

## The 66th special feature

## "Novel Aspects and Approaches to Experimental Methods for Electrochemistry"

### Preface for the 66th Special Feature

### "Novel Aspects and Approaches to Experimental Methods for Electrochemistry"<sup>†</sup>



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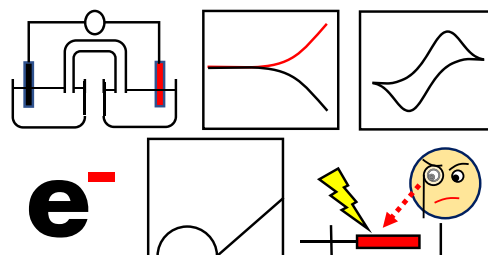
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#### ABSTRACT

The Kansai Branch of the Electrochemical Society of Japan publishes a collection of papers in *Electrochemistry*, which serve as a commentary to the 51st Electrochemistry Workshop. This attempt is motivated by the fact that the domestic seminars are now widely publicized through the on-demand event triggered by COVID-19. This preface consists of the significance of the publication and an introduction of the lecturers as a part of special future for "Novel Aspects and Approaches to Experimental Methods for Electrochemistry." in this issue of *Electrochemistry*.



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## 1. Introduction

The Kansai Branch of the Electrochemical Society of Japan (ECSJ) has been holding workshops on electrochemistry since 1971. The contents have been planned to meet the needs of researchers and engineers involved in electrochemistry in the industrial world unlike conventional lectures in academia, and the themes have been decided in accordance with the background of the times. Since electrochemistry involves interdisciplinary elements, it has become an important mission to provide opportunities for reeducation of electrochemistry for an increasing number of engineers who have not attended lectures in academia where the field is highly subdivided.

In the field of electrochemistry, it is important not only to understand the theory but also to practice measurement methods. For this purpose, it is important to devise experimental methods, understand the phenomena, and share the experience, rather than just giving lectures. The Hanshin industrial area is the center of the battery industry, and the demand for such batteries is very large, so we have been holding workshops every year with many participants.

The COVID-19 pandemic in 2020 forced us to reconsider how to hold the workshop, and while we covered past topics with hybrids in 2021, and we go back to the basics, combining the fundamentals of electrochemistry and the latest electrochemistry-related. The 51st Electrochemistry Workshop in 2022 will be held as online distribution, which will cover both basic electrochemistry and the latest measurement methods related to electrochemistry. The contents of the textbook, which has traditionally been delivered only to participants of the workshop, were highly appreciated by the field of research and development of electrochemical materials and systems. However, after publication, only a small number of back numbers were stocked, and due to copyright issues, it has been difficult to expand the value of the text. Although the texts consisted of academically established content, they also included advanced measurement and analysis techniques, and it was necessary to gather opinions on their content and interpretation methods. In light of

<sup>†</sup>This paper constitutes a collection of papers edited as the proceedings of the 51st Electrochemistry Workshop organized by the Kansai Branch of the Electrochemical Society of Japan.

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this viewpoint, we decided to compile a collection of papers in *Electrochemistry* that would lead to related publications for the first time in a 50-year history of the workshop.

This special feature consists of 10 comprehensive papers used as the text collection of the electrochemistry workshop organized by the Kansai Branch of ECSJ besides the original articles from electrochemical researchers. The comprehensive papers consist of five topics by experts in each field of electrochemistry. In addition, the slides used in the workshop are included in J-STAGE Data as Supplementary Materials. It is expected that the content will be expanded through video distribution and publication of the texts, regardless of time, for those attending the workshop. The authors of the comprehensive papers are experienced mid-career researchers based mainly in the Kansai area. The texts reflect their experiences in the research field, and we hope that readers will make wide use of them. The following is profiles of the authors with their representative references.

## 2. Profiles of Editors and Authors

### 2.1 Editors (Guest Editors of 66th Special Feature)

**Hirohisa YAMADA** is currently an associate professor of Department of Chemical Engineering, National Institute of Technology (KOSEN), Nara College. He earned Ph.D. in Engineering from Doshisha University in 2007. He was a postdoctoral researcher of Interface Phenomenon Research Center and New Energy and Industrial Technology Development Organization (NEDO) Project at Doshisha University from 2007 to 2009. In 2009, he moved to Nara KOSEN as an assistant professor. He promoted a senior lecturer in 2013 and an associate professor in 2014 at Nara KOSEN. Yamada has studied on oxygen reduction reaction to clarify the mechanism of hydrogen peroxide formation as a factor of membrane degradation,<sup>1,2</sup> and to improve the catalytic activity and stability in polymer electrolyte fuel cells (PEFCs). In addition, he published some tutorials of electrochemical methods such as the rotating ring disk electrode<sup>3,4</sup> and electrochemical quartz crystal microbalance<sup>3</sup> techniques for the field of PEFCs. He currently serves as the representative of the caretakers of the Kansai Electrochemistry Study Group organized by the Kansai Branch of the Electrochemical Society of Japan. He has published and contributed his papers with coauthors in *Electrochemistry* during his research experiences,<sup>4-9</sup> receiving Excellent Paper Award of ECSJ in 2008.<sup>5</sup>



