# Electrical Insulation News in Asia

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IEEJ

# CONTENTS

# PREFACE

**Dr. Mitsuyoshi ONODA**

## Organic Molecular Devices Engineering of 21st Century

The commencement of 21st century have witnessed the advanced visual communication-oriented society which is becoming more and more complicated leading to the emergence of so-called "ubiquitous" network. In order to meet the demands of such a visual communication-oriented society, it is essential to realize the functional diversity and the functional integration based on the hyperfine processing. However, the techno-scientific innovations in the semiconductor electronics seems to exhibit a downfall owing to the reachable physical limits.

Organic materials are quite fascinating due to availability of many metastable states which is considered to play a pivotal role for the next-generation electronics. Presently, a paradigm shift of technology from "Hard and Dry" to "Soft and Wet" is taking place. That is, the industrial importance is moving from heavy materials and silicon semiconductors to artificial intelligence and life science. Electronics materials of hard and dry technologies are silicon and inorganic semiconductors, electrons are playing the role of functions.

On the other hand, the materials for soft and wet are organics, and ions are working with electrons, and this research field is called organic "Iontronics". The word "Iontronics" is still unfamiliar words and has been created by the fusion of the two words "Ion" and "Electronics". It may be said that "Iontronics" is discipline handling various phenomena and device applications based on the behavior of ions and electrons. However, there may be sense of incongruity a little in comparison with words infiltrating the general public widely called "Electronics".

Recent years have seen rapid growth in the area of Biomolecular Electronics involving intricate expertise and association of physicists, biologists, chemists, electrical and electronic engineers and information technologies including AI (artificial intelligence). Bioelectronics has been emerged by combining the biology and electronics dealing with the study of living body functions electronically. The most familiar area biotechnology which is based on amicable use of unique biological functions towards betterment of human life and environmental conservation cannot deny the important role played by the ions. "Iontronics" does not mean to simply mimic electronics but it is intended to create possible novel and precise features assisted by ions. In order to realize the molecular devices such as functional elements of the next-generation electronics, a thought of "Iontronics" will be indispensable.

I would emphasize that multidisciplinary science is essential for bridging the existing gap between Electronics and Biosystems. Above all, the way of thinking for the insulation technology is indispensable for biomolecular electronics. I hope this EINA magazine would be able to provide an invaluable opportunity and forum to researchers for discussions in multidisciplinary science and its implications, for the benefit of mankind. I am sure that the fusion of insulation technology and bioelectronics will be very useful and fruitful for not only researchers but also engineers to summarize the recent progress in organic nanotechnology and biomolecular electronics for environmental preservation and prepare the new step for the next generation. That is, brain-storming discussions pertaining to the current status and problems for the state-of-art science and technology related to organic "Iontronics" will be made which is expected to prosper the next generation electronics technology.

Our goal is to realize next-generation organic Iontronics aiming towards energy harvesting.

**Dr. Mitsuyoshi ONODA**
Commission of Himeji City Fire Bureau
University of Hyogo

# OUTLINE OF TECHNICAL COMMITTEES IN IEEJ

## Dielectrics and Electrical Insulation (DEI)

Chairperson: Naoki Hayakawa (Nagoya Univ.)
Secretaries: Yoitsu Sekiguchi (Sumitomo Electric Industries)
Toshihiro Takahashi (CRIEPI*)
Assistant Secretaries: Yuuji Hayase (Fuji Electric)
Yoshinobu Murakami (Toyohashi Univ. of Tech.)
*CRIEPI: Central Research Institute of Electric Power Industry

The Technical Committee on Dielectrics and Electrical Insulation (TC-DEI) has a long history from 1970. The activity of the TC-DEI has been covering mainly solid and composite dielectric materials and their technologies.

The important activity of TC-DEI is the annual domestic Symposium on Electrical and Electronic Insulating Materials and Application in Systems (SEEIMAS). The symposium topics include diagnostic techniques, inverter surge and partial discharge phenomena, functional and new materials and so on. In 2019, the 50$^{th}$ anniversary of SEEIMAS was held at Nagoya University from September 17$^{th}$ to 19$^{th}$, 2019. Total 158 persons participated in this year's symposium, as shown in Fig. 1, in order to share their experiences and discuss the latest developments and future challenges confronting the field. The number of presented papers was 89 in total, which is highest in the history of SEEIMAS. The 50$^{th}$ anniversary symposium started with a special "Historical Session", where Prof. Toshikatsu Tanaka and the former chairpersons of TC-DEI looked back on the pioneering days and the subsequent progress in the fields of dielectrics and electrical insulation. The Ieda and Yahagi Memorial Awards in 2019 were given to Prof. Mitsumasa Iwamoto at Tokyo Institute of Technology and Dr. Shoshi Katakai at Sumitomo Electric Industries, Ltd., respectively.

The next 51$^{st}$ SEEIMAS will be held as the 9$^{th}$ International Symposium on Electrical Insulating Materials (ISEIM) at Waseda University, Tokyo, from September 13$^{th}$ to 17$^{th}$, 2020, after the 32$^{nd}$ Olympic and Paralympic Games in Tokyo.

Adding to organize some technical, academic and educational events, the TC-DEI runs Investigation Committees (IC's) that organize several technical meetings in a year. The following 6 IC's are on-going in their investigation research activities:

(1) Insulation Diagnosis Technologies for Electric Power Apparatus and Equipment Using New and Practicable Insulation Materials (04/2017-03/2020, Chairperson: Yoshiyasu Ehara, Tokyo City University)

(2) Standardization of Calibration and Advanced Measurements for Space Charge Distribution at High Temperature using Pulsed Electro-acoustic Method (04/2017-03/2020, Chairperson: Yasuhiro Tanaka, Tokyo City University)

(3) Advanced Nanomaterials and Nanostructure Control for Innovative Organic Devices and Life Science (07/2017-06/2020, Chairperson: Keizo Kato, Niigata University)

(4) Application of Quantum Chemical Calculations in the Field of Electrical and Electronic Insulating Materials (12/2018-11/2021, Chairperson: Satoshi Matsumoto, Shibaura Institute of Technology)

(5) Electrical Insulation Reliability of Power Module (12/2018-11/2021, Chairperson: Masahiro Kozako, Kyushu Institute of Technology)

(6) Information for Asset Management of Power Apparatus Based on Insulation Degradation (4/2019-3/2021, Chairperson: Katsumi Uchida, Chubu Electric Power Co., Inc.)

Fig. 1. Group photo in the 50$^{th}$ SEEIMAS at Nagoya University

# Electrical Discharges, Plasma and Pulsed Power (EPP)

Chairperson: Tatsuru Shirafuji (Osaka City University)
Vice-Chairperson: Akiko Kumada (The University of Tokyo)
Secretaries: Hiroki Kojima (Nagoya University)
Katsuyuki Takahashi (Iwate University)
Assistant Secretaries: Yusuke Nakagawa (Tokyo Metropolitan University)
Yasushi Yamanou (Saitama University)

The Technical Committee on Electrical Discharges, Plasma and Pulsed Power (TC-EPP) in the Fundamentals and Materials Society of the Institute of Electrical Engineers of Japan (IEEJ) was newly founded by integrating former Technical Committee on Plasma and Pulsed Power (TC-PPP) and Technical Committee on Electrical Discharges (TC-ED) in January 1, 2019. This new committee covers the research fields related to the science and technologies of electrical discharges, plasma and pulsed power.

The main purpose of the TC-EPP is the wide promotion of the research activities concerning to ta variety of electrical discharges, plasma and pulsed power in vacuum, gas, liquid and on surfaces of materials and their applications to advanced technologies, especially for realizing sustainable society for the next generation.

Our regular activities (technical meeting) in 2019 and early 2020 are as follows;

(1) January 25-26 at Amami Sun Plaza Hotel, Kagoshima, with the TC of Dielectrics and Electrical Insulation (TC-DEI) and of High Voltage Engineering (TC-HVE),
(2) May 15-17 at Machinaka Campus Nagaoka, Niigata,
(3) July 23-24 at Tsukuba University, Ibaraki, with the TC of Stationary Devices (TC-SD) and of Switching and Protecting Engineering (TC-SPE),
(4) October 24-25 at Miyazaki University (Kibana Campus), Miyazaki,
(5) December 5-6 at Sinfonia Technology Hibiki Hall Ise, Mie, with the TC-SPE and TC-HVE,
(6) January 24-25, 2020, at Mitsubishi Electric Corporation Yufugokan, Oita.

Each meeting consists of 20-40 oral presentations. Oral presentations by young researchers including undergraduate and graduate students are strongly encouraged, and they are nominated for young presentation award.

In addition to the regular activities, we organized the kick-off symposium of the newly born TC-EPP during the period of the annual meeting of IEEJ which was held in March 12-14, 2019 at Hokkaido University of Science, Hokkaido. This symposium was co-hosted with the TC-DEI, TC-SD, and TC-HVE.

The TC-EPP also contributes to organize an annual young researcher seminar in cooperation with the Institute of Engineers on Electrical Discharges in Japan for encouraging the young researchers in the field of electrical discharges, plasma and pulsed power. The seminar consists of lectures by a senior researcher, poster presentation by the participants, and the visit tour to the facilities. About 30 young researchers and engineers participate in the seminar and discuss vigorously the topics in November 29-30 at Koike Sanso Kogyo Co., Ltd. and Tokyo City University (Setagaya Campus), Tokyo.

International workshop or symposium are also important activities of the TC-EPP. In December 11-14, 2019, we co-hosted the 11th Asia-Pacific International Symposium on the Basics and Applications of Plasma Technology (APSPT-11) at The Kanazawa Chamber of Commerce and Industry, Kanazawa (Fig. 1). The chair of APSPT-11 was Professor Yasunori Tanaka in Kanazawa University. In March 19-21, 2020, we are going to co-host the 11th International Workshop on Plasma Scientech for All Something (PLASAS-11) at Gifu University, Gifu.


Fig. 1. A photograph of APSPT-11.

The chair of PLASAS-11 is professor Hiroyuki Kousaka in Gifu University.

Investigation committees, which are the affiliates of the TC-EPP, are established to survey the up-to-date research subjects. The activities of these committees usually continue for three years. Each committee publish a very useful technical report at the end of their active period. In 2019, our technical committee has the following three investigation committees;

(1) Food Sterilization and Processing Technology by Pulsed Electric Field (Chair: Professor Yasushi Minamitani in Yamagata University, Period: January 2019-December 2021),

(2) Plasma Surface Technology (Chair: Professor Ryuta Ichiki in Oita University, Period: January 2019-December 2021),

(3) Electrical Insulation of Inverter-driven Rotating Machines (Chair: Professor Akiko Kumada in The University of Tokyo, Period: December 2018-November 2021).

# Electrical Wire and Cables (EWC)

Chairperson: Naohiro Hozumi (Toyohashi University of Technology)
Secretaries: Hiroshi Nishino (Fujikura, Ltd.)
Kouji Miura (SWCC Showa Cable Systems Co., Ltd.)
Yoshihisa Nagoya (Furukawa Electric Co., Ltd.)
Kenichi Furusawa (Sumitomo Electric Industries, Ltd.)

Technical Committee on Electrical Wire and Cables (TC-EWC) is a committee organized in the IEEJ Power and Energy Society, and is comprised of members from cable manufacturers, power utilities, railway companies, universities and related research institutes such as Japan Electric Cable Technology Center (JECTEC) and Central Research Institute of Electric Power Industry (CRIEPI).

The technical committee organizes technical meetings to provide opportunities to present technical achievements and to promote R&D activities in this field. The technical committee so far held technical meeting as a joint meeting of TC-DEI (Technical Committee on Dielectrics and electrical insulation) and TC-EWC, on ‘Recent trends in technologies of electric wire and cables’ in September, 2019. The technical committee also hold one more technical meeting in Japanese FY2019, which was jointly organized by TC-DEI and TC-EWC. The topic of the technical meeting was ‘Insulation performance and aging of cable system, electric properties of insulating and dielectric materials". Until the end of FY2019 we will hold one more meeting on "Technology trends in cable and wire systems (product technology, aging mechanism clarification, diagnostics, evaluation, judgment methods)" under this scheme.

In FY 2019 TC-EWC participated the symposium on "Power facilities supporting Japanese lifelines", organized by the TC on Static Apparatus, and made a presentation on cable technologies.

In addition to organizing technical meetings, forums and symposia, the technical committee supervises investigation committees dealing with subjects related to electrical wire and cables. Two investigation committees are in active during FY2019 on the following subjects, respectively, i.e. "Technology transition and issues in distribution insulating wires and cables and their accessories responding to environmental usage", and "Status Quo and technology trends in power transmission cables". One more committee is now in preparation.

In FY2019 the technical committee members visited Decommissioning Archive Center in Fukushima that exhibits the nuclear accident and current status of the decommissioning work in September 12th, 2019 to lean what happened after the big earthquake and what is going on in order to stabilize the disaster in terms of the nuclear plant.

We strongly believe that Electric wire and cables occupy an important part of infra-structure that sustains stable supply of electric power. It is thus an important responsibility of us to clarify the social background and development process lead to the establishment of the technologies, and pass these onto the next generation.

Fig. 1. Visit to TEPCO Decommissioning Archive Center in Fukushima

# Activities of Investigation Committees in the DEI Technical Committee

## Standardization of Calibration and Advanced Measurements for Space Charge Distribution at High Temperature using Pulsed Electro-acoustic Method (HT-PEA)

Chairperson: Yasuhiro Tanaka (Tokyo City University)
Secretaries: Hiroaki Uehara (Kanto Gakuin University)
Yoshinobu Murakami (Toyohashi University of Technology)
Assistant Secretary: Hiroki Mori (Furukawa Electric Co., Ltd.)

