

Sustainable Ceramic Manufacturing Technologies

World Academy of Ceramics FORUM 2016

Prof. Ing. Paolo Colombo, President, WAC Forum

Ceramics, because of their superior functional, mechanical, and durability properties, are an integral part of advanced components and systems used in a wide range of industrial and high tech areas. Processing technologies are the key enablers that allow scientific discoveries to come to fruition in the interest of society. The Invited Lectures at WAC Forum 2016 focused on selected topics of great current interest and relevance in the field of manufacturing technologies, namely additive manufacturing, bio-inspired fabrication, rapid sintering and recycling and reuse technologies. Presentations given by members of the Academy, dealing with bioceramics, functional ceramics, laser processing, colloidal processing, SHS and SHS+SPS techniques, coatings and mechanical properties of ceramic components, complemented the program.

The WAC Forum 2016 was held at the Park Hotel Ravenna in Marina di Ravenna, Italy, a seaside resort just outside Ravenna, from June 14 - 17, 2016. About seventy academicians, invited speakers, and their spouses attended the Forum and social activities. The Forum activities started with the arrival of the participants and registration as well as a welcome dinner at the hotel on Monday, June 13.

Some of the highlights of the Forum 2016 are given below.

Tuesday, June 14, 2016

On June 14th, the opening ceremony was held in the Town Hall - Sala Consiliare in Faenza, which included a welcoming address from Prof. G. Messing, WAC Advisory Board President, describing the activities and membership details of the Academy. His remarks were followed by welcome speeches by Dr. P. Vincenzini, WAC Council Chairman, and Dr. G. Malpezzi, Mayor of Faenza.



Dr. T. Ohji, President of the WAC Nomination Committee, introduced the new Academicians and conducted their induction into the Academy. A total of 13 Academicians were inducted from all over the world, and most of them were able to attend the ceremony.



This was followed by the presentation of the International Ceramics Prize 2016 Laureates, by Dr. M. Singh, Vice-President of the WAC Advisory Board.





After the morning session and official pictures, the Academicians and prize winners visited the International Ceramics Museum of Faenza, which hosts a wide ranging collection of precious artifacts from every corner of the globe.

In the afternoon, Prof. P. Colombo, President of the Forum 2016 Committee, introduced the program of the Forum and gave a brief introductory address, thanking in particular WAC staff for the assistance throughout the meeting and the Forum 2016 Committee, who helped by suggesting outstanding invited lecturers. Then, the prize winners delivered their prize lectures. Prof. P. Greil, from the University of Erlangen-Nuernberg, Germany, spoke about fabrication of biomorphous ceramics from wood, showing how this unique approach enables the fabrication of components with tailored morphology and excellent properties. The second prize lecture was delivered by Prof. K. Uchino, from the Pennsylvania State University, USA, and was on piezoelectric actuators. He showed how several innovations he spearheaded led to what he termed a “renaissance” of these key ceramic electronic components.

The rest of the afternoon was occupied by the invited lectures of Prof. N. Setter from EPFL, Switzerland, who discussed how the creation of negative pressure in free standing particles, through innovative processing, leads to an enhancement of properties, and Dr. O. Guillon from Forschungszentrum Jülich and RWTH Aachen University, Germany, who offered insights about the state of the art concerning field assisted and spark plasma sintering of ceramics.

Wednesday, June 15, 2016

Three invited lectures dealing with automated manufacturing were given respectively by Prof. J. Guenster of BAM, Germany, Dr. N. Katsikis of H.C. Starck Ceramics, Germany, and Dr. C. Chaput of 3D Ceram, France. Prof. Guenster described recent efforts at improving the characteristics of printed components using an innovative indirect printing approach based on slurries instead of dry powder beds. Dr. Katsikis offered an industrial perspective on additive manufacturing of ceramic parts while Dr. Chaput gave examples of the successful production of several thousands of components per annum, based on a stereolithography fabrication approach. The morning continued with talks given by Prof. A. Leriche, University of Valenciennes, France, on the fabrication of calcium phosphate scaffolds for bone regeneration applications, Prof. P. Colombo, University of Padova, Italy, on additive manufacturing using preceramic polymers and Dr. F. Cambier, Belgian Ceramic Research Center, Belgium, who showed how, through laser-based subtractive



