

# RMW13

The 13th Workshop on Reactive Metal Processing

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March 16 (Fri.) - 17 (Sat.), 2018 @ MIT  
Cambridge, Massachusetts, USA

## Organizers

<b>Antoine Allanore,</b>	<i>Massachusetts Institute of Technology</i>
<b>Shunsuke Yagi,</b>	<i>Institute of Industrial Science (IIS), The University of Tokyo</i>
<b>Toru H. Okabe,</b>	<i>IIS, The University of Tokyo</i>
<b>Donald R. Sadoway,</b>	<i>Massachusetts Institute of Technology</i>

## Program Coordinators

<b>Takanari Ouchi,</b>	<i>IIS, The University of Tokyo</i>
<b>Mary Elizabeth Wagner,</b>	<i>Massachusetts Institute of Technology</i>
<b>Ryohei Yagi,</b>	<i>IIS, The University of Tokyo</i>

## Sponsors

- The Rare Metal Research Workshop, one of the Special Research Group organized by the Foundation for the Promotion of Industrial Science (FPIS) (RC-40: directed by Prof. T. H. Okabe)
- Donation to The University of Tokyo New York Office by Dowa Metals & Mining Co., Ltd., Mitsubishi Materials Corporation, Sumitomo Metal Mining Co., Ltd., and Tanaka Kikinzoku Kogyo K.K..
- Grant-in-Aid for Scientific Research (S) by JSPS (Project No. 26220910)
- Integrated Research Center for Sustainable Energy and Materials (IRCSEM)
- The Strategic Partnerships Project of the Top Global University Project by The University of Tokyo

<http://www.okabe.iis.u-tokyo.ac.jp/core-to-core/rmw>

# The 13th Workshop on Reactive Metal Processing

March 16 (Fri.) – March 17 (Sat.), 2018, MIT, Cambridge, MA

## Time:

- 1st day: on March 16 (9:30 – 16:45 and Banquet at 19:00)
- 2nd day: on March 17 (9:30 – 13:30)

Refreshments will be served around 8:30 AM on both days.

## Venue:

- **Haus Room and Allen Room for Workshop (Building 36)**

Poster session is held at the 6<sup>th</sup> floor lobby at building 36 on March 16, 2018.

- **Le Meridien Hotel for Banquet**

(see page 9 or [http:// www.lemeridiencambridge.com/](http://www.lemeridiencambridge.com/))

## Registration Fee:

\$200 / person

NOTICE: Please prepare to pay the registration fee in cash!

## Organizers:

<b>Prof. Antoine Allanore,</b>	<i>Massachusetts Institute of Technology</i>
<b>Prof. Shunsuke Yagi,</b>	<i>IIS, The University of Tokyo</i>
<b>Prof. Toru H. Okabe,</b>	<i>IIS, The University of Tokyo</i>
<b>Prof. Donald R. Sadoway,</b>	<i>Massachusetts Institute of Technology</i>

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## Contact:

Mary Elizabeth Wagner, *Massachusetts Institute of Technology*

E-mail: [rmw@iis.u-tokyo.ac.jp](mailto:rmw@iis.u-tokyo.ac.jp)

# Workshop Program

## Day 1

Morning, March 16 (Friday), 2018 @Haus Room and Allen Room at Building 36

8:30 – 9:30      **Coffee & Breakfast Service**

9:30 – 9:40      **Opening Remarks**

*Prof. Donald R. Sadoway*, Massachusetts Institute of Technology

*Prof. Toru H. Okabe*, IIS, The University of Tokyo

Session Chair: Prof. Georges J. Kipouros

9:40 – 10:10      **“Electrochemical Engineering of the Molten State”**

*Antoine Allanore*<sup>1</sup>

<sup>1</sup>Massachusetts Institute of Technology

10:10 – 10:40      **“Recent Progress in Mg Rechargeable Batteries”**

*Shunsuke Yagi*<sup>1</sup>

<sup>1</sup>Institute of Industrial Science, The University of Tokyo

10:40 – 10:55      **Break**

Session Chair: Dr. Takanari Ouchi

10:55 – 11:25      **“Technospheric mining of strategic materials”**

*Gisele Azimi*<sup>1</sup>

<sup>1</sup>University of Toronto

11:25 – 11:55      **“Measurement of density and surface tension of molten oxides at ultra-high temperatures”**