**Objective**

The investigation committee has two major purposes. First one is standardization of calibration for measurement of space charge distribution at high temperature using PEA (Pulsed electro acoustic) method. The PEA method has been used to measure space charge distribution in dielectric materials by many researchers, and it has been accepted, in general, as a useful method to understand electrical properties of dielectric materials. A basic measurement procedure at room temperature using PEA system has been already published by the domestic and international organizations for standardization, JEC (Japanese Electrotechnical Committee) and IEC (International Electrotechnical Commission), as JEC-TR-61004-2012 and IEC TS 62758, respectively. However, since many dielectric materials are expected to be used under high temperature and the demand to measure the space charge distribution under such environment has been increasing. Therefore, the investigation committee has been established to discuss and make a draft for the standard procedure to evaluate the PEA measurement equipment for high temperature measurement. Discussion in this committee is supposed to be reflected into the draft of TR in JEC and TS in IEC.

Another purpose is to investigate some advanced applications of the PEA measurement. The PEA method has been still improved by many researchers, and many advanced systems have been developed by them. For example, since the spatial and time resolution have been improved in the method, the dynamics of space charge formation is enable to be observed in thin films under very high electric field with short duration. Furthermore, the simultaneous measurements systems for space charge distribution and conduction current have been developed. These advanced improvements make it possible to be clear the relationship between breakdown and space charge formation, and the results obtained using the systems are very useful to estimate the dielectric properties of polymeric materials. Therefore, these advanced applications of the PEA technique is worthy to be introduced.

**Activities**

The committee is composed of 15 members, and investigating the followings.

(1) Proposal of the calibration method of PEA measurement at temperature from room temperature to 100 ˚C.

(2) Evaluation of the proposed method

(3) Investigation of the advanced measurement techniques

(a) Measurement at high temperature

(b) Measurement under high electric stress

(c) Measurement for sample with cable geometry

(d) Investigation of the relationship between PEA and Q(t) measurement

(e) Investigation of the relationship between PEA measurement and the advanced numerical simulation results

In the last June, the first meetings have been already held to discuss what kinds of objectives should be treated in the committee. The committee is also planning to collect more information about the newly developed measurement techniques.

**Technical Report**

The followings are contents of the technical report that will be published in September 2020. Normally, the report is published in Japanese. However, the committee decided to publish in English.

1. Preface
2. Principle of PEA Measurement
3. Improvement of Measurement
4. Measurement under Specific Environments
5. Under Various Electric Field
6. Various Shape
7. Various Materials
8. DC Current Integrated Charge (Q(t)) Method

# Insulation Diagnosis Technologies for Electric Power Apparatus and Equipment Using New and Practicable Insulation Materials

Chairperson: Yoshiyasu Ehara (Tokyo City University)
Secretary: Takashi Kurihara (Central Research Institute for Electric Power Industries)

**Objective**

The insulation materials and the structure of the electric power apparatus and equipment are different according to the manufacturing age and voltage class. The insulation materials were transformed to the artificial ones from natural ones, and they have been improved and diversified. Insulation technologies have also progressed, and breakdown and lifetime theories of insulation materials have been established. Also, an electric field calculation and the various new measuring methods have been established, and the technologies relating to the insulation materials have entered a mature phase.

For this reasons, the investigation committee on insulation diagnosis technologies for electric power apparatus and equipment using new and practicable insulation materials was established in April 2017 with a total of 23 persons' composition from universities, cable and electric power apparatus manufacturers, insulating material manufacturers, electric power companies, a research institute, a diagnostic company, and users. This investigation committee is aiming at investigating and examining the trend and problems on the degradation characteristics of insulation materials, diagnostic technologies, and practical use of IoT and big data in insulation diagnosis.

**Activities**

The committee performs the further investigation and examination to the above problems and future trends. The main investigations of the committee are as follows;

- Investigation of the newest insulation degradation measurement technologies for dielectric and electrical insulation materials.
- Investigate of material characteristics, degradation mechanisms, and insulation degradation diagnostic technologies relating to the electric power apparatus and equipment using new insulation material.
- Investigation of practical applications of IoT technologies or big data to insulation diagnosis.

**Term of Investigation Committee**

The term of this committee is three years from April 2017 to March 2020.

Fig. 1. A group photo of a visit to the National Institute for Fusion Science

# Advanced Nanomaterials and Nanostructure Control for Innovative Organic Devices and Life Science

Chairperson: Keizo Kato (Niigata University)
Secretary: Shin-ichiro Nakajima (Japan Aviation Electronics Industry, Ltd. )
Secretary: Yusuke Aoki (Mie University)
Assistant Secretary: Akira Baba (Niigata University)

Recently, research on organic electronics, such as the development of devices and sensors using organic materials, is making great progress. Organic materials are lightweight, flexible, cost-effective and easy to mass produce. Also, it is easy to fabricate a film-shaped multilayer structure device, and various molecular materials are being developed by controlling the structure of organic molecules, designing and synthesizing molecules. Ubiquitous and wearable devices are also expected as flexible devices. Research on printed electronics and bioelectronics are also active. Research on such organic devices can also be applied to life sciences. For this organic device development and life science application, nanomaterials and nanostructure control are considered to be very important, and various trials and research and development are currently underway.

The R&D committee was established in July 2017, with the term of three years. The investigation has focused attention on the nanomaterials and structure control for high-performance organic devices and life science related to:

1) advanced nanomaterials and nanostructure control technology,
2) surface/interface properties of nanomaterials and devices, and their evaluation technology,
3) nanostructure control of nanomaterials, organic thin films and composite films, and electronic and optical functions, and
4) innovative organic devices and life science applications of nanomaterials, organic thin films, and composite films.

As shown in Table 1, 10 meetings were held by the end of 2019. Lectures related to the above subjects were given by the committee members and non-member researchers. Recent research topics and trends were also introduced by the committee members, and earnest discussions were done. Figs. 1 and 2 show the group photos of the 8th and 10th meetings, respectively. Visiting the distinguished laboratories and investigations of the above subjects were also carried out. In addition, the Technical Meetings on "Dielectrics and Electrical Insulation" were held on July 28, 2017 (Toyama, Toyama Pref.), January 22-23, 2018 (Bangkok, Thailand), July 19-20, 2018 (Sanjo and Nagaoka, Niigata Pref.), January 22, 2019 (Minamichita, Aichi Pref.), on July 5-6, 2019 (Sado, Niigata Pref.), and on October 17, 2019 (Kochi, Kochi Pref.), in cooperation with this R&D committee.

Advanced technologies such as nanomaterials and nanostructure control will lead to the development of high-performance organic devices. In addition, new functions are expected to be realized by the nanostructure control technologies of nanomaterials and organic/composite thin films. The development of innovative organic devices and life science applications are greatly expected.

Table 1. Meetings of the Investigating R&D Committee.

| | Dates | Venue |
|---|---|---|
| 1st | Jul. 28, 2017 | Gofuku Campus, Toyama University |
| 2nd | Sep. 26, 2017 | Surugadai Campus, Nihon University |
| 3rd | Dec. 8, 2017 | Ookayama Campus, Tokyo Institute of Technology |
| 4th | Apr. 23, 2018 | Open Innovation Office, Osaka University |
| 5th | Jul. 19-20, 2018 | Head Office, Corona Corporation, Izumiya, and Machinaka Campus Nagaoka |
| 6th | Dec. 6, 2018 | Toyosu Campus, Shibaura Institute of Technology |
| 7th | Mar. 14, 2019 | Sapporo Campus, Hokkaido University |
| 8th | Jul. 5-6, 2019 | Sado Toki Fanclub Hall and Hotel Osado |
| 9th | Sep. 3, 2019 | Ueda Campus, Iwate University |
| 10th | Nov. 14, 2019 | Head Office, Japan Aviation Electronics Industry, Ltd |

Fig. 1. A Group photo of the 8th meeting held at Sado Toki Fanclub Hall, Sado, Japan.


Fig. 2. A group photo of the 10th meeting held at Head Office, Japan Aviation Electronics Industry, Ltd., Tokyo, Japan.

# Application of Quantum Chemical Calculations in the Field of Electrical and Electronic Insulation Materials

Chairperson: Satoshi Matsumoto (Shibaura Institute of Technology)
Secretary: Hiroaki Miyake (Tokyo City University)
Yoitsu Sekiguchi (Sumitomo Electric Ind., Ltd.)
Assistant Secretary: Masamichi Kato (Yuka Industries)

## 1. Objective

In recent years, along with the development of quantum chemical calculation techniques, research to understand dielectric and insulating materials using quantum chemical calculation techniques has expanded, and new knowledge has been obtained regarding the movement of electrons in polymer materials from the molecular view point. Unlike the periodic crystal structures of metals or semiconductors, polymer materials used for electrical and electronic insulation have a hierarchical higher-order structure based on the arrangement of molecular chains in polymers. In addition, chemical structure that represents the arrangement of atoms show a very complicated appearance and hence we have been struggling to understand and to estimate properties of polymers because the molecular structure of polymers hinder to understand the correlation between behavior of electrons and dielectric phenomena as shown in Fig.1. The committee will carry out investigation of applications for quantum chemical calculation in the field of dielectric and insulating materials, evaluation of its effectiveness and future viewing of dielectric and insulating technology. We expect an application of quantum chemical calculation in practical fields and upbringing of young researchers and engineers in the field.

## 2. Main survey items

The committee plans to study application examples of quantum chemical calculations in the field of dielectric and insulating materials by dividing them into several themes. Main themes are as follows.

A: Arrangement of relationship between calculated parameters and dielectric properties
B: Issues in large-scale calculations and trends in their solutions
C: Research trends overseas

Based on the results of these surveys, we will make presentations at study groups and national convention symposiums, and plan to compile them in technical reports.

## 3. Former activities and expected effects

**3.1 Former activities** As the committee's activities so far, regarding the application of quantum chemical calculations in the field of insulating materials, the APIANS (Analysis for Polymeric Insulating materials using Advanced Numerical Simulations) at the ISEIM (International Symposium on Electrical Insulating Materials) organized by the Investigation Committee on Advanced Tailor- made Composite Insulation Materials, and the Technical Committee on Dielectrics and Electrical Insulation. Various dielectric and insulating materials have been taken up in the special sessions, and active discussions have been made there. As a response to these developments, the committee, which began full-scale activities in 2019, has given researchers a direct lecture on the research results in Japan among the application of quantum chemical calculation in the field of dielectric and insulating materials in order to share information within the committee.

**3.2 Expected results** Validity of Quantum chemical calculation to the field of dielectric and insulating materials will be summarized in the committee, investigating themes shown in section 2 and rearranging the obtained information systematically. To approach dielectric and insulating materials from the view point of molecular world is a new challenge, and we believe that a broad survey of research results and trends in the world will provide guidance on the application and future development of dielectric and insulation materials. We also hope that such efforts will attract interests of young researchers and engineers, and create a new trend and wave in research on dielectric and insulating materials.

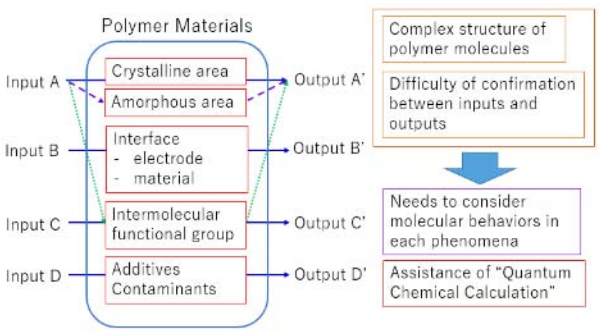


Fig. 1. Uniqueness of polymer materials and needs for quantum chemical calculation in the field of dielectric and insulating materials

# Electrical Insulation Reliability of Power Modules

Chairperson: Masahiro Kozako (Kyushu Institute of Technology)
Secretary: Naoya Kishi (Zeon Corporation)
Secretary: Yuji Hayase (Fuji Electric Co., Ltd.)

**Objective**

In recent years, while power electronics systems have attracted considerable attention as a key energy-saving medium, improvements in their electrical insulating materials are needed. The development of next-generation power modules must focus on aspects such as miniaturization, high density, high heat resistance, high withstand voltage, high efficiency, and high reliability. Additionally, the reliability of electrical insulation is of particular importance. Currently, established evaluation methods are applied; however, in the future, understanding electrical phenomenon with even more evolved electric fields is inevitable. Therefore, the "Investigation Committee on Electrical Insulation Reliability of Power Modules" (Power module Insulation and Evaluation technologies (PIE)) committee) was established in December 2018 under the ambit of the Technical Committee on Dielectric and Electrical Insulating Materials of the IEEJ. The objective of this committee is to discuss existing and newly developed evaluation methods and insulating materials and subsequently propose evaluation material technologies that are suitable for developing next-generation power modules.

**Activities**

The main fields of activity related to power modules are as follows. (1) Latest trends in development technology, (2) insulation performance reliability evaluation technology (current and new possibilities), (3) electrical insulating materials (current and new possibilities), and (4) insulation mechanism. The committee also takes an active interest in international activities related to setting standards for evaluating insulation reliability.

The investigation committee comprises 28 members from universities (9), laboratories (3), power-module makers (6), material makers (7), power-module users (1), experts (1), and agencies (1). The committee conducts four meetings at specific intervals during the course of a year.

**Term of Investigation Committee**

The term of this committee is three years from December 2018 to November 2021. The final technical report will be issued from IEE Japan in 2022.