**Kazuhiko MATSUMOTO** studied chemistry at Kyoto University where he received his PhD degree in 2004. He extended his research areas as a postdoc at Aichi Institute of Technology, McMaster University, and Kyoto University. He was appointed Assistant Professor in 2010 at Kyoto University and was promoted Associate Professor in 2015. His research interests are in inorganic fluorine chemistry and electrochemistry including structural characterization of new chemical species, synthesis and application of ionic liquids, and evaluation of electrolyte and electrode materials for electrochemical devices and processes.<sup>10-17</sup> He has been the member of Future Plan Committee, Convention Planning Committee, and Editorial Committee in the Electrochemical Society of Japan. He received the Molten Salt Prize for Young Researchers (Molten Salt Committee, the Electrochemical Society of Japan) in 2009, Young Researcher Award of The Electrochemical Society of Japan (Sano Award) in 2013, and Commendation for Science and Technology by the MEXT (Young Scientist Award) in 2017. He was on the Executive Committee of

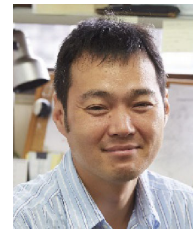


the Fluorine Chemistry Division of ACS from 2015 to 2020. He is currently a member of the Editorial Board of *Electrochemistry*, where he coordinates the Guest Editorship of this special issue.

**Kentaro KURATANI** is currently a group leader of Advanced Electrochemical Device Research Group at Research Institute of Electrochemical Energy, National Institute of Advanced Industrial Science and Technology (AIST). He is also a visiting associate professor at Kobe University. He received Ph.D. in Engineering from Kobe University in 2005. He started his career as a researcher in AIST from 2005. He promoted a senior researcher in 2013 and a group leader in 2021 at AIST. He was appointed as a visiting associate professor at Kansai University in 2014. His research interests include synthesis of inorganic compounds and application to electrochemical devices. He presented some kinds of novel nanomaterials for capacitors and fuel cells.<sup>18-21</sup> He also investigated physicochemical properties of electrolytes for sodium-ion based devices and assembled sodium-ion capacitor.<sup>22-25</sup> Recently, He focuses on sulfide-base all solid-state batteries.<sup>26,27</sup>



**Kingo ARIYOSHI** is currently an associate professor of Graduate School of Engineering, Osaka Metropolitan University. He earned Doctor of Engineering from Osaka City University in 2004. He was a research associate at Osaka City University from 2004 to 2008, and lecturer from 2008 to 2014. In 2014, he promoted an associate professor at Osaka City University. He has devoted himself to the research and development of lithium-ion batteries (LIBs), especially for lithium insertion materials used as positive and negative electrodes.<sup>28-31</sup> His recent work has concentrated on the kinetics of lithium insertion materials. He has provided some useful insights into the rate-determining step for lithium insertion reaction by using “diluted electrode” method<sup>32-35</sup> and the charge-transfer resistance by applying electrochemical impedance spectroscopy to the diluted electrodes.<sup>36,37</sup>



**Masaki MATSUI** is currently a professor at Hokkaido University. He received Ph.D. in Engineering from Tokyo Metropolitan University in 2008.<sup>38,39</sup> He worked at Toyota Motor Corporation from 2001 to 2008 as an engineer of Toyota Technical Center Higashi-Fuji. Then, he moved to Toyota Research Institute of North America as a manager of Materials Research Department.<sup>40,41</sup> He started academic carrier in 2012 at Mie University as a specially appointed associate professor, and his position changed to PREST researcher at Japan Science and Technology Agency (JST) in 2013, associate professor at Mie University in 2015.<sup>42-45</sup> He moved to Kobe University as an associate professor in 2016.<sup>46,47</sup> Then, he got the present position in 2021. His research interest is inorganic materials chemistry for beyond lithium-ion batteries such as solid state battery, sodium-ion battery, and rechargeable magnesium battery. He got the committee of battery technology award in 2015.