*Osamu Takeda*<sup>1</sup> and *Antoine Allanore*<sup>2</sup>

<sup>1</sup>Tohoku University

<sup>2</sup>Massachusetts Institute of Technology

11:55 – 13:00      **Lunch**

## Day 1

Afternoon, March 16 (Friday), 2018 @Haus Room and Allen Room at Building 36

Session Chair: Prof. Osamu Takeda

- 13:00 – 13:30      **“ZEBRA unchained: the liquid displacement battery”**  
H. Yin, B. Chung, F. Chen, T. Ouchi, J. Zhao, N. Tanaka, and *D.R. Sadoway*<sup>1</sup>  
<sup>1</sup>Massachusetts Institute of Technology
- 13:30 – 14:00      **“Electrodeposition of Si, Ti and W from water-soluble KF-KCl molten salts”**  
*Toshiyuki Nohira*<sup>1</sup>, Kouji Yasuda<sup>2,3</sup>, Yutaro Norikawa<sup>1</sup>, Kazumi Saeki<sup>2</sup>,  
Tomonori Kato<sup>1</sup>, Tatsuya Ide<sup>1</sup>  
<sup>1</sup>Institute of Advanced Energy, Kyoto University  
<sup>2</sup>Graduate School of Energy Science, Kyoto University  
<sup>2</sup>Agency for Health, Safety and Environment, Kyoto University, Japan
- 14:00 – 14:30      **“Current Distribution in a Silicon Furnace  
– What do we know and why is it important?”**  
*Gudrun Saevardsdottir*<sup>1</sup>  
<sup>1</sup>Reykjavik University
- 14:30 – 14:45      **Photo & Break**
- 14:45 – 15:45      **3-min Short Presentation by Poster Presenters**
- 15:45 – 16:45      **Poster Session at the 6<sup>th</sup> floor lobby at building 36 on March 16, 2018**
- 18:00 –              **Reception**              @ Le Meridien Cambridge  
19:00 –              **Banquet**                @ Le Meridien Cambridge

## Day 2

Morning, March 17 (Saturday), 2018 @Haus Room and Allen Room at Building 36

8:30 – 9:30      **Coffee & Breakfast Service**

9:30 – 9:40      **Opening Remarks**

*Prof. Antoine Allanore*, Massachusetts Institute of Technology

*Prof. Shunsuke Yagi*, IIS, The University of Tokyo

Session Chair: Prof. Antoine Allanore

9:40 – 10:10      **“Urban mining for a circular economy: Activities at SINTEF”**

*Ana Maria Martinez*<sup>1</sup>

<sup>1</sup>SINTEF

10:10 – 10:40      **“Development of novel pyrometallurgical recycling processes for rhenium from superalloy scraps”**

*Ryohei Yagi*<sup>1,2</sup>, *Toru H. Okabe*<sup>2</sup>

<sup>1</sup>Department of Materials Engineering, The University of Tokyo

<sup>2</sup>Institute of Industrial Science, The University of Tokyo

10:40 – 11:00      **Break**

Session Chair: Prof. Shunsuke Yagi

11:00 – 11:30      **“Direct metal value recovery by electro-reduction of solid oxide tailings in alkaline electrolyte”**

*Hirotaaka Higuchi*<sup>1</sup>

<sup>1</sup>Sumitomo Metal Mining Co, Ltd

11:30 – 12:00      **“Anodic Gas in Molten Sulfide Electrolytes: Electrochemical Engineering Considerations”**