Fig. 1. A group photo of a visit to the Osaka Research Institute of Industrial Science and Technology

# Information for Asset Management of Electric Power Apparatus Based on Insulation Deterioration (IAM)

Chairperson: Katsumi Uchida (Chubu Electric Power Co., Inc.)
Secretary: Kiyoka Suenaga (JFE Advantech Co, Ltd.)
Assistant Secretary: Yuta Makino (Central Research Institute for Electric Power Industries)

Many electric power apparatuses in Japan manufactured from the 1960s to the 1980s, and lots of them have been used. Therefore, it is required to maintain and replace them with minimizing maintenance costs and considering the fault risk. Asset management (AM) is one of the ways to achieve this.

Previous committees have surveyed various bibliographies and discussed strategic AM that can reduce and control maintenance costs by considering the deterioration and the fault risk on the electric power apparatus. Next step is application of AM widely in the user. The Investigation Committee of Information for Asset Management of Electric Power Apparatus Based on Insulation Deterioration (IAM) was established in 2019 to survey bibliographies and actual examples of applying AM to the apparatus and discuss what information is important for AM application. IAM is composed of 12 members from domestic and overseas universities, manufacturing and electric power companies, and research institute.

Main investigation topics are as follows.

(1) Understanding information for AM application to electric power apparatus.
(2) Investigation of accuracy of diagnostic techniques to electric power apparatus.
(3) Discussion appropriate AM.

It is assumed that there is appropriate information for AM on each electric power apparatus. It is also expected that continuous information collection is important. We will understand the information for AM application to apparatus by surveying bibliographies and actual examples. In addition, diagnostic techniques are applied to some apparatus in order to understand its condition. It is assumed that the diagnostic accuracy is improved with comparison of the diagnosis result and the condition of removed apparatus. We will discuss how AM is related to diagnosis techniques by investigating the diagnostic accuracy. Finally, we will show how appropriate AM can be conducted.

By these investigation and discussion, information for AM application can be collected widely and continuously, and AM will be conducted in earnest. As the result, it is expected that maintenance costs can be reduced and controlled.

IAM has be held two times. We have investigated current status of information collection, diagnostic techniques and actual AM application. We confirmed that the survey of removed apparatus is important to understand deterioration and improve the diagnostic accuracy. Finally, we will hold the Symposium about AM on the annual meeting of I.E.E. Japan in 2021.

# Cooperative Research Committee on EINA Magazine Publication


Chairperson: Masayuki Nagao (Toyohashi Univ. of Technology)
Editor: Yoshiyuki Inoue (Toshiba Mitsubishi-Electric Industrial Systems Corporation)
Secretary: Masahiro Kozako (Kyushu Institute of Technology)
Secretary: Norikazu Fuse (Central Research Institute for Electric Power Industries)


**Objective**

The EINA Committee, which publishes the magazine “Electrical Insulation News in Asia”, aims to construct an international interactive channel for information exchange in the field of dielectrics and electrical insulation in the Pan-Pacific region. We are currently providing an annual issue of EINA magazine as well as making it available in the EINA Website.

**Chronicle of the Committee**

The Committee, with official title “the Cooperative Research Committee (CRC) of Asian Interlink of Dielectrics and Electrical Insulation”, was established by the late Professor M. Ieda in 1991. It played the leading role in initiation of this kind of work from Jan. 1991 to Dec. 1992. The committee reviewed the present status of scientific and technological cooperation in the field of dielectrics and electrical insulation in Asian countries and sought appropriate ways to promote informative interaction among the countries.

On the basis of the former activities, the CRC of “Electrical Insulation News in Asia” was founded by Professor H. Yamashita, Keio University in April 1994. One of its key activities was publication of the “Electrical Insulation News in Asia (EINA)” from No. 1 (Sept. 1994) up to No. 6 (Sept. 1999). This dedication contributed greatly to mutual understanding of electrical insulation activities in Asia.

Professor T. Tanaka of Waseda University took over this role in 2000, and expanded its role to accommodate information flow among Asian countries and to facilitate more timely flow of information through its Website. Three international technical exchange sessions were held in ICPADM 2000 (Xian Jiatong University, China), ISEIM 2005 (the Kitakyushu Intern’l Conf. Center, Japan) and ISEIM 2008 (Yokkaichi Cultural Hall, Japan) for promotion of information exchange and human contact among researchers of Pan-Pacific region in the field.

Professor M. Nagao of Toyohashi University of Technology) has chaired the committee since 2009. In the past the EINA magazine had been published by both sending by mail as well as through the website. In 2015 we sent out questionnaires on the way of the publication to readers. As the collected answers coincided with our intention, we decided to publish the magazine mainly in electronic PDF form through the website. However, we still continue to send printed booklets for those requesting and authors of articles in the issue. They are also distributed at related international conferences.

**Activities**

Our present committee consists of 8 key members listed in the right of this page and 18 other members. One annual general meeting and also secretariat meetings as needed are held to plan, carry out and review its activities. The EINA Magazine No. 25 was published in electronic form in December 2018 as shown in Fig.1 and was also uploaded to our website **http://eina.ws/**. Please visit the website. It may be of interest to you.

The Committee has been financially supported by IEEJ as well as by voluntary contributions from Japanese enterprises.

**Term of Investigation Committee**

The term of this committee is two years from September 2019 to August 2021. Thereafter a succeeding committee will be set up every two years.

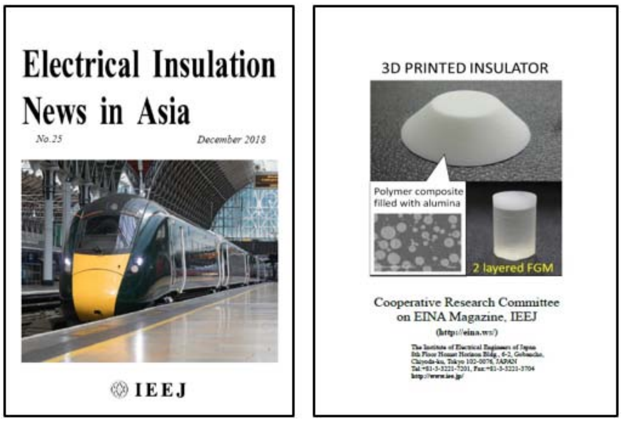


Fig. 1. Front and rear covers of the latest issue of EINA magazine (EINA No.25, Dec. 2018)

Chairperson
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Toyohashi Univ. of Tech.

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Task Force
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National Inst. of Tech., Numazu

Task Force
A.Prof. H.Miyake
Tokyo City Univ.

# Activities of Other Committees Related to Electrical Insulating Materials

## IEC TC 112 Japanese National Committee

Chairperson: Hiroya Homma (CRIEPI*)
Vice-chairperson: Hisaaki Kudoh (The University of Tokyo)
Secretary: Hiroaki Uehara (Kanto Gakuin University)
Associate Secretary: Kenichi Yamazaki (Toshiba)
*CRIEPI: Central Research Institute of Electric Power Industry

IEC TC 112 deals with many international standards and specifications on "Evaluation and qualification of electrical insulating materials and systems". TC 112 was established in 2005 based on the part of TC 15 and TC 98. TC 98 and the related sub-group in TC 15 were disbanded to the establishment of new technical committee. TC 112 Japanese National Committee (JNC) was also established in 2005 to correspond to the activities in TC 112 and to concern with related Japanese standards.

TC 112 involves eight working groups (WG) and dealing with more than 50 standards. TC 112 JNC includes eight corresponding WGs and one more WG that relates with the Japanese Industrial Standards (JIS). The WG structure of TC 112 JNC is shown in Table 1. Three conveners of the eight international WGs are now taken by Japanese, WG2 and WG7: Dr. Hisaaki Kudoh, and WG8: Prof. Yasuhiro Tanaka. In this reason, Japanese members are very active in this standard region.

Table 1. WG structure of TC 112 JNC

| WG | Subject |
|---|---|
| 1 | Thermal endurance |
| 2 | Radiation |
| 3 | Electrical strength |
| 4 | Dielectric/resistive properties |
| 5 | Tracking |
| 6 | General methods of evaluation of electrical insulation |
| 7 | Statistics |
| 8 | Various material properties |
| 9 | Japanese Industrial Standards (JNC only) |

From October 14 to 18, 2019, IEC TC 112 Meeting was held in Shanghai, China, and meetings of WGs were held during the weeks. 4 experts from JNC participated in the TC 112 meetings including the Plenary, Advisory group and WGs meetings.

The next meetings of TC112 will be held in Stockholm, Sweden from September 28 to October 9, 2020.

Recent standards discussed in TC112 are partly listed:

WG1: IEC 60216-3: Electrical insulating materials - Thermal endurance properties - Part 3: Instructions for calculating thermal endurance characteristics.

IEC 60216-5: Electrical insulating materials - Thermal endurance properties - Part 5: Determination of relative thermal endurance index (RTE) of an insulating material.

IEC 60216-6: Electrical insulating materials - Thermal endurance properties - Part 6: Determination of thermal endurance indices (TI and RTE) of an insulating material using the fixed time frame method.

WG2: IEC/TR 61244-4: Determination of long-term radiation ageing in polymers - Part 4: Effects of radiation under non-ambient environments; Effect of temperature.

IEC 60544-5: Electrical insulating materials - Determination of the effects of ionizing radiation - Part 5: Procedures for assessment of ageing in service.

WG3: IEC TS 61934: Electrical insulating materials and systems - Electrical measurement of partial discharges (PD) under short rise time and repetitive voltage impulses.

The plenary approved the issue of the NWIP of IEC 61251-2 as well as Mingli Fu as the PL.

WG4: IEC 62631-3-1: Dielectric and resistive properties of solid insulating materials Part 3-1: Determination of resistive properties (DC methods) – Volume resistance and volume resistivity, general method (PL: Jun Haruhara).

IEC 62631-3-2: Dielectric and resistive properties of solid insulating materials Part 3-2: Determination of resistive properties (DC methods) – Volume resistance and volume resistivity, Surface resistance and surface resistivity (PL: Jun Haruhara).

An interim WG4 meeting to discuss several documents is planned in Japan for March 2020.

WG5: IEC 60112: Method for the determination of the proof and the comparative tracking indices of solid insulating materials.

IEC 60587: Electrical insulating materials used under severe ambient conditions - Test methods for evaluating resistance to tracking and erosion.

IEC/TR 62039: Selection guide for polymeric materials for outdoor use under HV stress.

WG6: IEC 61857-32: Electrical insulation systems - Procedures for thermal evaluation - Multifactor evaluation by diagnostic procedures.

IEC 61857-33: Electrical insulation systems - Procedures for thermal evaluation - Multifactor evaluation with increased factors at elevated temperature.

IEC 61857-41: Electrical insulation systems - Procedures for thermal evaluation - Part 41: Specific requirements for electrical insulation systems for use in dry-type high-voltage transformers with operating voltages of 1kV and above.

IEC/TR 61858-3: Electrical insulation systems - Thermal evaluation of modifications to an established electrical insulation system (EIS) - Part 3: Clarification of major and minor components.

Future IEC 61857: Electrical insulation systems - Procedures for thermal evaluation - Part XX: Specific requirements for evaluation of an electrical insulation system (EIS) used for road transportation applications

WG7: IEC/TR 60493-2: Guide for the statistical analysis of aging test data - Part 2: Validation of procedures for statistical analysis of censored normally distributed data.

The WG7 agreed that the scope as displayed on the IEC website is changed

WG8: IEC/TS 62836: Measurement of internal electric field in insulating materials - Pressure wave propagation method.

IEC TS 62758: Calibration of space charge measuring equipment based on the pulsed electroacoustic (PEA) measurement principle.

Photo of the Plenary Meeting of IEC TC 112.

NC participants at the Plenary Meeting.

# CIGRE SC D1 Japanese National Committee ( Materials and Emerging Test Techniques )

Chairperson: Tsuguhiro Takahashi (CRIEPI)
Secretary: Toshiaki Rokunohe (Hitachi, Ltd.)
Secretary: Akiko Kumada (The University of Tokyo)

CIGRE (International Council on Large Electric Systems) has 16 Study Committees (SC) belonging to each of following 4 categories: A (Equipment), B (Subsystems), C (Systems) and D (Horizontal). Among them, our SC D1 has a horizontal character and contributes to other CIGRE SC's. The activity of CIGRE SC’s is principally research oriented one.

SC D1 has now following 5 Advisory Groups (AG): Strategic and Customer AG, Tutorial AG, AG D1.01 (Insulating Liquids), AG D1.02 (High Voltage Testing and Diagnostic) and AG D1.03 (Insulating Solids). SC D1 consists of these AGs and following 24 WGs.

