuesday, July 3, 2012 (morning)

Last day of the forum was devoted to the ceramics for environmental systems. First invited presentation was delivered by Dr. Kazushige Ohno, IBIDEN Co. Ltd., Japan who described innovative technologies for diesel emission control by SiC-DPF. After a brief introduction of DPF development, he focused on the enhancement of DPF durability and various regulatory issues worldwide. His presentation was followed by Prof. Alexander Michaelis, Fraunhofer Institute of Ceramic Technologies and Systems IKTS, Dresden, Germany who discussed the applications of ceramics for filtration and membrane technologies. He mentioned that although ceramic membranes are well established for micro-, ultra- or nano-filtration applications such as waste water purification, further innovations are required with improved control and reduction of pore size. This will allow for new applications in gas separation systems. He presented several new methods for preparation of such membranes including crystallographic cage structure of zeolites.



After the coffee break, Dr. Toshihiro Ishikawa from Ube Industries, Ltd., Japan talked about the photocatalytic fiber based system for water purification. He discussed the unique photocatalytic fibers composed of silica-based core structure and surface gradient composition of titania nano-crystals. He showed the excellent performance of water purifiers using this fiber which was designed for obtaining effective contact with organic pollutants. Many bacteria and organic chemicals were effectively decomposed into  $\text{CO}_2$  and  $\text{H}_2\text{O}$  using the above purifier.

Final talk of the session entitled “channeling the forces of nature” was presented by Prof. Emile H. Ishida, Tohoku University, Japan. In his often philosophical and emotional plea, he mentioned that more than ever, we must learn from nature that possesses the only sustainable society on earth and create technology which embraces such a view of nature.

He emphasized the use of Nature Technology, where for example a floor or wall becomes the alternative to an air conditioner. This is one example of how Nature Technology could provide a new lifestyle which is spiritually uplifting rather than just putting up with things.



### Tuesday, July 3, 2012 (afternoon)

The afternoon session started with interesting talk on novel ceramic filters based on macro-porous ceramics decorated with nanowires by Prof. Paolo Colombo, Università di Padova, Italy. He emphasized that the global environmental concerns over the presence of nano-sized particulates in various environments are prompting researchers to investigate more effective and affordable filters. He has grown nanowires in the foams which led to an increase of the specific surface area of the cellular ceramic substrates. He studied the permeation behavior and aerosol filtration and compared the results to those for commercial HEPA filters. The second talk of the afternoon was delivered by Prof. Lalit Mohan Manocha, Sardar Patel University, India. He talked about carbon, which is centuries old material, but has played key role as element and as material during all scientific fields and technological revolutions, be in metallurgy, electronics, ceramics, polymers and high performance composites (polymer and ceramics matrix) to nanotechnology. It still poses the scientific and technological curiosity, mainly because of big scope in playing with its structure and hence attaining exotic properties. He was followed by Dr. Hai-Doo Kim from Korea Institute of Materials Science who spoke about high-performance SRBSN (sintered reaction bonded silicon nitride). He presented the new manufacturing methods and new possibilities of SRBSN for various applications. Final talk of the forum was delivered by Prof. Raj Bordia from University of Washington, USA who discussed the control of hierarchical microstructures in ceramics. He demonstrated various processing strategies to control the microstructure of ceramics at different length scales. He showed that materials with designed anisotropic and hierarchical microstructures have the potential to optimally address the requirements.

*At the end of technical sessions, Dr. Mrityunjay Singh, President of WAC Forum thanked all the speakers, participants, WAC staff specially Stefania Bianchedi and WAC Council President Dr. Pietro Vincenzini. The technical program ended and all the attendees started gathering for the guided tour to Lago Trasimeno (Trasimeno Lake) & Social Dinner (Restaurant at the Lake). Before the dinner, attendees visited the lake area and some castles. The dinner at the lake was amazing experience for the attendees. The WAC forum was great success!!*