University of Udine and the AIST European Member Chapter Joined for a Two-Day Event Hosting the AIST John F. Elliott Lecture


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On 14 and 15 May 2018, the city of Udine, Italy, played host to a two-day event where locally based multinational companies and international researchers working in the iron and steel sector shared several interesting trends and inspiring topics together with a wide and diversified audience. The long-awaited moment was the AIST John F. Elliott Lecture, delivered by Prof. Donald R. Sadoway from the Massachusetts Institute of Technology.

The event was the result of a strong collaboration between the University of Udine and the AIST European Member Chapter (AIST EMC). Fabio Miani, associate professor of metallurgy at the University of Udine, had been the leading mind behind the forum: he wanted to share important perspectives and results of recent scientific studies and processes focused on an environmentally friendly metal production involving university students as well as professors, managers and researchers. This project fully met AIST's mission to advance the technical development, production, processing and application of iron and steel, as well as its vision of creating networking opportunities, promoting education and developing sustainability programs.

In addition to the presentation of the new European Member Chapter, the AIST team seized the opportunity to introduce the Material Advantage program for materials science and engineering students: it is the premier membership option for students all over the world to increase their knowledge, experience and networking through membership to its four membership societies, the American Ceramic Society (ACerS), Association for Iron & Steel Technology (AIST), ASM International® (ASM) and The Minerals, Metals & Materials Society (TMS).

The event started on Monday at Palazzo Garzolini di Toppo Wassermann of the University of Udine, a prestigious 18th century building in the city center. This day was designed especially for undergraduates, offering them the chance to meet with several steel-related companies. Presentations were given by Paola Riva and Luca Vian from Cimolai, Roberta Mallardo and Loris Bianco from Ferriere Nord - Pittini Group, Francesca Maurigh from ABS, and Gianfranco Iugovaz and Luigi Venir from NLMK. The presenters encountered great participation from the students, who had the opportunity to learn about real and astonishing projects, and gain an understanding of the opportunities offered by these companies and the sector itself.

On Tuesday, the conference moved inside the Castle of Udine, an imposing 16th century construction built on the top of the hill in the very center of the city, indeed one of the most emblematic

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landmarks of the Friuli region. The event took place in the Salone del Parlamento (Parliament Hall), where beautiful frescoes surrounded and framed the discussions.

Vittorio Boneschi from Lucefin Group introduced the first session, presenting on the manual *Stainless Steel* and the brand-new publication *Steel Metallurgy*. Both volumes are written by Marco Boniardi and Andrea Casaroli, from the mechanical department of Politecnico Milano, thanks to the cooperation with Lucefin.

The second session was moderated by Stefano Miani, private meltshop technology advisor, who alternated between a roundtable discussion and the presentations of the speakers' last papers, all recipients of AIST Technology Committees Awards in the last few years: Peter Marco Cudicio of SMS group Inc., Marcellino Fornasier of Danieli Group, Luca Gemo of ABS, Pello Uranga of CEIT-IK4 and Miani himself.

The lively debate touched upon the advancements and benefits of their technological innovations applied to real cases, the context in which their ideas developed, the investments in research supported by the companies in comparison with foreign competitors' strategies and market demands. It was also pointed out that four speakers are steel specialists from Friuli, a region that can be considered a "steelmaking know-how cluster," as Miani put it, and that is recognized worldwide for its fundamental and primary contribution to the sector.

In the third session, speakers from Renishaw highlighted 3D metal printing opportunities. They develop additive manufacturing systems for manufacturing components in a variety of metals using a process called metal powder bed fusion (or laser melting). The range of applications is wide, including both the industrial and health care sectors — a very interesting pathway for 3D solutions.

So, the question was posed, what's next? Is a low-cost metal production possible as well as an environmentally sound alternative way to today's carbon-intensive thermochemical metals reduction processes? Prof. Donald R. Sadoway knew the answer. He was the honorable guest of the two-day event, and was the recipient of the 2017 AIST John F. Elliott Lectureship.