**[Liquids]** JWG D1/A2.47(New frontiers of DGA interpretation for transformers and their accessories), WG D1.65(Mechanical properties of insulating materials and insulated conductors for oil immersed power transformers), JWG A2/D1.46(Field experience with transformer solid insulating ageing markers), JWG A2/D1.51(Improvement to partial discharge measurements for factory and site acceptance tests of power transformers), WG D1.68(Natural and synthetic esters-Evaluation of performance under fire and the impact on environment), WG D1.70 (Functional Properties of modern insulating liquids for transformers and similar electrical equipment), WG D1.74(PD measurement on insulation systems stressed from HV power electronics)

**[Testing & Diagnosis]** WG D1.50(Atmospheric and altitude correction factors for air gaps and clean insulators), WG D1.54(Basic principles and practical methods to measure the AC and DC resistance of conductors of power cables and overhead lines), WG D1.60(Traceable measurement techniques for very fast transients), WG D1.61(Optical corona detection and measurement), WG D1.63(Partial discharge detection under DC voltage stress), WG D1.69(Guidelines for test techniques of High Temperature Superconducting (HTS) systems),

**[Gases]** JWG D1/B3.57(Dielectric testing of gas-insulated HVDC systems), WG D1.66 (Requirements for partial discharge monitoring systems for gas insulated systems), WG D1.67(Dielectric performance of new non-SF6 gases and gas mixtures for gas-insulated systems)

**[Solids]** JWG D1/B1.49(Harmonized test for the measurement of residual inflammable gases), WG D1.56(Field grading in electrical insulation systems), WG D1.58(Evaluation of dynamic hydrophobicity of polymer insulating materials under AC and DC voltage stress), WG D1.59(Methods for dielectric characterization of polymeric insulating materials for outdoor applications), WG D1.62(Surface degradation of polymeric insulating materials for outdoor applications), WG D1.64(Electrical insulation systems at cryogenic temperatures), WG D1.72(Test of material resistance against surface arcing under DC), WG D1.73(Nanostructured dielectrics: Multi-functionality at the service of the electric power industry)

The preferential subjects for the 2020 SC D1 Paris group meeting are PS1: Testing, Monitoring and Diagnostics / Experience and insight from monitoring systems, Reliability of test equipment and systems for testing, monitoring, and diagnostics, Data handling, analytics, and advanced condition assessment, PS2: Functional Properties and Degradation of Insulation Materials / New stresses, e.g. power electronics, load cycling, higher temperatures, and compact applications, Materials with lower environmental footprint, during production, operation, and disposal, Characterisation methods for validating functional properties, PS3: Insulation Systems of Advanced Components / Materials under high stresses, e.g. field stress, flux, electric current, and frequency, Experience and requirements for new test procedures and standards, Development of new materials, e.g. 3D printing; lamination; casting; and additive or subtractive manufacturing.

From Japan, following 1 paper has been accepted in abstract reviewing: “3D Printed Solid Insulator: Possibilities and Challenges” by M. Kurimoto, Y. Suzuoki and K. Uchida (PS3).

The next meeting is scheduled to be held in Paris, France on August 23-28, 2020, The Japanese National SC D1 will hold 2 or 3 meetings for its preparation.

# RESEARCH ACTIVITIES AND TECHNICAL EXCHANGES IN ASIAN COUNTRIES

# Conference Records

## 2nd International Conference on Electrical Materials and Power Equipment (ICEMPE 2019)

The 2nd IEEE International Conference on Electrical Materials and Power Equipment (ICEMPE 2019), was held in Guangzhou, China, from April 7 to 10, 2019. The conference was co-sponsored by the Engineering Dielectrics Committee of China Electrotechnical Society (CES) and the IEEE Dielectrics and Electrical Insulation Society (DEIS), and organized and technically supported by South China University of Technology (SCUT). Shengtao Li was the general conference chair. Yanpeng Hao was the executive chair of ICEMPE 2019. ICEPME is a promotion of the Chinese National Conference on Engineering Dielectrics (NCED), which was founded in 1983 as a biennial forum.

More than 220 participants from 13 countries, with 32 participants from outside China, attended the conference. A total of 166 papers were carefully selected by 52 academic and industrial reviewers from 260 submissions, after the review of 385 abstracts. Of these, 1 Chen Jidan Memorial Lecture, and 13 invited papers, and 15 oral papers are presented in oral sessions, and 137 papers are presented in poster sessions.

The welcome reception on Sunday evening was held at the Soluxe Hotel Guangzhou, where Yanpeng Hao, the executive chair, and Lin Yang, the secretary of the conference, welcomed the participants.

The opening ceremony was held on Monday morning and presided by Yanpeng Hao. Shengtao Li welcomed the attendees. He was followed by ZhihuaWang, deputy secretary general of CES, Reimund Gerhard, president of IEEE DEIS, and Davide Fabiani, meetings chair of IEEE DEIS. Finally, Yechun Wu, vice president of SCUT, presented the welcome address.


*Group Photo of Conference attendees.*

After the opening ceremony, the Chen Jidan Award was given to Tatsuo Takada, Emeritus Professor of Tokyo City University, Japan. He gave the Chen Jidan Memorial Lecture with the title of “Studies on Space Charge Accumulation Properties in Dielectric Materials- Measurement Methods and Quantum Chemical Calculation Analysis”.

After the Chen Jidan Memorial Lecture, oral and poster sessions were held from Monday to Wednesday, which covered six topics including New Issues & New Theories, Performance of Insulating Materials, Nanodielectrics and New Dielectrics, Power Cable, Transformer and External Insulation, Transformer and External Insulation, GIS and Electric Apparatus. In addition, there is a China Session in the last, with the aim of improving the communication skills of engineers in China.

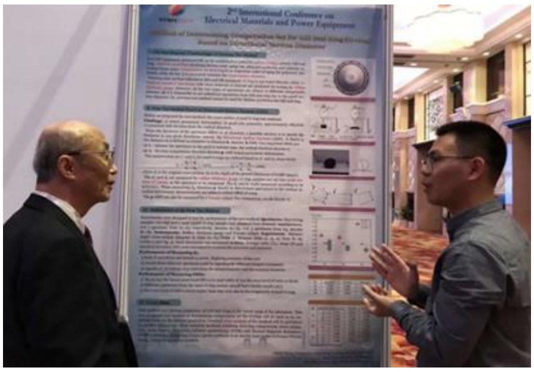
*Shengtao Li and George Chen, Chair of the International Advisory Board presented Tatsuo Takada with Chen Jidan Award.*

*The conference venue.*


*Invited talk by Zhongdong Wang.*

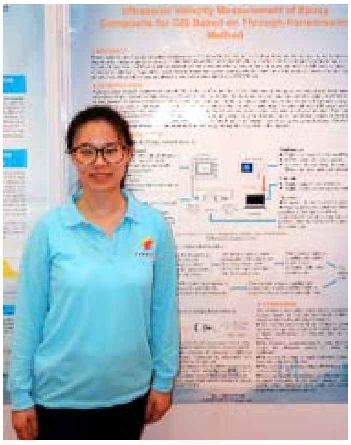

*Shengtao Li and Yasuhiro Tanaka presented Xuzhu Dong with an invited talk certificate.*

*Zhimin Zhang discussed with Y. Tanaka*



*Yong answered questions from Tatsuo Takada*

*Gilber Teyssèdre asked questions during an oral session.*

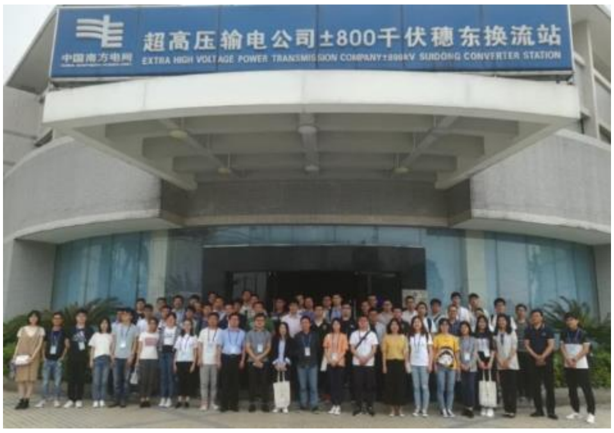


*Yiao Zouzhou from SCUT at her poster.*

*At a poster session*

*International Advisory Board Meeting: (left to right)Lin Yang, Mingli Fu, Juneho Lee, Lisheng Zhong, Gilbert Teyssedre, Yewen Zhang, Yoshimichi Ohki, Rongsheng Liu, George Chen, Yanpeng Hao, Shengtao Li, Davide Fabiani, Suwarno Harjo,and Feipeng Wang.*

On Tuesday afternoon, a technical visit to ±800kV Suidong Converter Station took place. ±800kV Suidong Converter Station is the receiving-side of the Yunnan-Guangdong Ultra High Voltage DC Project, which is the first Ultra High Voltage power transmission project in the world. After the visit, there were a banquet, where Yanpeng Hao made a thank you speech.




*One of two groups of Technical Tour to Suidong Converter Station.*

*Reimund Gerhard and Davide Fabiani presented Yanpeng Hao with a certificate acknowledging her contribution as Executive Chair.*

On Wednesday afternoon, Excellent Student Paper Awards were granted to four student presenters demonstrating excellent research works. Then, the closing ceremony was held by Shengtao Li. It was announced that the conference will be held in Chongqing 2021 and Shanghai 2023. In the end, a brief introduction for the 2021 conference to take place in Chongqing, China, was taked by Feipeng Wang. After the closing ceremony, a number of conference attendees enjoyed the night view of Guangzhou on Pearl River Cruise.

I would like to thank all the members of the local organizing committee, including the PhD and master students from SCUT, for their valuable contribution to the organization and success of ICEMPE 2019.


*Shengtao Li, George Chen and Yewen Zhang presented the certificate to four students for excellent student paper.*


*Volunteers from SCUT.*

**Yanpeng Hao**
South China University of Technology
Executive Chair of ICEMPE 2019

# The 2nd International Conference on High Voltage Engineering and Power System 2019 (ICHVEPS 2019)

The 2[nd] International Conference on High Voltage Engineering and Power System 2019 (ICHVEPS 2019) was held in Inna Grand Bali Beach Hotel Sanur Bali, Indonesia on 1-3 October 2019. The ICHVEPS 2019 is a biannual conference organized by the School of Electrical Engineering and Informatics, Institut Teknologi Bandung (ITB), Indonesia and sponsored by IEEE Indonesia Section, IEEE Power and Energy Society Indonesia Chapter, IEEE Indonesia Student Branch and Indonesian Electric Power Company PT. PLN (Persero).

The conference is designed to be an international forum for exchange ideas, discussion and dissemination of research results and recent technologies in the field of High Voltage Engineering and Power System from power utilities, universities, research institutes as well as industries. 136 papers from 14 countries (Indonesia, Germany, Malaysia, India, Australia, South Korea, China, Japan, Taiwan, Vietnam, Canada, Italy, USA, and Morocco were presented.

The papers deal with the following aspects of high voltage engineering and power systems:

1. High voltage generation, measurement, and Instrumentation
2. High voltage insulation system
3. Condition monitoring and diagnosis for power equipments and power systems
4. Dielectric materials and their aging mechanisms
5. New and environmental friendly materials for high voltage application
6. Degradation assessment for power equipment
7. Lightning and Transient Phenomena
8. Outdoor Insulation
9. High voltage insulation for UHV AC and HVDC system
10. High Voltage Apparatus: Reliability and Maintenance
11. Grounding system
12. Power quality
13. Electromagnetic compatibility
14. Smart grid technology power system
15. Power system stability
16. FACTS
17. Renewable energy and microgrid

The papers were presented in 4 plenary sessions and 16 parallel sessions. On October 2[nd] evening there was a gala dinner organized at Sanur Beach. Indonesian foods were served along with live Bali dances with gamelan orchestra performances. During the gala dinner, 3 students were selected to be The Best student papers recipients. They are 2 students from Germany and 1 student from Indonesia.

On the first day, October 1st, the workshop on High Voltage Engineering and Power System 2019 was held with 90 participants from 8 countries. Both workshop and conferences were very successful. The 3[rd] ICHVEPS will be held in 2021.

Invited plenary speakers:

Prof. Masayuki Hikita, Kyushu Institute of Technology, Japan

Ir. Didik, PT PLN , Indonesia

Prof. Guan-Jun Zhang, Xian Jiaotong University, China

Dr. Nanang Hariyanto, Institut Teknologi Bandung, Indonesia

Prof. Ahmed Abu Siada, Curtin University Australia

Evy Hariyadi, S.T., M.Sc., PT PLN, Indonesia

Prof. Andrea Cavallini, Bologna University, Italy

Prof. Zulkurnain Abdul-Malek, Universiti Teknologi Malaysia

Franco D'Alessandro,Phd, LPI, Australia

Table 1.
Paper number from each country

| Country | Count of Country |
|---|---|
| Indonesia | 111 |
| India | 4 |
| Germany | 3 |
| Taiwan | 3 |
| Vietnam | 2 |
| China | 2 |
| Australia | 1 |
| Canada | 1 |
| Italy | 1 |
| Japan | 1 |
| Malaysia | 1 |
| Morocco | 1 |
| South Korea | 1 |
| United States | 1 |
| **Total** | **133** |

List of participants

| Country | Count of Country |
|---|---|
| Australia | 2 |
| Canada | 2 |
| China | 2 |
| France | 1 |
| Germany | 4 |
| India | 5 |
| Indonesia | 176 |
| Italy | 2 |

| | |
|---|---|
| Japan | 1 |
| Malaysia | 2 |
| Morocco | 1 |
| South Korea | 1 |
| Taiwan | 3 |
| United States | 1 |
| Vietnam | 2 |
| **Grand Total** | **204** |

Photograph of attendances of ICHVEPS 2019 at Pandawa Stage of Sanur Beach

Photograph after Workshop on October 1st at Bali Hai Hall 10th floor Grand Bali Beach Hotel


Gong for formal opening by General Chairman, Prof. Suwarno

After plenary session on 2nd October in Great Hall Grand Bali Beach Hotel

Prof. HIKITA delivering a plenary presentation


Prof. Zhang (China), Prof. Cavallini (Italy), Dr. Jeff Butler (US) and Prof. Siada (Australia) at Gala dinner

Prof. Cavallini delivering a lecture during Workshop


GALA DINNER


GALA DINNER at Pandawa Stage, Sanur Beach


Bali Dance with live Gamelan at GALA DINNER

**Prof. Dr. Suwarno**
School of Electrical Engineering and Informatics
Institut Teknologi Bandung
Bandung, Indonesia 40132
suwarno@ieee.org

# 2019 5th International Conference on Electrical Power Equipment – Switching Technology (ICEPE-ST 2019)

The 2019 5th International Conference on Electric Power Equipment – Switching Technology (ICEPE-ST 2019) was held from October 13 to 16, 2019 at Kitakyushu International Conference Center, Kitakyushu, Japan. ICEPE-ST 2019 was hosted by the Japanese Local Organizing Committee which consists of the professionals from universities, research institutes, and manufactures listed in Table 1.