*Brian Chmielowiec*<sup>1</sup>, *Antoine Allanore*<sup>1</sup>

<sup>1</sup>Massachusetts Institute of Technology

12:00 – 12:10      **Information for the Next RMW**

*Prof. Toru H. Okabe*, IIS, The University of Tokyo

12:10 – 12:20      **Closing Remarks**

*Prof. Donald R. Sadoway*, Massachusetts Institute of Technology

12:20 – 13:30      **Lunch**

13:30 –      **Laboratory Tour (for applicants)**

## List of Poster Presentations

- 1. “A fundamental study of platinum recovery using "dry aqua regia"”**  
*Akihiro Yoshimura*<sup>1</sup> and Yasunari Matsuno<sup>1</sup>  
<sup>1</sup>Graduate School of Engineering, Chiba University
- 2. “Electrodeposition of crystalline Si films in KF–KCl molten salts using SiCl<sub>4</sub> gas as a Si source”**  
*Kouji Yasuda*<sup>1,2</sup>, Kazumi Saeki<sup>2</sup>, Kazuma Maeda<sup>2</sup>, Rika Hagiwara<sup>2</sup>, Toshiyuki Nohira<sup>3</sup>  
<sup>1</sup>Agency for Health, Safety and Environment, Kyoto University, Japan  
<sup>2</sup>Graduate School of Energy Science, Kyoto University  
<sup>3</sup>Institute of Advanced Energy, Kyoto University
- 3. “Electrochemical Deoxidation of Titanium Scraps Utilizing Molten Magnesium Chloride–Yttrium Chloride”**  
*Chenyi Zheng*<sup>1,2</sup> and Toru H. Okabe<sup>2</sup>  
<sup>1</sup>Department of Materials Engineering, The University of Tokyo  
<sup>2</sup>Institute of Industrial Science, The University of Tokyo
- 4. “Development of the new sintering process for titanium powders using deoxidation technique”**  
*Akihiro Iizuka*<sup>1,2</sup>, Takanari Ouchi<sup>2</sup>, and Toru H. Okabe<sup>2</sup>  
<sup>1</sup>Department of Materials Engineering, The University of Tokyo  
<sup>2</sup>Institute of Industrial Science, The University of Tokyo
- 5. “Investigation into possible positive-electrode active materials for magnesium batteries”**  
*Jonghyun Han*<sup>1,2</sup> and Shunsuke Yagi<sup>2</sup>, Kohei Shimokawa<sup>3</sup> and Tetsu Ichitsubo<sup>3</sup>  
<sup>1</sup>Department of Materials Engineering, The University of Tokyo  
<sup>2</sup>Institute of Industrial Science, The University of Tokyo  
<sup>3</sup>Institute for Materials Research, Tohoku University
- 6. “Novel recycling process for rhenium from superalloy scrap using Zn treatment and hydrometallurgical method”**  
*Iori Narita*<sup>1,2</sup>, Ryohei Yagi<sup>1,2</sup>, and Toru H. Okabe<sup>2</sup>  
<sup>1</sup>Department of Materials Engineering, The University of Tokyo  
<sup>2</sup>Institute of Industrial Science, The University of Tokyo
- 7. “Copper-selective alumina membranes for high temperature electrochemical measurements”**  
*Caspar Stinn*<sup>1</sup> and Antoine Allanore<sup>1</sup>  
<sup>1</sup>Massachusetts Institute of Technology

## List of Poster Presentations

8. **“The thermodynamics of barium-lead binary alloys”**  
*Jarrod Gesualdi*<sup>1</sup>  
<sup>1</sup>Pennsylvania State University
9. **“Measurements of thermodynamic properties of Sr/Cs-liquid metal alloys via the electromotive force method”**  
*Nathan Smith*<sup>1</sup>  
<sup>1</sup>Pennsylvania State University
10. **“Electrochemical separation of alkaline-earth metals from LiCl-KCl molten salts”**  
*Tim Lichtenstein*<sup>1</sup> and Hojong Kim<sup>1</sup>  
<sup>1</sup>Pennsylvania State University
11. **“Effect of baked anode populations on aluminium cell reduction performance”**  
*Petre Manolescu*<sup>1</sup>  
<sup>1</sup>Reykjavik University
12. **“Critical raw materials electrolysis at SINTEF”**  
*Karen Sende Osen*<sup>1</sup> and Ana Maria Martinez<sup>1</sup>  
<sup>1</sup>SINTEF
13. **“Ultra-High-Temperature Electrolytic Titanium Extraction From Waste Slag”**  
*Samuel Martin-Treceno*<sup>1</sup>, Thomas Hughes<sup>1</sup>, Catherine Bishop<sup>1</sup>, Ian Brown<sup>2</sup>, Yaodong Jia<sup>2</sup>, Aaron Marshall<sup>1</sup>, Matthew Watson<sup>1</sup>  
<sup>1</sup>University of Canterbury  
<sup>2</sup>Callaghan Innovation
14. **“Activity and vapor-liquid equilibrium (VLE) of**  
*Lingxin Kong*<sup>1,2</sup>, Bin Yang<sup>1</sup>  
<sup>1</sup>National Engineering Laboratory for Vacuum Metallurgy, Kunming University of Science and Technology  
<sup>2</sup>Institute of Industrial Science, The University of Tokyo
15. **“Workshop on Reactive Metal Processing (Introduction of RMWs)”**