**Minoru MIZUHATA** is a professor of Graduate School of Kobe University. He earned his Ph.D. degree in Science from the Graduate School of Science and Technology, Kobe University in 1992. After working as a researcher at the Osaka National Research Institute, AIST (now the Kansai Center of the National Institute of Advanced Industrial Science and Technology, AIST) (1992–1996), a Research Associate at the Faculty of Engineering, Kobe University (1996), and an Associate Professor (2005), he has been a Full Professor since 2011. His research interests include inorganic materials

synthesis<sup>48</sup> and electrochemistry,<sup>49,50</sup> especially ionic conduction<sup>51</sup> and interfacial electrochemistry from the viewpoint of solution properties at the solid–liquid interface.<sup>52,53</sup> He has published about 200 peer-reviewed papers in these research areas. He serves as Deputy Editor-in-Chief of *Electrochemistry* (2020–) and head of Kansai branch (2022–) of the Electrochemical Society of Japan. He was appointed as a visiting professor at the Jagiellonian University, Poland (2019). He received the 2005 Excellent Paper Award from The Electrochemical Society of Japan<sup>54</sup> and the 2015 Molten Salt Prize from Molten Salt Committee,<sup>55</sup> The Electrochemical Society of Japan, and the 71th CerSJ Awards for Academic Achievements in Ceramic Science and Technology from the Ceramics Society of Japan in 2016.<sup>56</sup>



## 2.2 Authors

### 2.2.1 Electrode potentials

**Kohei MIYAZAKI** is currently an associate professor at Graduate School of Engineering, Kyoto University. He earned Ph.D. in Engineering from Kyoto University in 2008 under the supervision of Prof. Zempachi Ogumi. Miyazaki was an assistant professor from 2008 to 2018 and was promoted to associate professor in 2018 at Kyoto University. His research topics are electrocatalysts, ion conductors, and rechargeable batteries, especially with aqueous electrolytes. He received Sano Prize of Electrochemical Society of Japan (2014),<sup>57</sup> Young Investigator Award of Carbon Society of Japan (2017),<sup>58</sup> and Shikata Medal of Polarographic Society of Japan (2020).<sup>59</sup> He worked as a guest scientist at Paul Scherrer Institute, Switzerland in 2014 and as a visiting professor at University of Strasbourg, France in 2015. He has published about 120 papers and one of them has received Excellent Paper Award of The Electrochemical Society of Japan in 2021.<sup>60</sup>



**Jinkwang HWANG** received a BSc degree in Chemistry from Nagoya University and received Master and Ph.D. degrees in Energy Science from Kyoto University under the supervision of Prof. Rika Hagiwara. He was the recipient of research fellowships for young scientist from the Japan Society for the Promotion of Science (JSPS). He is currently an Assistant Professor in the Graduate School of Energy Science at Kyoto University. His current research interests are focused on new electrode materials and electrolytes for Li- and Na-secondary batteries and investigation of their electrochemical and physical properties.<sup>11,17,61–66</sup>



**Takayuki YAMAMOTO** graduated from Graduate School of Energy Science, Kyoto University, and received his Ph.D. degree (Doctor of Energy Science) in March 2016. He worked as JSPS Research Fellowship for Young Scientist (2015–2016), and Researcher in the office of Society Academia Collaboration for Innovation, Kyoto University (2016–2017). He moved to Institute of Advanced Energy, Kyoto University as Assistant Professor in April 2017. He was awarded Young Researcher Award of The Electrochemical Society of Japan (Sano Award) in 2022.<sup>67</sup> He has devoted himself to the research of rechargeable batteries using ionic liquids and various charge carriers, and has made contributions to the enhanced performance of sodium secondary batteries,<sup>68–70</sup> and



the development of potassium secondary batteries<sup>71–73</sup> and fluoride-shuttle batteries<sup>74,75</sup> with ionic liquid electrolytes.

**Atsushi SAKUDA** is currently an associate professor of Osaka Metropolitan University (OMU). He received his Ph.D. from Osaka Prefecture University (OPU) in 2011. He worked as a JSPS postdoctoral fellow at OPU, and then worked as a researcher and a senior researcher at the National Institute of Advanced Industrial Science and Technology (AIST). He moved to OPU as an assistant professor in 2017 and promoted an associate professor in 2020. In 2022, OPU and Osaka City University united to form the OMU. He was awarded Young Ceramist Awards of the Ceramic Society of Japan (2018), Young Researcher Award of The Electrochemical Society of Japan (Sano Award) (2019), and The Young Scientists' Prize in the 2020 Commendation for Science and Technology, from the Japanese Minister of Education, Culture, Sports, Science and Technology (2020). He has made contributions to the field of Electrochemistry. In particular, he has played an important role in the research on inorganic materials chemistry for all-solid-state secondary batteries. He has published 149 research papers which are divided into the following categories: lithium-ion and sodium-ion conducting glasses and glass-ceramics,<sup>76–78</sup> amorphous transition metal polysulfide electrode materials,<sup>79</sup> mechanical properties of battery materials,<sup>80</sup> core technology for all-solid-state batteries.<sup>81,82</sup>