The ICEPE-ST is held in China, Republic of Korea, or Japan every two years with topics encompassing the science, technology and application of electric power equipment, focusing on switching technology. After four successful conferences held in Xi'an, China 2011, Matsue, Japan 2013, Busan, Republic of Korea 2015, and Xi'an, China 2017, the 5$^{th}$ conference was held again in Japan in 2019.

We set the slogan of this conference as "Frontiers of switching technology for a future sustainable power system". Based on this slogan, we accepted 170 papers, covering the scientific topics in Table 2. The number of papers was the largest, except the last conference held in China, and the number of papers seems be gradually increasing (Fig. 1).

**Table 1. Member of Local Organizing Committee**

| Title | Name | Affiliation |
|---|---|---|
| Chair | Eiji Kaneko | University of the Ryukyus |
| Vice chair | Yasunobu Yokomizu | Nagoya University |
| Secretary | Hajime Urai | Hitachi, Ltd. |
| Member | Tadashi Koshizuka | Tokyo Denki University |
| | Masahiro Kozako | Kyushu Institute of Technology |
| | Mikimasa Iwata | Central Research Institute of Electric Power Industry |
| | Motohiro Sato | Mitsubishi Electric Corporation |
| | Kunihiko Tomiyasu | Hitachi, Ltd. |
| | Gaku Asanuma | Fuji Electric Co., Ltd. |
| | Masayuki Hikita | Kyushu Institute of Technology |
| | Takeshi Shinkai | Tokyo University of Technology |
| | Yuki Inada | Saitama University |
| | Hiroyuki Iwabuchi | Yokohama National University |
| | Hiroki Kojima | Nagoya University |
| | Yasushi Yamano | Saitama University |
| | Hitoshi Saito | Meidensha Corporation |
| | Yasunori Tanaka | Kanazawa University |
| | Kazuto Yukita | Aichi Institute of Technology |
| | Shinya Ohtsuka | Kyushu Institute of Technology |
| | Yoshimitsu Niwa | Toshiba Infrastructure Systems & Solutions Corporation |
| | Naoki Asari | Toshiba Infrastructure Systems & Solutions Corporation |
| | Shigeyuki Tsukao | TEPCO Power Grid, Incorporated |
| | Kennichi Kitajima | TAKAOKA TOKO CO.,LTD. |
| | Keishi Nishimura | Togami Electric Mfg. Co., Ltd. |
| | Yoshihisa Ogawa | TAKAOKA TOKO CO.,LTD. |
| | Naoki Osawa | Kanazawa Institute of Technology |
| Audit | Akiko Kumada | The University of Tokyo |

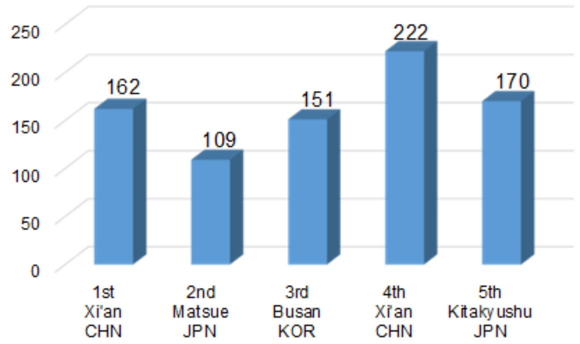



**Fig. 1. Number of papers submitted in past conferences and this conference**

During the conference, 214 participants from 11 countries attended (Table 3), who were from universities, research institutions, utilities, and manufactures, shared their experiences and discussed the latest developments and future challenges.

Due to a strong typhoon hitting Japan the day before the conference, some flights were suspended, and 17 participants could not attend the conference. However,

**Table 2. Number of papers by category (170 in total)**

| Category | | # |
|---|---|---|
| A | Switching phenomena in $SF_6$ gas | 13 |
| B | $SF_6$ alternative gases for switching applications | 13 |
| C | Switching phenomena in vacuum | 22 |
| D | Switching phenomena in air | 7 |
| E | DC switching technology | 25 |
| F | Semi-conductor switching technology | 2 |
| G | Fault current limiting technology | 10 |
| H | Fundamental physics and electrical insulation | 23 |
| I | Digital design and simulation in switchgear | 10 |
| J | Testing and measurement in switchgear | 16 |
| K | Operating mechanism in switchgear | 9 |
| L | Electrical contacts | 5 |
| M | Digital and IoT application in switchgear | 2 |
| N | Others | 13 |

**Table 3. Number of papers and participants by country**

(a) Papers (170 in total)

| Country | # |
|---|---|
| China | 116 |
| Japan | 31 |
| Republic of Korea | 12 |
| Germany | 3 |
| Norway | 3 |
| Switzerland | 1 |
| The Netherlands | 1 |
| Iran | 1 |
| Bosnia and Herzegovina | 1 |
| USA | 1 |

(b) Participants (214 in total)

| Country | # |
|---|---|
| China | 108 |
| Japan | 69 |
| Republic of Korea | 22 |
| Republic of Indonesia | 4 |
| Norway | 3 |
| The Netherlands | 2 |
| Bangladesh | 1 |
| India | 1 |
| Spain | 1 |
| Sweden | 1 |
| Switzerland | 1 |
| United Kingdom | 1 |

**Fig. 2. Group photo after plenary lectures in Main Hall**

many participants gathered from the opening ceremony on October 14. The group photo taken after the plenary lectures is shown in Fig. 2.

The conference started with an opening speech from Prof. Satoru Yanabu of Xi'an Jiaotong University, who is the chair of the International Scientific Committee, and welcome speeches from Prof. Eiji Kaneko of University of the Ryukyus, who is the chair of the Local Organizing Committee of this conference, and Prof. Yasunobu Mitani, vice president of Kyushu Institute of Technology. Professor Mingzhe Rong of Xi'an Jiaotong University from China and Dr. Young-Geun Kim of LSIS Co., Ltd. from Republic of Korea, addressed their representative greetings (Fig. 3).

The four plenary lectures in Table 4 were delivered at the Main Hall (Fig. 4). The topics of the lectures covered past evolution, recent developments, and future technology: (1) general innovation of switching technologies by Dr. Hiroki Ito, (2) recent computational progress for switching equipment by Prof. Mingzhe Rong, (3) environmental challenges for $SF_6$-free policy by Dr. Jaeseop Ryu, and (4) history and future prospective of vacuum switching technology by Prof. Leslie T. Falkingham.

A special session was organized to present the developments in high-voltage DC circuit breaker technology by Dr. René Smeets after his invited lecture titled "HVDC circuit breaker technology" (Fig. 5). The five panelists listed in Table 5 gathered and discussed recent developments in HVDC circuit breakers, testing, and field demonstrations (Fig. 6).


**Fig. 3. Opening ceremony**

**Fig. 4. Plenary lecture**

Regular oral presentations were held in five sessions in parallel from the afternoon of the 14th to morning of the 16th. There were heated discussions during each session (Fig. 7). A poster session was held on the afternoon of the last day (Fig. 8). The poster session was conducted for the young researchers who applied for the Wang Jimei Young Investigator Award as the selection process of the award. The applicants made poster presentations after their oral presentations. International Scientific Committee members conducted interviews for the award candidates. The young researchers also engaged in heated discussions during the poster session.

The Local Organizing Committee arranged some social events. At the beginning, a welcome reception party took place at the conference venue from 5 PM after registration. Although some Japanese participants were delayed and absent due to the typhoon, many

**Table 4. Plenary and invited lectures**

| Speaker | Affiliation | Title |
|---|---|---|
| Hiroki Ito (Plenary) | Mitsubishi Electric Corporation | Innovation of switching technologies in power systems |
| Mingzhe Rong (Plenary) | Xi'an Jiaotong University | Computation for Electrical Switching Equipment |
| Jaeseop Ryu (Plenary) | LSIS Co., Ltd., | $SF_6$ free power equipment development for environmentally friendly policy |
| Leslie T. Falkingham (Plenary) | Vacuum Interrupters Limited | Vacuum Switchgear; Past, Present, and Future |
| René P. P. Smeets (Invited) | KEMA Laboratories of DNV GL | HVDC circuit breaker technology |
| Masayuki Hikita (Invited) | Kyushu Institute of Technology | Recent Insulation and diagnostic technology in power apparatus and power electronics |

**Table 5. Panelist of DCCB special session moderated by Dr. René Smeets**

| Panelist | Affiliation |
|---|---|
| Nadew Adisu Belda | DNV GL KEMA Laboratories |
| Yi Wu | Xi'an Jiantong University |
| Takashi Inagaki | Mitsubishi Electric Corporation |
| Wei Gu | Sieyuan Electric Co., Ltd. |
| Lv Wei | NR Electric Co., Ltd. |

Fig. 5. Invited lecture


Fig. 6. DCCB panel discussion

Fig. 7. Q&A at oral session

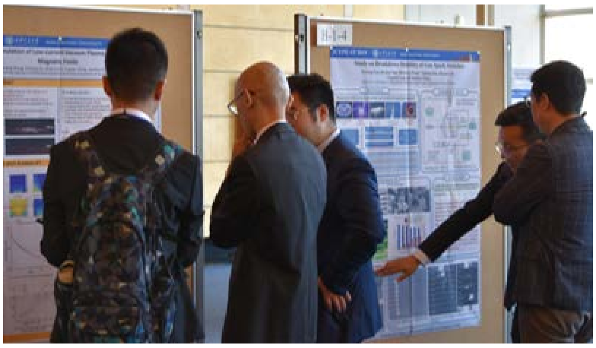


Fig. 8. Poster session for Young Investigator Award

Fig. 9. Welcome reception

Fig. 10. International Scientific Committee dinner for plenary and invited lectures

Fig. 11. Welcome drinks in Japanese garden

participants from abroad enjoyed skewer-style cuisine with Japanese sake (Fig. 9).

The secretaries of the Local Organizing Committee hosted a special dinner party for the members of the International Organizing Committee and invited lecturers and panelists at the former Matsumoto residence (Fig. 10); a national cultural asset and Japanese-style house attached to the main western-style house originally built in 1911 for Matsumoto Kenjiro who founded Kyushu Institute of Technology.

The Local Organizing Committee invited all the conference participants to a banquet at ART HOTEL Kokura New Tagawa, following welcome drinks served in the Japanese garden there (Fig. 11). The party started with Kagami Biraki (Fig. 12), and a drum performance "Kokura Gion Daiko" was presented in the middle of the party (Fig. 13). Socialization among the researchers was encouraged using a sake tasting event.

The Local Organizing Committee arranged three courses of excursions. The first group went to YASKAWA Innovation Center (Fig. 14) including robotics factory tours of YASKAWA Electric Corporation. Other city tour groups went to Kokura castle or Moji port (Fig. 15).

In the conference, Wang Jimei Best Paper Award and Best Young Investigator Awards were conferred. The award winners are listed in Table 5. The Wang Jimei Award was established in honor of late Prof. Wang Jimei. The Best Paper Award was given to the Dr. Hui Ma of Xi'an Jiaotong University (Fig. 16), who presented the paper in the previous ICEPE-ST and the extended paper was published in IEEE Transactions on Plasma Science. Four award-winners of the Wang Jimei Best Young Award out of 51 candidates received their certifications at the closing ceremony from Prof. René Smeets, Chair of the Scientific Award Committee (Fig. 17).

**Fig. 12. Ceremony of Japanese sake barrel opening at banquet**

**Fig. 13. Drum performance of Kokura Gion Daiko at banquet**

**Fig. 14. Visit to YASKAWA Innovation Center**

**Fig. 15. Visit to Moji port**

ICEPE-ST 2019 concluded on a successful note by Prof. Yokomizu. Then, the next ICEPE-ST was announced to be held in Seoul in 2021 by Dr. J. Ryu of the Korean Local Organizing Committee.

ICEPE-ST 2019 was sponsored by Nagoya University, City of Kitakyushu, and Kitakyushu Convention & Visitors Association and supported by Kyushu Institute of Technology, The Institute of Electrical Engineering of Japan (IEEJ), Technical Committee on Switching and Protecting Engineering of IEEJ, and Kyushu branch of IEEJ. The Local Organizing Committee acknowledged financial support

**Table 5. Wang Jimei Awards**

(a) Best Paper Award

| Winner | Affiliation | Title |
|---|---|---|
| Hui Ma | Xi'an Jiaotong University | Experimental Investigation of the Anode Current Radial Distribution in Vacuum Arcs |

(b) Best Young Investigator Award

| Winner | Affiliation | Title |
|---|---|---|
| Fuminori Kondo | Nagoya University | Suppression of Conditioning Effect in Vacuum by Micro- Protrusions from Anode |
| Wenlong Yan | Xi'an Jiaotong University | Study on Breakdown Stability of Gas Spark Switches |
| Nadew Adisu Belda | Technische Universitat Darmstadt | High-Frequency Current Interruption of Vacuum Interrupters in an Experimental DC Circuit Breaker |
| Tatsuya Ishii | Nagoya University | Critical Electric-Field Strength of High-Temperature $SF_6$ Mixture Gas with Ablated PTFE/BN Vapor at Temperatures of 300 – 4000 K |

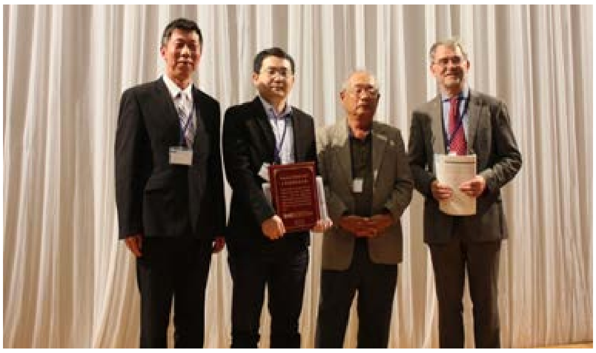


**Fig. 16. Winner of Wang Jimei Best Paper Award**

**Fig. 17. Winners of Wang Jimei Best Young Investigator Award**

from Kitakyushu Convention & Visitors Association. The conference was also technically co-sponsored by IEEE Power and Energy Society. All accepted papers will be published on IEEE Xplore.