Sadoway is the John F. Elliott Professor of Materials Chemistry in the Department of Materials Science and Engineering at the Massachusetts Institute of Technology (MIT). He's not only an

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eminent professor, but also a keynote speaker: his TED Talk "The Missing Link to Renewable Energy" has been viewed more than 1,860,000 times, and in 2012 he was named by *Time Magazine* as one of the "100 Most Influential People in the World." Sadoway holds a B.A.Sc. degree in engineering science, and an M.A.Sc. and a Ph.D. in chemical metallurgy. He joined the MIT faculty in 1978. He is the author of more than 160 scientific papers, he holds 25 U.S. patents and he co-founded Ambri Inc. (formerly Liquid Metal Battery Corp.) and Boston Metal (formerly Boston Electrometallurgical Corp.). The overarching theme of his work is electrochemistry in non-aqueous media focused on liquid metal batteries for stationary storage applications, solid-polymer-electrolyte batteries for portable power applications, and environmentally sound electrochemical extraction of metals. The latter was the key point of his breakthrough presentation: "Innovation in Metals Extraction: Molten Oxide Electrolysis."

Sadoway led the audience through a journey starting from Alessandro Volta, the inventor of the battery, which gave rise to the new field of electrochemistry, and going through the Hall-Héroult process for smelting aluminum, ending with molten oxide electrolysis (MOE), a technique that uses high-temperature electrolysis to make liquid metal and oxygen from a metal oxide feedstock.

Along with his MIT team, he demonstrated the feasibility of producing emission-free metal, such as steel, as well as oxygen, using abundant and affordable metals, alloys in particular, as inert anode in high-temperature electrolysis. He overcame the limitations of the process' high cost and the fact that it only works with consumable or highly expensive and rare anode materials.[1]

Compared with traditional methods of extractive metallurgy, MOE is a greener and cheaper way to produce metal of higher purity, while eliminating greenhouse gas emissions, reducing energy consumption and process cost, and guaranteeing efficiency and flexibility in raw materials. The technology may even be useful for producing oxygen as well as metals during extraterrestrial exploration, for instance on missions to the Moon or Mars (In-Situ Resource Utilization project by NASA).[2]

Sadoway also introduced a variant of MOE called molten sulfide electrolysis (MSE), which is the electrolytic decomposition of a metal sulfide into molten metal and elemental sulfur. Direct sulfide electrolysis completely avoids generation of problematic fugitive emissions (CO_2, CO and SO_2), significantly reduces energy consumption, increases productivity in a single-step process (lower capital and operating costs) and is broadly applicable to a host of electronically conductive transition-metal chalcogenides.[3]

Quoting Prof. Amon, dean of the University of Toronto, Sadoway is indeed "an innovative, accomplished and committed to research, teaching and mentoring person; he seeks to establish the technologies required to make efficient use of energy and natural resources in an environmentally sound manner."

With MOE, Sadoway is paving the road to the sustainable production of metals.

A cocktail hour and gala dinner concluded the event in the fine restaurant near the castle. As many guests noted, it was another inspiring moment for networking and an opportunity for sharing ideas, besides the fine food, good wine and beautiful view from the location.

The University of Udine and AIST EMC joined forces and succeeded in creating a memorable event pursuing their mission to spread knowledge, encourage ideas and involve the next generation of practitioners. A special thanks to Quaker Chemical Corp. and SIME S.r.l., who sponsored the second day's reception and dinner.

References

1. A. Allanore, L. Yin and D. Sadoway, "A New Anode Material for Oxygen Evolution in Molten Oxide Electrolysis," *Nature,* 8 May 2013.
2. P. Curreri, E. Ethridge, S. Hudson, T. Miller, R. Grugel, S. Sen and D. Sadoway, "Process Demonstration For Lunar. In Situ Resource Utilization-Molten Oxide Electrolysis (MSFC Independent Research and Development, Project No. 5–81)," 2006.
3. H. Yin, B. Chung and D.R. Sadoway, "Electrolysis of a Molten Semiconductor," Nature Communications, Vol. 7, 24 August 2016.

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Photo Captions

1. AIST John F. Elliott Lecture, 15 May 2018, Castle of Udine.
2. Castle of Udine, external view.
3. Prof. Donald R. Sadoway, Massachusetts Institute of Technology.
4. Peter Marco Cudicio, SMS group Inc.
5. Marcellino Fornasier, Danieli Group.
6. Students of University of Udine were among the audience of the AIST John F. Elliott Lecture.
7. Vittorio Boneschi, Lucefin Group.
8. Prof. Fabio Miani, University of Udine.
9. Members from the AIST European Member Chapter executive committee along with the keynote speaker and main organizer from the University of Udine. From the right: Mauro Bianchi Ferri (Acciarium Alliance), Donald R. Sadoway (MIT), Maria Elena Fabiani (SIME), Jerney Pretnar (Quaker Chemical) and Fabio Miani (University of Udine).
10. Frescoes of Salone del Parlamento (Parliament Hall), Castle of Udine.