### 2.2.2 Electrochemical polarization

**Kazuhiro FUKAMI** is currently an Associate Professor at Department of Materials Science and Engineering, Kyoto University. He received his PhD degree from Osaka University in 2006. As a PhD candidate, he was also a Research Fellow of the Japan Society for the Promotion of Science (DC2). Immediately after obtaining his PhD, he joined Institute of Advanced Energy at Kyoto University as an Assistant Professor. During his assistant professorship, he was also a Research Fellow of the Alexander von Humboldt Foundation at Technische Universität München from 2011 to 2012. In 2013, he was promoted to Associate Professor at the present department. His research interests include surface processing based on self-organization in electrochemical reactions, fundamental understanding of electrochemical reactivity based on lattice defects, and the production of multicomponent alloys such as medium- and high-entropy alloys by electrodeposition.<sup>83–91</sup> He has published more than 110 peer-reviewed scientific papers. Currently, he is an active member of CNRS France–Japan Laboratoire International Associé on “Chiral Nanostructures for Photonic applications.” He also serves as a scientific advisory board member of Cluster of Excellence “e-conversion” supported by Die Deutsche Forschungsgemeinschaft.



**Hiroaki TSUCHIYA** is currently an associate professor at Osaka University. He earned his Ph.D. from Osaka University in 2004. He was a designed instructor of Osaka University in 2004 and then worked as a post-doctoral fellow and a senior scientist in University of Erlangen-Nuremberg, Germany, from 2004 to 2005. He moved back to Osaka University as an assistant professor in 2006 and has been an associate professor at Osaka University since 2012. His research interests focus on materials science and electrochemistry, especially on the design and electrochemical synthesis of nanoporous materials, their applications<sup>92–97</sup> as well as corrosion of metallic materials.<sup>98–101</sup> His works have been highly evaluated in the relevant research fields and as a result, some papers





were selected as Electrochemistry Communications Best Cited Paper Award 2008<sup>92</sup> and Current Opinion in Solid State & Materials Science Most Cited Article 2006–2010 and 2007–2011,<sup>94</sup> and he received The Japan Institute of Metals and Materials Young Researcher Award in 2006, Morris Cohen Graduate Student Award from the Corrosion Division of The Electrochemical Society in 2006, Hans-Jürgen Engell Prize from International Society of Electrochemistry in 2007, The Japan Institute of Metals and Materials Meritorious Award in 2019.

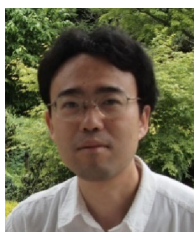
**Hiroyuki USUI** is an Associate Professor of Tottori University. In 2003, he has received Ph.D. degree from Kagoshima University. He has worked at National Institute of Advanced Industrial Science of Technology (AIST), Kobe University, and Research Institute for Electric and Magnetic Materials, in Japan. He received young investigator awards from Japan Association for Chemical Innovation (JACI) in 2013, GSC Network in 2016, Rare Earth Society of Japan in 2017 (Adachi Prize), and Electric Technology Research Foundation of Chugoku in 2021. He has studied liquid-phase synthesis of semiconductive oxide nanomaterials and their morphology control for optical and electronic devices.<sup>102–104</sup> The current research interest is anode materials using rutile TiO<sub>2</sub><sup>105,106</sup> and inorganic compounds<sup>107–109</sup> for Li-ion battery and Na-ion battery. Another interest is opto-electric conversion and energy storage using TiO<sub>2</sub>/MnO<sub>2</sub> composite electrodes for photoelectrochemical capacitor.<sup>110,111</sup> He has published more than 100 peer-reviewed journal articles with the *h*-index of 29, and one of them has received 2011 Excellent Paper Award from ECSJ.<sup>107</sup>



**Masanobu CHIKU** is currently an associate professor of Graduate School of Osaka Metropolitan University. He earned Ph.D. in engineering from Keio University in 2010. In 2010, he moved to Osaka Prefecture University as an assistant professor. He promoted an associate professor in 2018 at Osaka Prefecture University. Osaka Prefecture University has changed its name to Osaka Metropolitan University in 2022. Over a long period of time, Chiku has devoted himself to the research of electrochemistry and the development of Aluminum batteries and earned the Awards for The Committee of Battery Technology from the committee of battery technology in the electrochemical society of Japan in 2018. His work on aluminum rechargeable batteries covers all aspects of battery technology, including positive electrode active materials and electrolytes.<sup>112–119</sup> In 2015, he fabricated an aluminum rechargeable battery using vanadium oxide as the positive electrode material, pioneering the work currently being done by many researchers on aluminum rechargeable batteries. In addition, his research on all-solid-state lithium-ion rechargeable batteries includes the development of electrochemical analysis methods and the application of metallic lithium in rechargeable batteries with porous current collectors. He also contributed to the section of cyclic voltammetry in this special feature.