methods instead than additive manufacturing methods, that it is possible to fabricate oxide ceramic components with quite remarkable degrees of morphological complexity and details at a very fine scale. The afternoon sessions included talks by Prof. J. Adair, The Pennsylvania State University, USA, who discussed calcium phosphosilicate hydrate nanoparticles for drug delivery, Prof. L. Bergstrom, Stockholm University, who showed how it is possible to obtain novel components through colloidal processing and assembly of ceramics and inorganic-organic hybrids, Prof. M. Ferraris, Turin Polytechnic, Italy, who presented innovative antibacterial layers based on nanocluster doped silica and Prof. M. Yoshimura, National Cheng Kung University, Taiwan, who gave a talk on how processing of advanced ceramics could benefit and learn from what occurs in natural bio-systems in terms of low temperature, low energy materials synthesis. The day was closed by a trip to visit Ravenna's UNESCO sites, which included the Sant'Apollinare Nuovo Basilica, the Galla Placidia Mausoleum and the Church of San Vitale, with their stunning mosaics.

Thursday, June 16, 2016

The next morning started with the invited lectures given by Prof. A. Studart, from ETH Zurich, Switzerland, who showed how innovative fabrication approaches can lead to unique bio-inspired ceramic structures that possess outstanding properties, by Prof. D. Zhang, from Shanghai Jiao Tong University, China, who discussed how replica techniques applied to appropriate biological templates can generate complex morphogenetic architecture, and by Prof. C. Sanchez, from UMR CNRS-Université Pierre et Marie Curie, France, who demonstrated that using bottom-up processing strategies can generate well controlled nanostructured inorganic and hybrid materials suitable for a wide range of advanced applications.

The session then continued with talks given by Prof. T. Prikhna, National Academy of Sciences, Ukraine, who presented novel nanostructured multifunctional materials based on MAX-phases, and Prof. Alexander Rogachev, ISMAN and National University of Science and Technology, Russia, who discussed the use of SPS and SHS+SPS techniques for the rapid synthesis and consolidation of ceramics and metals.

In the afternoon, the attendees visited the city of Ferrara, which included a guided tour of the castle as well as a visit to some of the most important monuments in the town.

Friday, June 17, 2016

The morning session started with invited lectures by Dr. K. Halada, from National Institute for Materials Science, Japan, who discussed how life cycle analysis can be applied to ceramic materials and their production, to highlight the critical role played in the process by some specific elements, and by Prof. S. Kiriwara, who showed how using stereolithography together with finite element analysis can lead to the fabrication of components with tailored morphologies enhancing specific properties.

The session then continued with talks given by Prof. L. Klein, Rutgers University, USA, on low temperature sol-gel hybrid coatings that, being synthesized at low temperature, can benefit sustainability and Prof. W. Kriven, University of Illinois at Urbana-Champaign, USA, on carbothermally reacted geopolymer-based composites containing silicon carbide and SialON phases. The morning was concluded by Prof. H.-T. Lin, Guangdong University of Technology, China, who presented a local, well structured project on innovation in the field of advanced ceramics for sustainable manufacturing, Prof. R. Danzer, Leoben University, Austria, who showed the importance of considering the effect of defects on the mechanical properties of real life ceramic components, and Prof. R. Bordia, Clemson University, USA, who concluded the scientific program of the Forum presenting a model that accounts for the role of heterogeneities and anisotropy on the mechanical properties of hierarchical porous ceramics.

It was very encouraging to see that all the talks given throughout the Forum were followed by lively discussions and interaction among the attendees.

The technical program ended with a visit to the IX century Pomposa abbey, followed by the Social Dinner at the Alexander Restaurant, located in a splendid Liberty-style cinema in Ravenna.

The WAC Forum was once again a great success!!!