The 10th International Workshop on Crystalline Silicon for Solar Cells (CSSC10)

The 10th anniversary of the international workshop on crystalline silicon for solar cells (CSSC) was celebrated in its birthplace, Institute for Materials Research, Tohoku University (Sendai, Japan), and was held from April 8th to April 11th, 2018. About 100 researchers joined to this workshop from all over the world. The participants enjoyed not only the scientific presentations including cutting edge results but also the nature and culture of Sendai and Japan during the workshop.

CSSC provides an opportunity to exchange scientific information among worldwide specialists in science and technology on crystalline Si for solar cells by especially placing emphasis on fundamental material science.
In the past, CSSC was held in Sendai (IMR), Japan (2006), Xiamen, China (2007), Trondheim, Norway (2009), Taipei, Taiwan (2010), Boston, USA (2011), Aix-les-Bains, France (2012), Fukuoka, Japan (2013), Bamberg, Germany (2015), and Tempe, USA (2016).
The 10th anniversary was celebrated in its birthplace, Sendai (IMR). Registration and reception was held at the evening on April 8. The participants enjoyed the reunion and discussion among the researchers with Miyagi's sake and light meal.

Fig. 1 Registration and reception.

Fig. 2 Welcome address by Prof. Takanashi (Director of IMR).

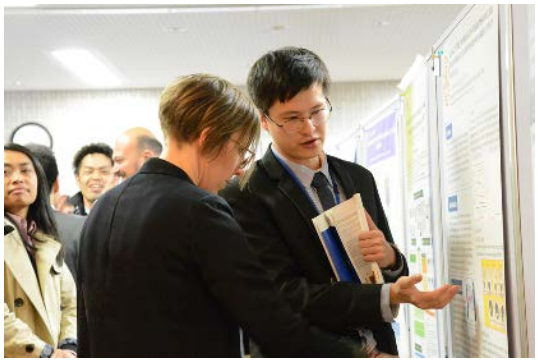

Fig. 3 Active discussions at poster session.

Scientific lectures began on the morning of April 9 with the welcome address of Prof. Takanashi, director of IMR. In the opening session, three invited speakers gave the lectures about recent topics towards high efficiency of silicon solar cells. In the session 2, we enjoyed four lectures about the fundamentals of crystal growth for producing high-quality silicon crystals. After enjoying Japanese foods and cakes at the lunch time at SAKURA-HALL, we discussed the crystal growth technology of Si ingots in the session 3. After that, 36 young researchers and students gave poster presentations at the evening. We really enjoyed very active discussions in the poster session (session 4).
The third day, April 10, was a very sunny and beautiful day. In the session 5 at the morning, we learned the recent developments of recycling, sawing, and feedstock. And, the following session 6 was the special session.

Prof. Kazuo Nakajima who was the “Father” of CSSC gave a special lecture about the crystal growth of silicon. Then, the 5 researchers who are the Past Ulrich-Gösele Young Scientist Award Winners gave lectures. In the afternoon, we enjoyed Japanese and Miyagi’s nature, culture, and food at the excursion and banquet. The beautiful cherry blossoms called “Hitome-Senbon-SAKURA” at Ogawara and delicious sea foods at Matsushima were the highlight other than the scientific lectures in this workshop.

Fig. 4 Beautiful SAKURA and SUNSET at excursion and banquet.

In the final day, April 11, we enjoyed scientific lectures from morning to afternoon. Novel materials for solar cells were introduced in session 7, evaluation techniques of substrates and solar cells were discussed in session 8, and advanced characterization methods were presented in the final session.
As summarized above, CSSC 10 successed covering a wide range of research topics from fundamental to application. 109 researchers from 15 countries participated in CSSC 10 (including 45 researchers from overseas). This indicates that CSSC born in IMR has grown to be one of the important workshops in the field of solar cells.
In the closing session, it was announced that next CSSC 11 will be held in Portugal.

Fig. 5 Participates enjoyed lectures.

Fig. 6 Meet again in Portugal!

The detail of the program of CSSC 10 is shown in the next page.

Finally, we sincerely thank ICC-IMR for their generous support.