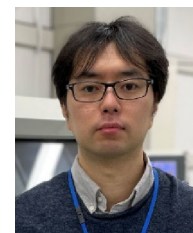
**Shin-ichi YAMAZAKI** is currently a senior researcher in Advanced Fuel Cell Research Group at Research Institute of Electrochemical Energy, National Institute of Advanced Industrial Science and Technology (AIST). He received Ph.D. in agriculture from Kyoto University in 2002. He worked as a postdoctoral fellow in Osaka City University from 2002 to 2003. He joined AIST in 2003. His main research interests are electrocatalysts for cathode and anode of a polymer electrolyte fuel cell (PEFC). He



studied electrochemistry of biological systems such as metabolism of microorganism<sup>120</sup> and enzymatic reactions<sup>121</sup> when he was a student and postdoctoral fellow. After joining AIST, he has been engaged in the development of organic material-modified electrocatalysts. He presented a new CO-tolerant anode catalyst for PEFC<sup>122</sup> using Rh porphyrin-based CO oxidation catalyst.<sup>123,124</sup> He also studied electrocatalysts for direct fuel cells using metal-lococomplexes.<sup>125,126</sup> Recently, he has been developing a Pt cathode catalyst modified with *N*-containing aromatic compounds,<sup>127,128</sup> based on the findings that the compounds promote the oxygen reduction reaction on the Pt surface.

### 2.2.3 Cyclic voltammetry

**Kazuki YOSHII** is currently a Senior Researcher of National Institute of Advanced Industrial Science and Technology (AIST). He received his Ph. D degree from Osaka University under the supervision of Prof. Susumu Kuwabata in 2014. During the time, he joined the Chemical Science Division, Oak Ridge National Laboratory, USA, as a visiting researcher under the supervision of Dr. Sheng Dai. He started his academic career at Keio University in 2014 as a Research Associate (Prof. Yasushi Katayama group). In 2017, he moved to AIST as a researcher and was promoted to a Senior Researcher in 2021. His research interest is related to energy conversion systems using nonaqueous electrolytes and ionic liquid science. He has been working on the preparation of metal nanoparticles and electrodeposition using ionic liquids,<sup>129,130</sup> development of novel ionic liquids,<sup>131</sup> and structure-property relationships of ionic liquids.<sup>132,133</sup> In addition, he has studied lithium metal anodes<sup>134,135</sup> and conversion-type cathodes in organic electrolytes.<sup>136</sup> He received the Molten Salt Prize for Young Researchers (Molten Salt Committee, the Electrochemical Society of Japan (ECSJ)) in 2010 and Young Researcher Award of The Electrochemical Society of Japan (Sano Award) in 2021.<sup>137</sup>



**Masafumi ASAHII** is currently a researcher of Research Institute of Electrochemical Energy, National Institute of Advanced Industrial Science and Technology (AIST). He has been a researcher of AIST from 2011 and he has been engaged in the development of cathode catalysts of polymer electrolyte fuel cells (PEFCs). On the way of his career, he earned Ph.D. in Engineering from Osaka University in 2018. Throughout of his career, his interest of research is the electrocatalysts which catalyze the oxygen reduction reaction (ORR) that proceeds in the cathode of PEFCs. He addresses the investigation of ORR of some copper-complex-based catalysts which are model complexes of enzymes and proteins activating dioxygen.<sup>138–140</sup> He developed several copper-complex-based catalysts with unveiling crystallographic structures.<sup>140</sup> Currently, he also addresses the development of a novel activation method toward platinum-based cathode catalysts. Recently, he and coauthors have found that the modification of some nitrogen-containing-organic molecules on the surface of platinum elevates the ORR activity of not only commercially available platinum-carbon catalysts<sup>141,142</sup> but also highly active core-shell catalysts.<sup>143</sup> He holds several patents about both non-platinum-based and platinum-based catalysts.