## History of RMW

- 2006    **The 1st Workshop on Reactive Metal Processing (RMW1)**  
March 17 (Fri.) - March 19 (Sat.), Cambridge, MIT
- 2006    **The 2nd Workshop on Reactive Metal Processing (RMW2)**  
November 16 (Thurs.) - November 17 (Fri.), Tokyo, The University of Tokyo
- 2007    **The 3rd Workshop on Reactive Metal Processing (RMW3)**  
March 2 (Fri.) - March 3 (Sat.), Cambridge, MIT
- 2008    **The 4th Workshop on Reactive Metal Processing (RMW4)**  
March 14 (Fri.) - March 15 (Sat.), Cambridge, MIT
- 2010    **The 5th Workshop on Reactive Metal Processing (RMW5)**  
February 18 (Thurs.) - February 19 (Fri.), Seattle, Red Lion Hotel on 5th Avenue
- 2011    **The 6th Workshop on Reactive Metal Processing (RMW6)**  
March 4 (Fri.) - March 5 (Sat.), Pasadena, Caltech
- 2012    **The 7th Workshop on Reactive Metal Processing (RMW7)**  
March 16 (Fri.) - March 17 (Sat.), Cambridge, MIT
- 2013    **The 8th Workshop on Reactive Metal Processing (RMW8)**  
March 8 (Fri.) - March 9 (Sat.), Cambridge, MIT
- 2014    **The 9th Workshop on Reactive Metal Processing (RMW9)**  
February 21 (Fri.) - February 22 (Sat.), Pasadena, Caltech
- 2015    **The 10th Workshop on Reactive Metal Processing (RMW10)**  
March 20 (Fri.) - March 21 (Sat.), Cambridge, MIT
- 2016    **The 11th Workshop on Reactive Metal Processing (RMW11)**  
February 19 (Fri.) - February 20 (Sat.), Cambridge, MIT
- 2017    **The 12th Workshop on Reactive Metal Processing (RMW12)**  
March 3 (Fri.) - March 4 (Sat.), Cambridge, MIT