Finally, we would like to sincerely express our gratitude to all the participants, members of the organizing committee, and staff who worked part-time. We also appreciate the volunteer reviewers. We hope that all the participants will meet again at the next ICEPE-ST in Seoul, Republic of Korea in 2021.

**Dr. Hajime Urai**

Hitachi, Ltd. R&D Group, Center for Technology Innovation – Energy

Omika-cho 7-1-1, Hitachi-shi, Ibaraki, 319-1292

# 4th International Conference on Condition Assessment Techniques in Electrical Systems (CATCON 2019)
## IIT Madras, Chennai, India

The 4th International Conference on Condition Assessment Techniques in Electrical Systems has been hosted by Indian Institute of Technology Madras during 21-23rd November 2019. The conference was previously hosted by Jadavpur University in 2013, CPRI Bangalore in 2015 and by IIT Ropar in 2017.

The conference was organised with main focus on following topics:

- Condition assessment of electrical equipment
- Condition assessment of intricate electrical systems
- Advanced Signal Processing Tools & Computational Algorithms in Condition Assessmentpt

We received 121 manuscripts for review and only 60 papers were invited for oral presentation. The young research scholars were provided an opportunity for oral presentation, to motivate them.

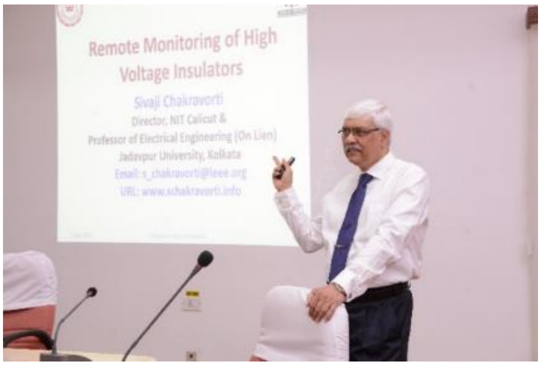
On day 1, Prof. Sivaji Chakravorthi invited all the participants of the conference and the sessions was started. The experts gave presentation on the first day. The details of which are provided in Table-1.

The local organising committee members and Prof. Sivaji Chakravorthi met to decide the next venue of the conference and unanimously decided that National Institute of Technology, Calicut India will be hosting it. Dr. T.K. Sindhu will be the convenor of the conference.

Day-2 about 30 papers were presented in four sessions. The sessions were started by morning 8.30 AM and was over by 6 pm followed with 11 posters were presented by the IIT Madras research scholars working in the area of high voltage engineering. At 7 pm conference dinner was provided and the day was over by 9 pm.


Prof. G.C. Montanari giving Invited Talk

in CATCON 2019




Prof. Sivaji Chakravorthi delivering his lecture

On day 3 about 30 papers were presented in four sessions. The sessions were startedby 8.30 AM and was over by 5.30 PM. All three days, each and every paper was discussed thoroughly and was possible because of eminent session chairs.

Prof. R. Sarathi concluded the sessions by saying vote of thanks to all International and National advisory committee members, local committee members and the chairs of Technical committee.

Table 1. Experts Talk

| |
|---|
| Condition Assessment of Electrical Equipment in Harsh Electrical Environment by Prof. G. C. Montanari |
| Remote Monitoring of High Voltage Insulators by Prof. Sivaji Chakravorti |
| Measuring Air Core Inductance of 1-φ and 3-φ Transformer Windings Using FRA Data by Prof. L. Satish |
| Epoxy resin with montmorillonite nanofillers: Flashover voltages and surface discharges by Prof. M.G. Danikas |
| Role of electromagnetic field analysis in diagnostics of high voltage apparatus by Prof. Udaya Kumar |
| Investigation for a reference material for the dynamic drop test (DDT) with a reproduceable and repeatable retention time by Prof. Stephan Kornhuber |
| Power Quality- how the utilities are preparing to brace for it by Dr. Subrat Sahoo |
| Pulsed Electroacoustic System for Measurement of Space Charges in Dielectrics of Power Cable by Prof. C.C. Reddy |


Group photo of CATCON 2019 participants

Prof. L.Satish Delivering his talk in Catcon 2019


Prof. M.G. Danikas delivering his speech in the CATCON 2019

Organising committee members of CATCON 2019

Handing over memento to Dr. Reddy by Dr. Sahoo

Handing over memento to Prof. S. Kornhuber by Prof. L. Satish

IITM HV Research scholars with Prof. Stephen kornhuber

**Prof. R. Sarathi**
High Voltage Division
Department of Electrical Engineering
Indian Institute of Technology Madras

# International Conference to be held in Asia

## ISEIM 2020 (9th International Symposium on Electrical Insulating Materials)

**Dates:** September 13-17, 2020
**Venue:** Waseda University, Tokyo, Japan
**Sponsored by:**
IEEJ Technical Committee on Dielectrics and Electrical Insulation
**Technically co-sponsored by:**
IEEE Dielectrics and Electrical Insulation Society
**Co-sponsored by:**
Kagami Memorial Laboratory for Materials Science and Technology, Waseda University
**Honorary Chair**
Prof. Y. Ohki (Waseda University)
**General Chair**
Prof. N. Hayakawa (Nagoya University)
**URL:** http://www2.iee.or.jp/~adei/ISEIM2020/

ISEIM is positioned as the international version of the domestic symposium held every year by IEEJ TC-DEI. The 9th conference will take place in Waseda University, Tokyo. Followings are some events that organizing committee is newly preparing for.

1) The 2020 Inuishi Memorial Lecture will be given by Emeritus Prof. Leonard Dissado of University of Leicester. Emeritus Prof. Dissado is very well known as one of the leading experts in the field of dielectrics and electrical insulation for a long time, and has been a visiting professor at the University Pierre and Marie Curie in Paris, Paul Sabatier University in Toulouse, and Nagoya University in Japan. Emeritus Prof. Dissado will give us his Inuishi Memorial Lecture based on his long and rich experience.
2) The plenary lecture will be given by Prof. Suwarno of Bandung Institute of Technology, Indonesia.
3) ISEIM2020 will have special sessions such as (i) asset management and diagnosis for electric power equipment, (ii) organic electronics and bioelectronics for innovative devices, (iii) advanced and improved electrical insulating resins and their applications, and (iv) case study of electric power apparatus from viewpoint of electrical insulation due to deterioration, natural disasters, etc.

**Important Dates:**
Abstract Submission: Jan. 24, 2020
Acceptance/Rejection Notices: Middle of Mar., 2020
Manuscript Submission: May 29, 2020
End of Early Bird Registration: Middle of July
Conference Dates: Sept. 13 - 17, 2020

**Conference Secretaariat:**
Dr. Norikazu Fuse
Central Research Institute of Electric Power Industry, 2-6-1 Nagasaka, Yokosuka, Kanagawa 240-0196, Japan
E-mail: iseim2020@ieej.org

## CMD 2020 (8th International Conference on Condition Monitoring and Diagnosis)

**Dates:** October 25 - 28, 2020
**Venue:** Phuket Graceland Resort and Spa, Patong Beach, Phuket, Thailand
**Organized by:**
The Department of Electrical Engineering, Faculty of Engineering, KMITL, Thailand and
Electrical Engineering /Electronics, Computer, Telecommunications and Information Technology (ECTI) Association, Thailand.
**Technically Supported by:**
The IEEE Dielectrics and Electrical Insulation Society and the IEEE Power and Energy Society Thailand Chapter.
**Chairperson:**
Dr. Norasage Pattanadech, KMITL, (King Mongkut's Institute of Technology Ladkrabang), Thailand
**URL:** http://www.cmd2020.org/

CMD provides an excellent opportunity to academics and experts to discuss and to share ideas, results as well as experiences on electric power apparatus monitoring, fault diagnosis and asset management.

**Conference Topics**

1. Evaluation of failure and degradation of power equipment based on CMD
2. Advanced sensors and diagnosis techniques for Smart Grids
3. Strategy planning and asset management for power equipment
4. Applications of Big data and IoT on Condition Monitoring and Diagnosis
5. New trends in Insulation structure and design
6. Degradation and operational life assessment of power equipment, renewable energy conversion systems and energy storage
7. Low voltage insulation design, testing, monitoring, and diagnosis

**Important Dates:**

| | |
|---|---|
| Abstract Submission: | January 31, 2020 |
| Notification for Authors: | March 27, 2020 |
| Paper Submission: | May 29, 2020 |
| Notification of Paper Acceptance: | July 31, 2020 |
| Early Bird Registration: | August 28, 2020 |
| Conference Dates: | October 25 – 28, 2020 |

**Contact Information**

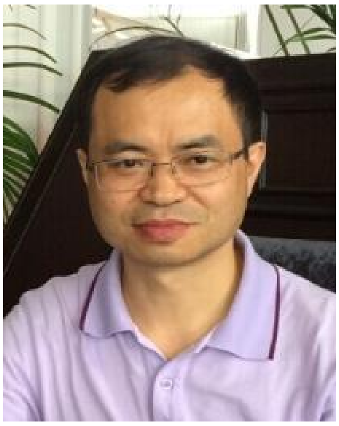
**Chairperson:** Dr. Norasage Pattanadech, KMITL, Thailand

**CMD2020 Office:** High Voltage Engineering Laboratory, Faculty of engineering, King Mongkut’s Institute of Technology Ladkrabang. 1, Ladkrabang, Bangkok, 10520, Thailand.

# China Corner

## China Su-Tong 1000 kV UHVAC GIL Project in Operation

Shengtao Li



**Prof. Shengtao Li**
Xi'an Jiaotong Univ.
Xi'an China

### 1. Overall

Recently, the world's highest voltage level (1000 kV), the largest transmission capacity (total transmission capacity of 10 GW) and the highest technical level (the deepest depth, the longest total pipe length, the maximum water pressure and installation accuracy) Suzhou -Nantong (Su-Tong) 1000kV UHVAC Gas-Insulated Transmission Line (GIL) project has been completed and put into operation, achieving a new milestone in the world power grid. The overview of Su-Tong GIL project is shown in Figure 1. After completion, East China power grid will be more effective in receiving power from outside the region and reach to a power capacity of 69.8 GW. It can reduce 170 million tons of coal for power generation, 310 million tons of $CO_2$ and 960,000 tons of $SO_2$ emission per year, thereby significantly improving the environment of East China. Meanwhile, it is of great significance to enhance China's leading level in the world's power transmission and electrical equipment manufacturing technology.

Su-Tong GIL is the first project that adopts UHVAC GIL transmission technology in important transmission lines in the whole world. This project started from Nantong in August 2016 and ended at Suzhou. The GIL pipeline was laid through the Yangtze River and double-circuit and six-phase 1000 kV lines were applied in it. The shield tunnel (5468.5 m) of Su-Tong GIL integrated pipeline project got through on August 21, 2019. The Su-Tong GIL integrated pipeline tunnel is 74.83 m away from the Yangtze River and the water pressure of the tunnel exceeds 0.9 MPa. Two 500 kV cables and municipal general pipelines such as communication and cable TV are reserved in the tunnel.

The 1000 kV UHVAC GIL transmission technology enables to compress a double-circuit 1000 kV UHV overhead line corridor (450-meter-high and 100-meter-wide) into a tunnel with an inner diameter of 10.5 m. Su-Tong GIL integrated pipeline is equipped with intelligent control systems, including optical fiber monitoring systems, safety warning systems for electrical equipment, online monitoring systems for telescopic sections and so on. The unified management, online monitoring and intelligent evaluation of the data from the pipeline have realized the automatic processing of equipment diagnosis and intelligent control. These systems and equipment ensure the safety and stability of the GIL pipeline.

Su-Tong GIL is directly connected in series to 1000kV UHVAC transmission lines. There are nearly 400 GIL chambers, over 2,000 units, 780-ton $SF_6$ gas, and nearly 6000 insulators.[2] Compared with UHVAC GIS in substations, it is necessary to further develop the equipment manufacturing techniques and improve the electrical performance of GIL.

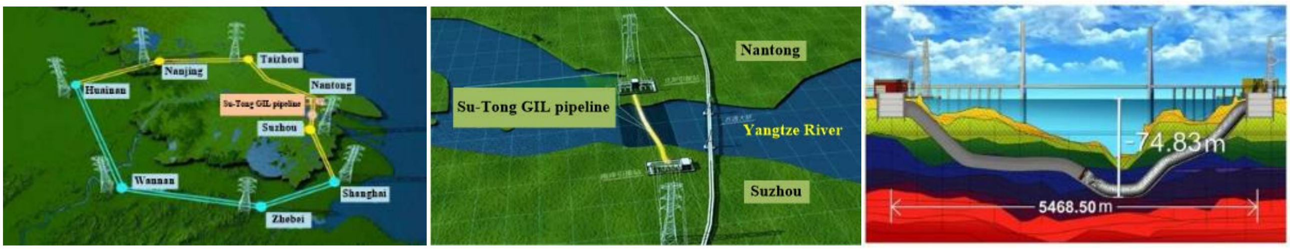



Figure 1. Overview of Su-Tong GIL project[1]

### 2. GIL development in China

Since the 1970s, GIL have gradually been put into use worldwide. In China, they are mainly applied in nuclear power plants and large hydropower stations. Tianshengqiao Hydropower Station 500 kV GIL in China Southern Power Grid manufactured by CGIT Westhoro in 1992 is utilized to connect transformers and gas-insulated bushing. Laxiwa Hydropower Station in Qinghai Province is an important power support point for the 750 kV power systems in Northwest China, where 750 kV GIL is applied to the outlet.[3]

Su-Tong GIL integrated pipeline is one of the impressive GIL projects in the world because of the highest voltage level, the largest transmission capacity and the highest technical level of it. Its lateral structure and sectional view are shown in Figure 2. It exists the longest unit, the highest insulation strength and resistance to arc ablation, and the lowest gas leakage rate in the world. The length of the unit and the total six-phase lines along Su-Tong 1000kV UHVAC GIL are 18 m and 35 km, respectively. The power-frequency withstand voltage of Su-tong GIL reaches 1265 kV, which is 1.15 times of the UHV switchgear. Moreover, the arc ablation resistance time is up to 0.3 s, and the annual gas leakage rate is reduced to 0.01%. The withstand voltage tests are shown in Figure 3. It is the first time that the project uses a high-precision helium leak test method to achieve the sealing performance test of large-size UHVAC equipment.