**Yuki KITAZUMI** is currently an assistant professor of Graduate School of Agriculture, Kyoto University. He earned Ph.D. from Kyoto University in 2010. He was an assistant professor of Graduate School of Engineering, Kyoto University from 2010 to 2012. Kitazumi has devoted himself to the research of electrochemistry for ionic surfactants at the interface between two immiscible electrolyte solutions and bioelectrochemistry for redox enzymes at the electrode

surface. He constructed a simultaneous measurement system of a voltammogram and an electrocapillary curve of a hanging drop electrode.<sup>144</sup> He formulated the potential-dependent adsorption of surface-active ions at the liquid–liquid interface<sup>145</sup> and that of redox-active species at the electrode surface.<sup>146</sup> He developed simple construction of microelectrodes suitable to the electrochemical sensors.<sup>147,148</sup> He investigated diffusion-limited bioelectrocatalysis at the microelectrode<sup>149</sup> and applied the biosensor.<sup>150,151</sup> The application of these researches into electrochemical sensors earned the Japan Society for Analytical Chemistry Award for Younger Researchers in 2016.<sup>152</sup>



#### 2.2.4 Electrochemical impedance spectroscopy

**Zyun SIROMA** is currently a senior researcher in Advanced Electrochemical Device Research Group, Research Institute of Electrochemical Energy, National Institute of Advanced Industrial Science and Technology (AIST). He graduated from Kyoto University in 1994 and earned Master of Engineering in 1996. He has been working for Osaka National Research Institute (ONRI, currently AIST after organization restructuring at 2001) since 1996. He earned Doctor of Engineering from Kyoto University in 2008. He has devoted himself to research of polymer electrolyte membrane fuel cell (PEFC), especially from the viewpoint of electroanalytical chemistry, including investigation of degradation mechanism,<sup>153,154</sup> modelling,<sup>155</sup> and development of measurement method.<sup>156</sup> He is also developing measurement methods for lithium ion battery (LIB).<sup>157,158</sup> Based on a work in the field of electrochemical impedance spectroscopy (EIS), he received Excellent Paper Award of ECSJ in 2016.<sup>159</sup> Currently he is developing EIS analysis methods, not limiting any specific device including PEFC and LIB, from fundamental aspect.<sup>160,161</sup>



**Atsushi MINESHIGE** is currently a professor at graduate school of engineering, University of Hyogo. He earned Ph.D. in engineering from Kyoto University in 1998. He was a research associate at Himeji Institute of Technology (currently University of Hyogo due to integration) from April 1996 to September 2011. He studied at Case Western Reserve University as a visiting researcher for the period October 2003 to September 2004. He promoted an associate professor in 2011 and a full professor in 2022 at University of Hyogo. Over a long period of time, Mineshige has been engaged in the research and development of inorganic solid electrolytes to be applied to fuel cells<sup>162,163</sup> and batteries.<sup>164,165</sup> He has also worked on the relationships between crystal, electronic and defect structure and electrical properties of solid electrolytes and mixed conductors using various techniques such as diffraction, reflectometry, and spectroscopy.<sup>163–165</sup> He has published ca. 110 papers and contributed his papers with many coauthors in *Electrochemistry* during his research experiences,<sup>166–169</sup> and one of them has received Excellent Paper Award of ECSJ in 2015.<sup>168</sup>



**Mitsuhiro TAKENO** is currently a Senior Engineer of Panasonic Energy Co., Ltd. He was born in 1972. He graduated from Graduate School of Engineering of Kansai University in March 1996. He has been working in Panasonic Energy Co., Ltd. (formerly Matsushita Electric Industrial Co., Ltd.). He received his Ph.D. degree from Kyoto University under the supervision of



Prof. Takeshi Abe in 2017. His research interest are energy storage device material and manufacturing process analysis. Particularly, his main concern is electrochemical impedance spectroscopic analysis for practical lithium-ion batteries.<sup>170–173</sup>

**Tomokazu FUKUTSUKA** is currently a professor at Graduate School of Nagoya University. He was a research associate at Himeji Institute of Technology (currently University of Hyogo) from 2000 to 2007. He earned Doctor of Engineering from Kyoto University in 2005. In 2007, he moved to Kyoto University as a research associate (Graduate School of Human and Environmental Studies). He was promoted to an associate professor in 2010 (Graduate School of Engineering). In 2018, he moved to Nagoya University as a full professor. He was awarded Young Researcher Award of The Electrochemical Society of Japan (Sano Award) in 2011. His research interests are energy conversion devices such as lithium-ion batteries and next-generation rechargeable batteries (all-solid-state Li, Na, Mg, and F) and fundamental research and new material development are undergoing. He has published over 100 papers,<sup>174–178</sup> contributed his papers with many coauthors in *Electrochemistry* during his research experiences,<sup>173,179,180</sup> and one of them has received Excellent Paper Award of ECSJ in 2021.<sup>60</sup>