**RMW1 in 2006 at MIT**



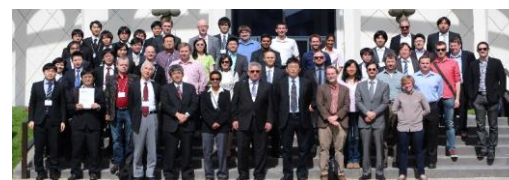
**RMW2 in 2006 at IIS**



**RMW5 in 2010 at Seattle**



**RMW9 in 2014 at CALTECH**

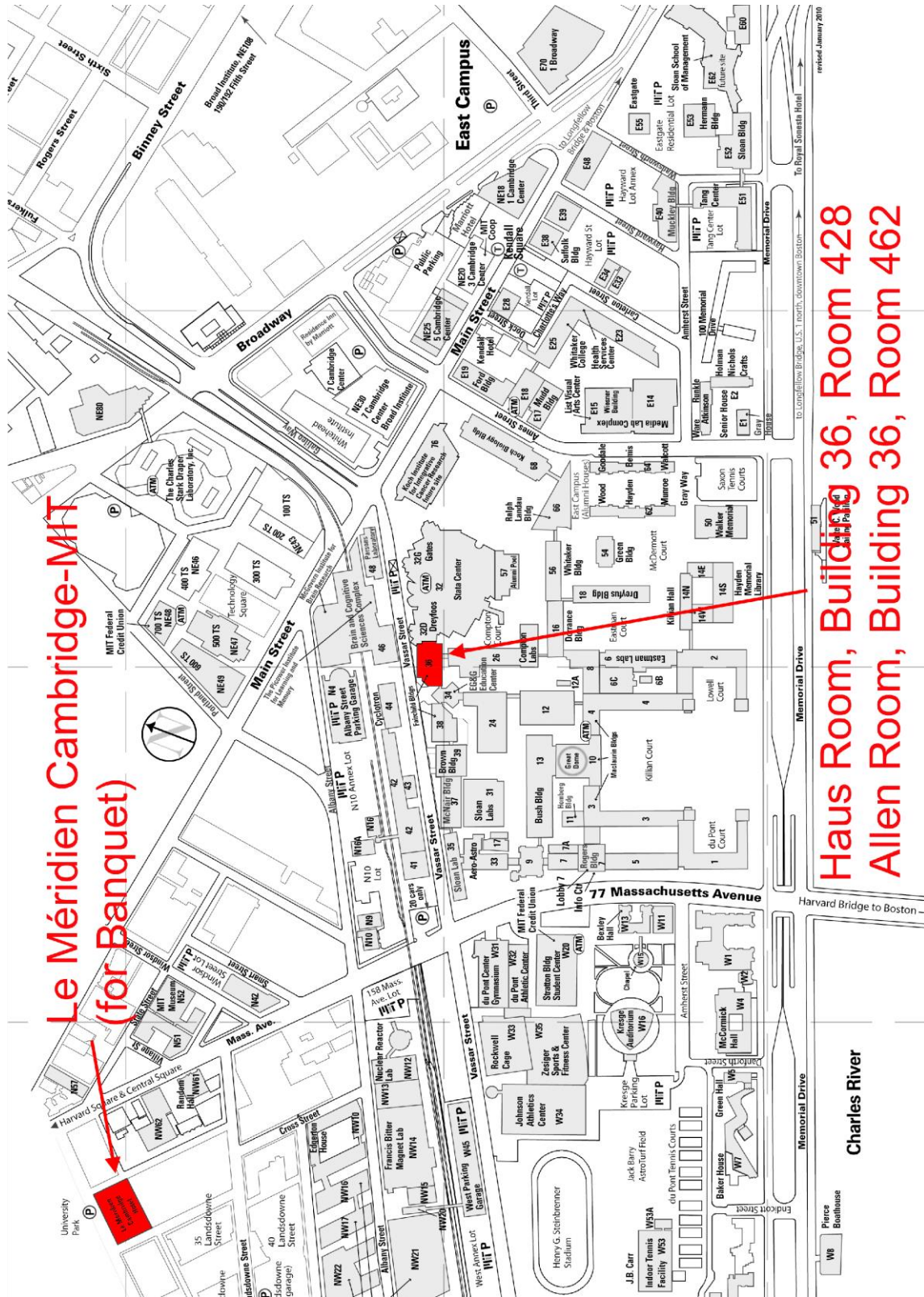


**RMW12 in 2017 at MIT**





# MAP



## List of Participants

Adam C. Powell, IV	Chief Technology Officer	INFINIUM, Inc.
Akihiro Iizuka	Graduate Student	IIS, The University of Tokyo
Akihiro Yoshimura	Assistant Professor	Chiba University
Ana Maria Martinez	Senior Research Scientist	SINTEF
Andrew Caldwell	Graduate Student	MIT
Antoine Allanore	Associate Professor	MIT
Brian Chmielowiec	Graduate Student	MIT
Bradley Nakanishi	Recent PhD Graduate	MIT
Caspar Stinn	Undergraduate Student	MIT
Chenyi Zheng	Graduate Student	IIS, The University of Tokyo
Donald Sadoway	Professor	MIT
Eriko Hayashi	Administration Staff	IIS, The University of Tokyo
Fusamitsu Yamamoto	Administration Staff	IIS, The University of Tokyo
Georges J. Kipourous	Adjunct Professor	University of Waterloo
Gisele Azimi	Assistant Professor	Univesity of Toronto
Gudrun Saevarsdottir	Associate Professor	Reykjavik University
Guillaume Lambotte	Senior R&D Scientist	Boston Electrometallurgical Corporation
Hiroataka Higuchi	Manager	Sumitomo Metal Mining Co, Ltd
Iori Narita	Graduate Student	IIS, The University of Tokyo
Jarrod Gesualdi	Research Assistant	Pennsylvania State University
Ji Zhao	Postdoc Associate	MIT
Jo Okabe	Undergraduate Student	Tohoku University
Jonghyun Han	Graduate Student	IIS, The University of Tokyo
Karen Sende Osen	Senior Research Scientist	SINTEF
Lingxin Kong	Visiting Associate Research Fellow	IIS, The University of Tokyo
Lucas Caretta	Graduate Student	MIT
Kouji Yasuda	Assistant Professor	Kyoto University
Mary Elizabeth Wagner	Graduate Student	MIT
Mika Utsugi	Administration Staff	IIS, The University of Tokyo
Minoru Kawasaki	President	Nippon PGM America, Inc.
Nathan Smith	Graduate Student	Pennsylvania State University
Osamu Takeda	Associate Professor	Tohoku University

## List of Participants

Parker Buntin	Graduate Student	MIT
Petre Manolescu	Graduate Student	Reykjavik University / Laval Univesity
Rebecca Miller		
Rich Bradshaw	Director of Operations	Boston Electrometallurgical Corporation
Ryohei Yagi	Graduate Student	IIS, The University of Tokyo
Samuel Martín Treceño	Graduate Student	University of Canterbury, New Zealand
Shunsuke Yagi	Associate Professor	IIS, The University of Tokyo
Simone Carneiro		
Tadeu Carneiro	CEO	Boston Electrometallurgical Corporation
Takanari Ouchi	Research Associate	IIS, The University of Tokyo
Takashi Nakamura	Project Professor	IIS, The University of Tokyo
Tim Lichtenstein	Graduate Student	Pennsylvania State University
Toru H. Okabe	Professor	IIS, The University of Tokyo
Toshiyuki Nohira	Professor	Kyoto University
Youyang Zhao	Graduate Student	MIT