Figure 2. Su-Tong GIL lateral structure and sectional view [2]


Figure 3. (a) The engineers were checking the wiring for the UHVAC withstand voltage test, (b) a discharge locator is required on each section of the GIL units before subjecting to the withstand voltage test.[4-5]

## 3. GIL key scientific issues

GIL have proven their worth for a number of decades now. Even so, many engineers and scientists have been engaged in this field to improve the technology, thus making Su-tong GIL more efficient, low-cost and eco-friendly from the following aspects.

### 3.1 Key design principles

Su-tong GIL are the safe and flexible alternative to overhead lines and take up much less space while providing the same power transmission. It is supposed that 5000 m-wide Yangtze River needs to be crossed if overhead lines are used. Under this circumstance, it demands the construction of two 455 m-high towers in the Yangtze River to support these overhead lines, whereas this method would affect the river shipping and urban construction.

To satisfy the latest environmental and technical demands, GIL systems are filled with an insulating gas mixture consisting mainly of $N_2$ and a smaller proportion of $SF_6$.

GIL installations have been realized in every conceivable layout. The prefabricated structural elements are used to tunnel installation in Su-tong GIL project, as shown in Figure 4. The tunnel elements are assembled in a trench, which is then backfilled. Otherwise, tunnels can be created using a traditional boring method, to prevent any long-term disfiguring of the local landscape. With this method of installation, the land above the tunnel can be fully restored to agricultural use. The system stays accessible for easy inspection and high transmission capacity is ensured.

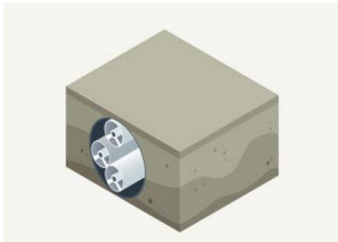


Figure 4. Tunnel installation of Su-tong GIL[6]

### 3.2 Electromagnetic field

GIL consist of two concentric aluminum tubes. The inner conductor rests on cast-resin insulators, which center it within the outer housing. This housing is formed from a stable aluminum tube, which ensures a solid mechanical and electrical packaging for the system, as shown in Figure 5.

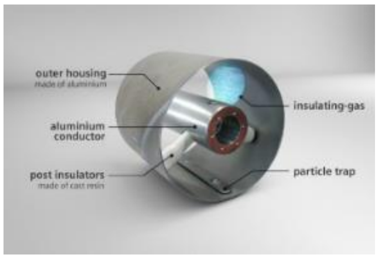



Figure 5. GIL inside structure[6]

The phase current induces an almost identical reverse current in the outer housing. This means the magnetic field outside the GIL is negligible. In the case of the three-phase GIL, metal housing must be connected to form a loop to ensure that the induced current is utilized.

### 3.3 Dielectric tests

During the GIL installation process, surface scratches or defects caused by misplacement, suspended dust, remaining conductive particles and burrs may occur in GIL, as observed in Figure 6, resulting in premature failures after GIL are put into operation. Therefore, in order to avoid accidents after they are in service, it is essential to perform dielectric tests once the GIL installation finishes.

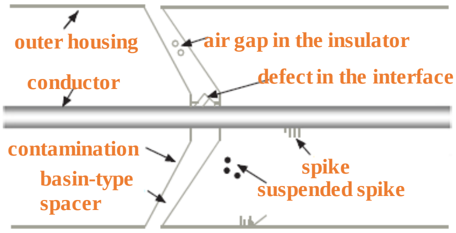



Figure 6. Common fault types in GIL[7]

3.3.1 Dielectric withstand test

It is essential to carry out the AC dielectric withstand test on site. To ensure inspected results, it is recommended to perform the test under $U_m/\sqrt{3}$ and $1.2U_m/\sqrt{3}$ voltage for 10 min and 20 min, respectively. Then, the voltage is increased to $U_m$ and held for 1 min. Afterwards, the voltage is reduced to $1.2U_m/\sqrt{3}$ and held for 30 min. During this stage, ultrasonic or ultra-high-frequency partial discharge detection is performed.

3.3.2 Electrical performance of insulators

As the main component of the GIL, the tri-post insulator plays an important role in supporting the central conductor and electrical insulation, as shown in Figure 7. The electrical performance of the tri-post insulator are critical for the safety and reliability of the entire GIL.

The overall shape of the tri-post insulator determines the electric field distribution, which directly affects the flashover voltage of $SF_6$ gas along the surface of the insulator. Incorrect structure of the tri-post insulator will result in uneven electric field distribution, thereby causing aging, flashover or even breakdown. In order to achieve uniform electric field distribution, it is necessary to optimize the tri-post insulator structure. According to the structural characteristics, the effect of structural parameters on the electric field distribution of the tri-post insulator has been explored.

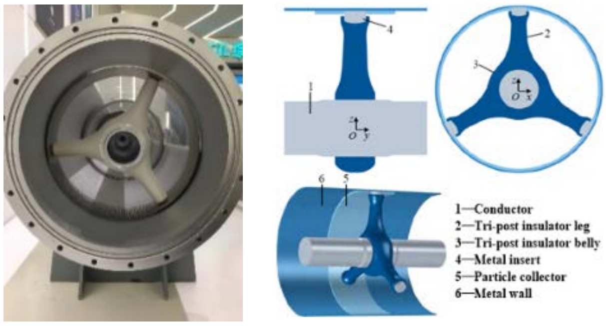



Figure 7. Physical map and calculation model of UHVAC GIL dumbbell-type tri-post insulator[8]

A model was proposed for the UHVAC tri-post insulator to calculate the overall electric field distribution. Aiming to obtain the effect law of the key structural parameters on the electric field, the tangential electric field strength and the maximum electric field strength of the metal insert surface were considered. After optimization, dumbbell-type insulator was obtained. On this basis, MPGA algorithm was further used to optimize the dumbbell-type insulator structure. Then the fat-headed dumbbell-type tri-post was achieved, as descripted in Figure 8. The maximum electric filed strength after optimizing on the metal insert surface was 9.1 kV/mm, which was about 14.2% lower than that of the original structure, as listed in Table 1.

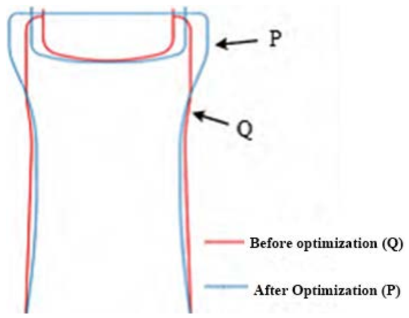



Figure 8. Comparison of tri-post insulator before and after dumbbell type optimization[8]

Table 1. Comparison of maximum electric strength before and after optimization

| Key parts | Metal insert | Combined electric field | Tangential electric field |
|---|---|---|---|
| Before optimization | 10.6 | 18.4 | 9.0 |
| After optimization | 9.1 | 17.3 | 9.1 |
| Improvement | 14.2% | 4.9% | - |

Since Su-Tong GIL may operate under many complicated factors such as electrical, thermal and mechanical strengths, temperature and pressure changes, the electric-thermo-mechanical characteristics of GIL insulators were also taken into consideration to optimize the structure parameters, as shown in Figure 9. Given the GIL discharge characteristics, the effects of structure parameters on the gas-solid interface discharge were studied. It proposed methods of averaging the electric field and eliminating the interface effect. A series of innovative achievements in theses researches provides an important basis for the technologies of the world's first UHVAC GIL.

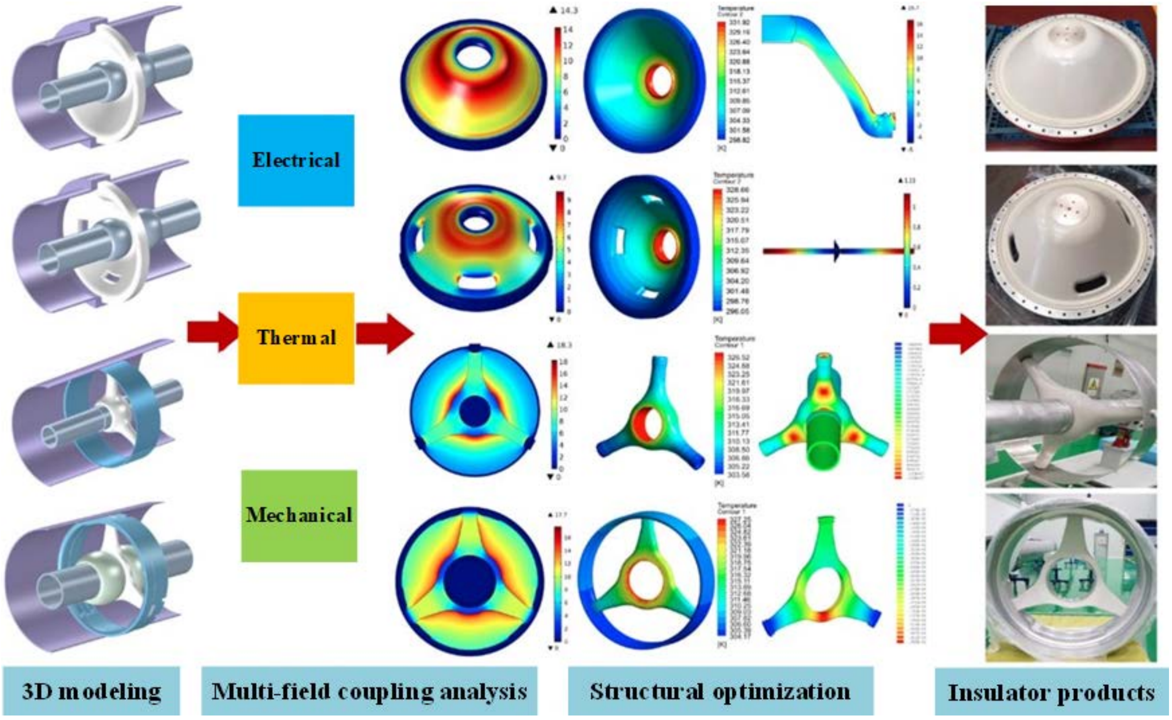



Figure 9. Structural parameter analysis and optimization of UHVAC GIL insulator[9]

## 4. Summary

Su-Tong 1000 kV UHVAC GIL integrated pipeline project in operation is a new milestone in the world's power grid technology. We mainly introduce this great project and some key technologies from some aspects, including the design principles of GIL, dielectric withstand tests and the strategy of structural design for the tri-post insulator. The design and construction technologies meet the engineering requirements for the safety and reliability of the world's first UHVAC 1000kV GIL.

## Author:

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(His photo is on the first page of this article.)

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# Korea Corner

## Laboratory for Electromagnetic Multiphysics

**Some of Lab. Members** (from left to right): Prof. Se-Hee Lee, Yoonho Park, Rakesh Kumar Jha, Su-Hun Kim, Minhee Kim

### 1. Introduction

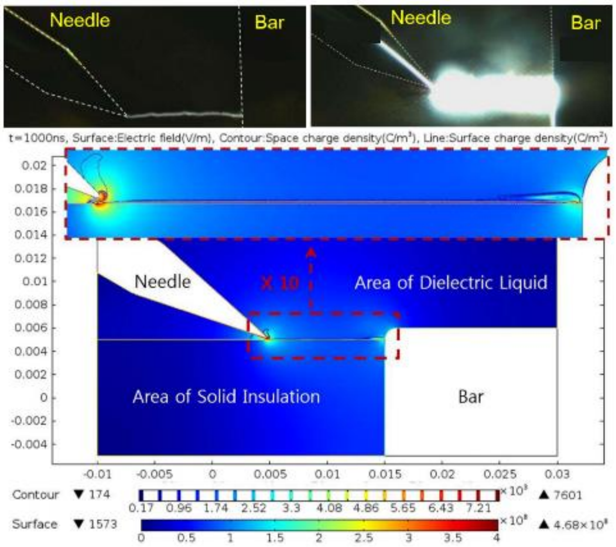
The Laboratory for Electromagnetic Multiphysics (LEM) at Kyungpook National University (KNU) in Korea performs research on fusion techniques applied to fundamental and applied problems in electromagnetic Multiphysics. Our interests are specifically in analysis and design for electromagnetic Multiphysics problems spanning the nano- to the macro-scales. We build numerical simulation tools and conduct experimental studies in electromechanical dynamics, continuum electromechanics, electric discharge and insulation in dielectric media, electromagnetic nano and microfluidics, and power and energy devices.

Recently we are studying and focusing on the high voltage areas: field and ionic current analysis under HVDC transmission line, insulation design techniques for HVDC systems based on electric field analysis, loss reduction technology for power transformer, and particle transport system with electrohydrodynamics (EHD).