**Takeshi ABE** is currently a professor at Graduate School of Kyoto University. He graduated from the Department of Industrial Chemistry, Faculty of Engineering, Kyoto University in 1992. He earned his MS and PhD degrees from the Graduate School of Engineering, Kyoto University. Upon completion of his PhD degree he joined the Graduate School of Engineering, Kyoto University, as a Research Associate in 1997, and became an Associate in 2002 and a Professor in 2009. His initial research focused on the graphite intercalation compounds and graphite negative electrode for lithium-ion batteries.<sup>181–184</sup> His current research focusses on various secondary batteries and its interfacial phenomena. He has published more than 300 peer-reviewed papers and has co-edited several books on new technologies for advanced rechargeable batteries and electrochemistry. His achievements and technical contributions were recognized in 2002 by Young Researcher Award of The Electrochemical Society of Japan (Sano Award), and in 2006 by the Battery Technology Award from The Committee of Battery Technology, The Electrochemical Society, Japan, as well as the Research Award from the Carbon Society, Japan.



**Satoshi UCHIDA** is currently a researcher of National Institute of Advanced Industrial Science and Technology (AIST). He earned Ph.D. in Engineering from Kansai University in 2013. He was a post-doctoral fellow from 2013 to 2015 and a research associate from 2015 to 2018 of Kansai University. In 2018, he moved to AIST as a researcher. Uchida has been extensively engaged in research on lithium secondary batteries focusing on positive electrode materials,<sup>185–187</sup> composite electrode design,<sup>188,189</sup> and electrode/electrolyte interfaces,<sup>190,191</sup> one of which has received the Excellent Paper Award of ECSJ in 2018.<sup>186</sup> In recent years, he has also focused on elucidating ion transport phenomena in non-aqueous electrolytes and has published several papers on this subject.<sup>192–195</sup>



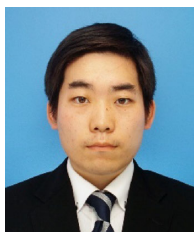


### 2.2.5 Electrochemical in situ/*operando* spectroscopy and microscopy

**Yuki ORIKASA** is currently a professor of Ritsumeikan University. He has PhD in Human and Environmental Studies from Kyoto University in 2010. He worked as an Assistant Professor of Kyoto University for 2010–2015 and moved to Ritsumeikan University as an Associate Professor in 2016, then promoted to Professor in 2021. Research topics are developing new technologies using synchrotron X-ray, *operando* XRD and X-ray absorption technologies, to obtain information of reactions in batteries under their operation with solid state chemistry relating to battery.<sup>196</sup> He has aimed at combining solid material science and X-ray analysis in various systems of lithium ion batteries. The study includes dynamics of phase transition in battery active materials in micro scale<sup>197</sup> and reaction distributions in micro- and meso-scale of commercial and model battery systems.<sup>198</sup> Based on their fundamental research, he also developed next generation battery materials.<sup>199</sup> Prof. Orikasa earned Young Researcher Award of the Electrochemical Society of Japan (Sano Award) in 2015.<sup>200</sup>



**Tomoki UCHIYAMA** is currently an assistant professor of Graduate School of Human and Environmental studies, Kyoto University. He earned Ph.D. in Engineering from Interdisciplinary Graduate School of Engineering Sciences, Kyushu University in 2016. He was a post-doc researcher of Japan Synchrotron Radiation Research Institute (JASRI/SPring-8) from 2016 to 2017. In 2017, he moved to Kyoto University as a postdoc researcher. He promoted an assistant professor in 2018 at Kyoto University. Over a long period of time, He has devoted himself to the research and development of electro-catalyst materials and their synchrotron analysis under in-situ/*operando* conditions.<sup>201–205</sup>



**Naoya NISHI** is currently an associate professor in Graduate School of Engineering, Kyoto University. He earned Ph.D. in Engineering from Kyoto University in 2003, supervised by Professor T. Kakiuchi, and then became Assistant Professor in the same lab, before being promoted to the present position in 2009. He was a visiting researcher at University of California, Irvine (USA) working with Professor Robert M. Corn in 2008–2009, at Université Claude Bernard Lyon 1 (France) working with Professor Pierre-François Brevet in 2014, and at Université de Strasbourg (France) working with Professor Rachel Schurhammer in 2022. He was awarded Young Researcher Award from The Japan Society for Analytical Chemistry in 2011, Young Researcher Award for Science from The UBE foundation in 2011, and Young Researcher Award for Science, Division of Colloid and Surface Chemistry, Chemical Society of Japan in 2014. His current research interests include electrochemistry, interfacial spectroscopy, and interfacial chemistry at the solid/liquid and liquid/liquid interfaces of ionic liquids. Especially, he has revealed the structure and dynamics at the electrochemical interfaces of ionic liquids by using several techniques including x-ray reflectometry,<sup>206,207</sup> neutron reflectometry,<sup>208,209</sup> and surface plasmon resonance,<sup>210,211</sup> to name a few. He also pursued to functionalize the liquid/liquid interfaces of ionic liquids as the two-dimensional reaction media for electroless metal deposition.<sup>212,213</sup> He has published ca. 120 papers including the ones in *Electrochemistry*.<sup>214–216</sup>