CSSC-10 PROGRAM

April 8, Sunday

17:00-19:00 Registration & Reception Lounge; Build#2, Institute for Materials Research, Tohoku University

April 9, Monday

8:00 Registration

Auditorium, Build#2, Institute for Materials Research, Tohoku University

Session 1: Opening Chairperson: Noritaka Usami

9:00 **Welcome address** K. Takanashi (Director, IMR, Tohoku University)

9:05 **Opening address** K. Fujiwara (Co-Chair of CSSC10, IMR, Tohoku University)

9:10 **Pushing the limits of industrial n-type wafers, solar cells and bifacial modules : efficiency and productivity** A. Jouini (CEA-INES)

9:40 **Silicon crystal growth of solar cells: Lessons learned from the pasts** K. Kakimoto, et al. (Kyushu Univ)

10:10 **Silicon material challenges for high efficiency devices** G. Coletti (ECN Solar Energy and UNSW)

Session 2: Crystal Growth Fundamental Chairperson: Kozo Fujiwara

11:10 **In situ X-ray based investigation of grain competition and defects during silicon crystal growth** T. Riberi-Béridot et al. (Aix-Marseille Univ, CNRS, ESRF)

11:40 **Numerical investigations on grain evolution during direct solidification of silicon** W. Miller et al. (IKZ, West Univ of Timisoara, Xi'an Jiaotong Univ)

12:10 **3D visualization and analysis of defects distribution in multicrystalline silicon ingot** Y. Hayama et al. (Nagoya Univ)

12:25 **In situ observation of crystal/melt interface and infrared measurement of temperature profile during solidification of silicon plate** T. Liao, and C.W. Lan (National Taiwan Univ)

Session 3: Advanced Crystallization Chairperson: Nathan Stoddard

14:00 **Recent progress and challenges of casting technology for silicon photovoltaics** C.W. Lan et al. (National Taiwan Univ, Solartech Energy Co.)

14:30 **Influencing the incorporation of oxygen during the directional solidification of multi-crystalline silicon by adjusting the silicon nitride coating** S. Schwanke et al. (Fraunhofer IISB; AlzChem AG)

14:45 **Dislocation confinement by SMART approach in crystallization of G2 sized silicon ingots** P. Krenckel et al. (Fraunhofer ISE1, Nagoya Univ)

15:00 **Controlling dislocation multiplication in mono-like silicon by using <110>-oriented seeds** F. Zhang et al. (Zhejiang Univ, LDK Solar Co. Ltd)

15:15 **Development of the granulate crucible method for growth of large silicon crystals** K. Dadzis et al. (Leibniz Institute for Crystal Growth)

15:30 **An alternative Czochralski growth technique of monocrystalline silicon for high-efficiency PV cells** T. Fukuda et al. (AIST, FTB Co. LTD., Tohoku Univ)

15:45 **Reducing light induced degradation of mono silicon solar cells by using continuous Czochralski produced gallium doped silicon** Y. Zhang et al. (Longi Green Energy Technology, GT Advanced Technologies)

Session 4: Posters 16:30-18:30

April 10, Tuesday

8:00 Registration

Session 5: Recycling, Feedstock and Sawing Chairperson: Koji Arafune

8:30 **Implementation of a circular economy based on recycled, reused and recovered indium, silicon and silver materials for photovoltaic and other applications** N. Adamovic et al. (TU Wien, CEA)

9:00 **Thermodynamic investigations of phosphorous removal from silicon under high vacuum** G. Chichignoud et al. (Univ. Grenoble Alpes, CNRS)

9:15 **Phase diagram on carbothermic reduction of silica and alumina** K. Itaka (Hirosaki Univ)

9:30 **Limitations to sawing of ultrathin silicon wafers by diamond multi wire saw** B. Ryningen et al. (SINTEF Industry)

9:45 **Recovery of kerf-loss silicon from diamond wire sawing** H.L. Yang et al. (National Taiwan Univ)

Session 6: Special Session: 10th Anniversary of CSSC

Special Commemorative Lecture by the Father of CSSC Chairperson: Chung-Wen Lan

10:20 **Growth of high quality Si ingots for solar cells using the dendritic cast method and the noncontact crucible method** K. Nakajima (Emeritus Professor, Tohoku Univ)

Lectures by the Past Ulrich-Gösele Young Scientist Award Winners

11:00 **Neogrowth silicon: a new single crystal, high purity, low oxygen bulk crystal growth method** N. Stoddard et al. (II-VI Optical Systems, Silfex, GCL, Arizona State Univ, Institute for Energy Technology, Freiberger Compound Materials)