**Yuto MIYAHARA** is currently an assistant professor at Graduate School of Engineering, Kyoto University. He earned

Ph.D. in Engineering from Kyoto University in 2017. During his Ph.D. study, he focused on oxygen electrocatalysis in alkaline media including fundamental analyses of reaction pathway,<sup>217,218</sup> and development of novel catalysts with high activity.<sup>219</sup> He started his academic career as the assistant professor in 2017. As well as continuous studies on oxygen electrocatalysis,<sup>220,221</sup> his current research focuses on lithium-ion batteries<sup>60,222,223</sup> and other rechargeable batteries. One of the papers published in *Electrochemistry* has received Excellent Paper Award of ECSJ in 2021.<sup>60</sup>



**Misae OTOYAMA** is currently a researcher of National Institute of Advanced Industrial Science and Technology (AIST). She studied all-solid-state batteries at Osaka Prefecture University in bachelor, master, and doctoral courses from 2014 to 2020. She was a Japan Society for the Promotion of Science (JSPS) research fellow DC1 from 2017 to 2020. She participated in the Research Visits of JSPS Research Fellows to European Research Council (ERC)-supported European teams and studied at Collège de France from 2017 to 2018. She earned Ph.D. in Engineering from Osaka Prefecture University in 2020 and received the 10th JSPS Ikushi prize for her research. She has evaluated reaction distributions in sulfide all-solid-state lithium batteries by Raman imaging,<sup>224,225</sup> confocal microscopy,<sup>226,227</sup> and scanning probe microscopy.<sup>228</sup> She received the Award in the 60th Battery Symposium in Japan held in 2019 for her research on *operando* observation for reaction distributions of graphite electrodes by confocal microscopy. In addition, she has studied chemical stability of sulfide solid electrolytes and oxide positive electrodes.<sup>229</sup> Moreover, she proposed degradation mechanism of interfaces between sulfide solid electrolytes and lithium metal based on results of X-ray computed tomography and scanning electron microscopy.<sup>230</sup> She revealed electrochemical redox mechanism of Na(Li)-rich ruthenium oxides at Collège de France.<sup>231</sup> She moved to AIST in 2020 and has developed sulfide solid electrolytes exhibiting high ionic conductivity and high air stability.<sup>232,233</sup>



**Tetsuya TSUDA** is a professor in Graduate School of Science and Engineering at Chiba University (CU). He received his Ph.D. in Energy Science from Kyoto University in 2001. He started his academic career at The University of Mississippi under the direction of Professor Charles L. Hussey, who is one of the fathers of modern ionic liquid (IL) science. In 2008, he moved to Graduate School of Engineering, Osaka University (OU) as a tenure-track assistant professor (Professor Susumu Kuwabata, who is a former President of The Electrochemical Society of Japan, was a mentor.). He got tenure at OU and was then promoted to associate professor in 2013. In 2022, he was appointed as a professor at CU. His research interests are energy science and materials science related to electrochemistry in IL.<sup>234–240</sup> His current h-index is 35.<sup>241</sup>



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### CRedit Authorship Contribution Statement

Hirohisa Yamada: Conceptualization (Lead), Project administration (Lead), Writing – review & editing (Equal)

Kazuhiko Matsumoto: Conceptualization (Lead), Project administration (Lead), Writing – review & editing (Equal)

Kentaro Kuratani: Conceptualization (Lead), Project administration (Lead), Writing – review & editing (Equal)

Kingo Ariyoshi: Conceptualization (Lead), Project administration (Lead), Writing – review & editing (Equal)

Masaki Matsui: Conceptualization (Lead), Project administration (Lead), Writing – review & editing (Equal)

Minoru Mizuhata: Conceptualization (Lead), Project administration (Supporting), Writing – original draft (Lead)

### Data Availability Statement

The data that support the findings of this study are openly available under the terms of the designated Creative Commons License in J-STAGE Data listed in D1 of References.

### Conflict of Interest

The authors declare no conflict of interest in the manuscript.

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