11:20 **Role of crucible material and functional diffusion barrier coatings on the material quality of directionally solidified silicon ingots**
M. Trempa et al. (Fraunhofer IISB, Fraunhofer THM)
11:40 **Understanding the efficiency limitation of silicon material for solar cells**
M. C. Schubert et al. (Fraunhofer Institute for Solar Energy Systems, Univ of Freiburg, Univ of New South Wales, Australian National Unive)
12:00 **Casting industrial-scale multicrystalline silicon with ultralow carbon and ultralow dislocation density** B. Gao (The Institute of Technological Sciences, Wuhan Univ)
12:20 **Hydrogenated heterojunction p-type silicon solar cells with open circuit voltages > 700 mv using Czochralski and multicrystalline wafers** B. Hallam et al. (Univ of New South Wales, Arizona State Univ, Apollon Solar, FRANCE)

April 11, Tuesday

8:00 Registration

Session 7: Novel Material Chairperson: Yutaka Ohno

8:30 **Single crystal growth of silicon clathrate** H. Morito et al. (Tohoku Univ)
9:00 **Recent achievements towards high-efficiency BaSi2 homojunction solar cells**
T. Suemasu (Univ of Tsukuba)
9:30 **Carrier transport in crystalline silicon heterojunction with organic thin-layer (HOT) solar cells** H. Shirai et al. (Saitama Univ)
9:45 **The impact of silicon contents in the aluminum paste designed for rear metallization of perc solar cells** M. Nakahara et al. (TOYO ALUMINIUM)
10:00 **Silicon thin foil solar cells on low cost mechanical supports**
P. Bellanger et al. (ICube, Univ of Strasbourg-CNRS, SINTEF, Department of Industrial Processes S'TILE, Faculdade de Ciências, Universidade de Lisboa/IDL)

Session 8: Fundamental Materials Science Chairperson: Wolfram Miller

10:45 **Superacid-derived surface passivation for measurement of ultra-long lifetimes in silicon photovoltaic materials** N. E. Grant et al. (University of Warwick, UK)
11:00 **Interface analysis of hydrogenated amorphous silicon passivation layer deposited by facing target sputtering** Y. Shiratori et al. (Tokyo institute of technology)
11:15 **Characterization of hydrogen around a-Si:H/c-Si interface by resonance nuclear reaction analysis**
K. Gotoh et al. (Nagoya Univ, The Univ of Tokyo, Nagoya Institute of Technology)
11:30 **Insights into striations in n-type Czochralski wafers investigated via low-temperature hyperspectral and temperature-dependent spectral photoluminescence**
R. L. Chin et al. (Univ of New South Wales, Energy Research Centre of the Netherlands, Solar Energy Research Center (MIB-SOLAR),Univ of Milano-Bicocca3)
11:45 **Influence of dislocations in n-type CZ monocrystalline wafers on the performance of SHJ and PERT cells** M. Albaric et al. (Univ Grenoble Alpes, CEA, LITEN, DTS, LMPS, INES, Univ Grenoble Alpes, CEA, LITEN, DTS, LHET, INES, Univ Grenoble Alpes, CEA, LITEN, DTS, LHMJ, INES)
12:00 **Interaction of sodium atoms with stacking faults in silicon crystals with different doping levels** Y. Ohno et al. (Tohoku Univ)

Session 9: Advanced Characterization Chairperson: Martin Schubert

13:45 **Quantification of low-level carbon in Si by photoluminescence at liquid nitrogen temperature and higher after electron irradiation** M. Tajima et al. (Meiji Univ)
14:15 **Investigating defect states in monocrystalline silicon with temperature and injection dependent lifetime spectroscopy** M. S. Wiig et al. (Institute for Energy Technology, Univ of Oslo)
14:30 **Adaptive mapping for quick material evaluation**
K. Kutsukake et al. (Nagoya Univ, Fujitsu Laboratories, Tohoku Univ)
14:45 **Machine learning for recognition of etchpits on as-sliced surface of multicrystalline silicon**
T. Kojima et al. (Meiji Univ, Kyocera Corporation)
15:00 **Impact of the Σ9 grain boundary structure on its electrical activity: HR-TEM and STEM investigation**
M. G. Tsoutsouva et al. (Norwegian University Science and Technology, NTNU, SINTEF Industry)

Session 10: Closing Chairperson: Kozo Fujiwara

15:15 **Closing remark** N. Usami, and J. M Serra

Keywords: solar cells, crystal growth, energetic material
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