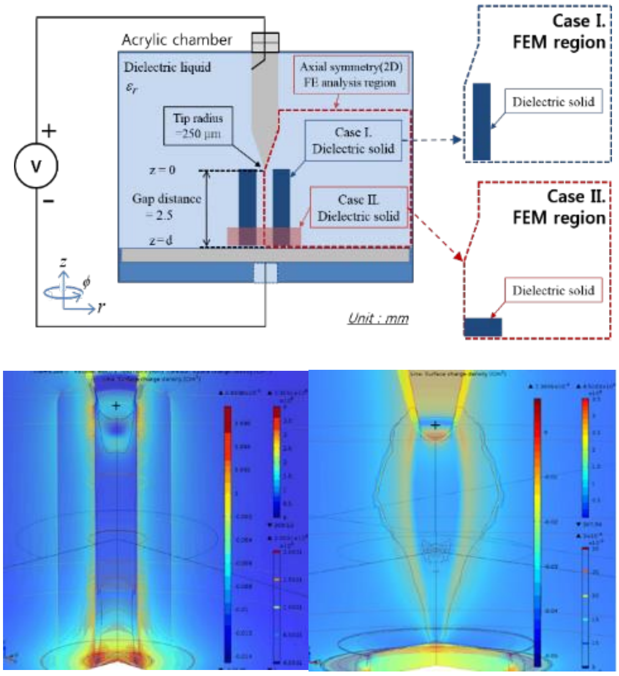
Photo 1. Small Workshop 2019 for High Voltage Research in Korea

### 2. Electromagnetic Multiphysics Analysis

Multiphysics analysis is a simulation technique by coupling various physical components such as fluid-structure, thermal-structure, and electromagnetic field-fluid. We mainly use the Multiphysics analysis method to solve the coupling problems such as generated heat, flow dynamics, mechanical structure, and physical dynamics based on electromagnetic phenomena. These problems are solved by computational numerical analysis such as the finite element method (FEM) and finite volume method (FVM). Further experiments are performed to secure the reliability of numerical analysis results. Figure 1 shows some of the numerical results which were conducted in our lab.




(a) Surface discharge with fluid-solid interface




(b) Space charge propagation with horizontal and vertical dielectric barrier

Figure 1. Applications of Multiphysics Analysis for High Voltage Areas.

## 3. Recent Research Topics Related to Multiphysics Analysis for High Voltage Research

A) Electrohydrodynamics (EHD)

Dielectrophoresis (DEP) is one of the EHD phenomena and it can explain the movement of dielectric particles embraced in a medium with the non-uniform electric field. Specially, these phenomena actively researched in the medical and biological fields that require control of micro- or nano-sized particle motion. We analyze the DEP force acting on the particle and the movement in real time based on the FEM technique as shown in Figure 2.

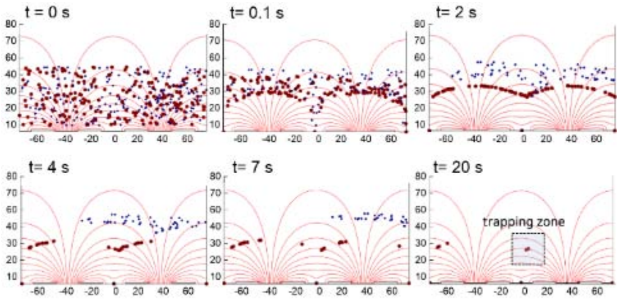



Figure 2. Multiphysics Analysis for EHD Applications.

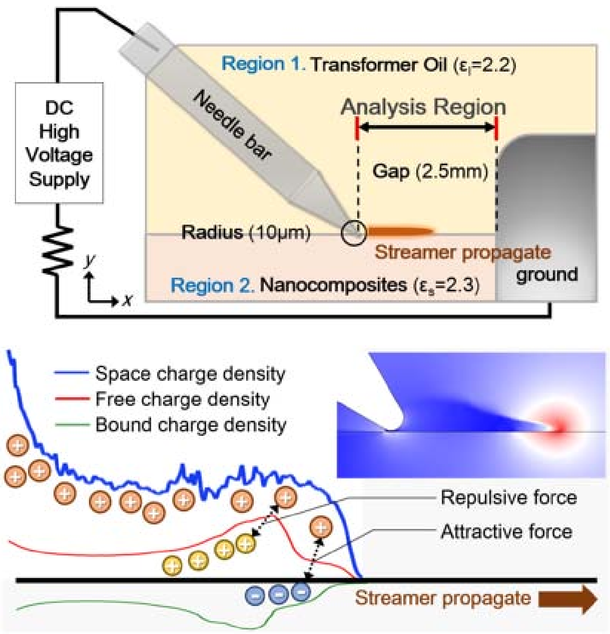



Figure 3. Analysis of Charge Transport Mechanism at the Interface between Liquid and Solid Dielectrics Incorporating with the BCT Modeling.

B) Discharge Analysis with Interface

The charge transport mechanism is a quite interesting research subject with insulating materials and the surface charge behavior is difficult to analyze at the interface of two or more insulators, which compose heterogeneous interfaces. To analyze these interesting phenomena, we are trying to build a Multiphysics analysis technique incorporating with the Bipolar Charge Transport (BCT) modeling as shown in Figure 3. By using this numerical analysis, the space and surface charge behavior can be analyzed and explained in detail based on the physical law.

C) Polymer Breakdown with Multiphysics Analysis

Recently, the polymer-nanocomposite material is promising as new insulating materials with high breakdown voltage. To analyze this breakdown phenomena with polymer, we are developing a Multiphysics analysis technique employing the BCT model and molecular chain displacement theory as shown in Figure 4. The systematic and quantized prediction of breakdown would be possible after building up this analysis technique.

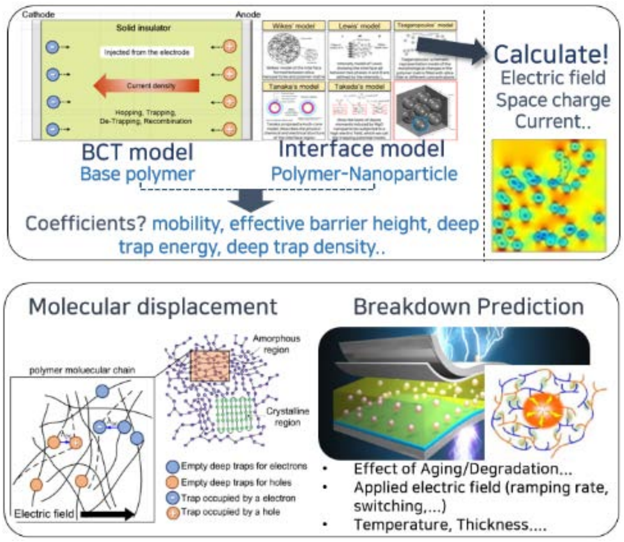



Figure 4. Analysis of Charge Transport and Molecular Chain Displacement Mechanism in Dielectric Polymer Nanocomposite.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# *Indonesia Corner*

## Sidrap -Tolo : The First Wind Powers in Indonesia


Prof. Suwarno Ir. Suroso Isnandar M.Sc.

### 1. Introduction

Indonesia is an archipelago country located at tropical area. Several thousand islands are scattered around the equator between 6° northern latitudes and 11° southern latitudes and 95° east longitude and 141° east longitude.

The population in 2019 is 267 millions. One of the nation determination is to electrify all people in all area. As a measure, a term electrification is used. This term refers to the ratio between the number of people that have electricity in their homes and the population. According to the 2015-2034 National Electricity General Plan (RUKN), the electrification ratio for all of Indonesia is targeted to reach 100% by 2025. In year 2010 electrification ratio was only 67.2%. This figure increased to 98.3% in 2018 and currently at the end of 2019 electrification is 98.5%. With this progress there are still around 5.2 million people without electricity[1].

### 2. Indonesian Electricity

Electricity is an essential for citizen. Indonesian government has put strong efforts to electrify all parts of Indonesian area to reach all its citizen. Currently, the national capacity is 65 GW with 63 % owned by Indonesia Electric Power Company (PT. PLN) and the rest from Independent Power Producers. More than 60 % of the electricity is produced using coal as primary energy source. In 2027 the coal portion should be reduced to about 58 % and renewable energy source should increase from currently 15.1 % to 23 % by 2025. The current situation of electric power production and distribution in Indonesia is shown in figure 1 while the fuel mix to produce electricity in 2018 and targeted in 2027 are shown in figure 2 [2,3].

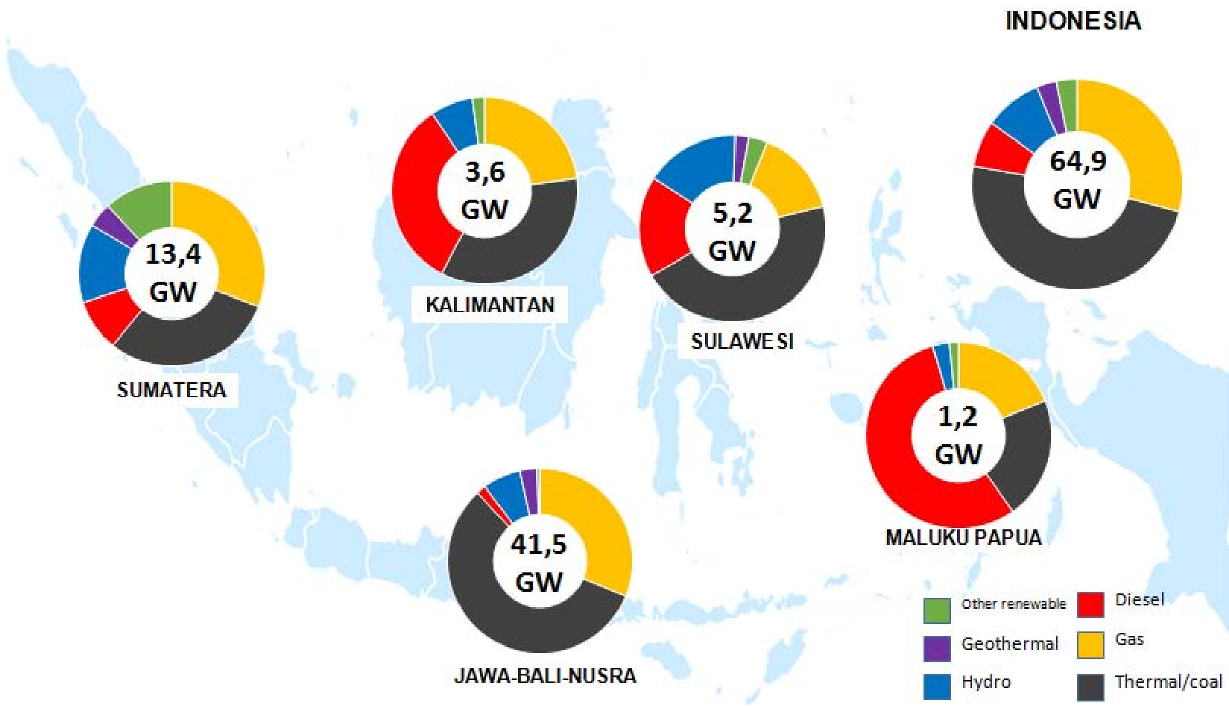
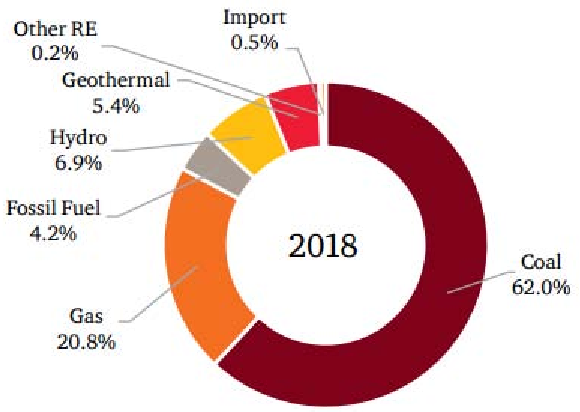
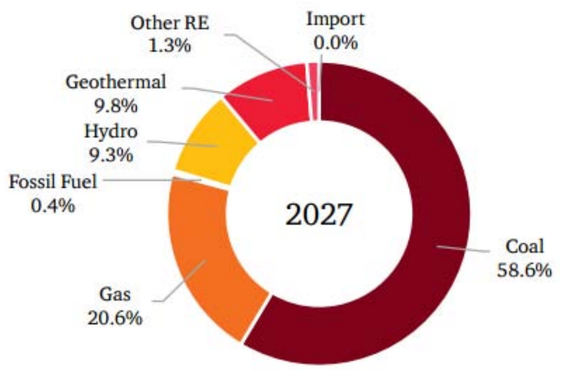



Figure 1. Current electric power production in Indonesia




(a)




(b)

Figure 2. Fuel mix for producing electricity in Indonesia (a) 2018 (b) 2027

## 3. Renewable Energy and Wind Power Plants in Indonesia

As shown in figure 1 and 2, the renewable energy in Indonesia electricity system is still very low and mainly hydro and geothermal power plants. The most prospective renewable energy source is geothermal. Indonesia is home of large geothermal energy with capacity of 28.000 MW. Currently, a total of 1,950 MW geothermal generating stations are in Indonesia from its target of 7,200 MW which should be achieved in 2025. It is believed that utilizing the geothermal energy in larger scale will help Indonesia to improve the renewable energy percentage in its energy mix. It was a rare discussion to have wind power stations in Indonesia. The reason is because the wind speed, in general low to be used for generating electricity. According a study conducted by ministry of energy and mineral resources the wind power resources are summarized in table 1 [4].

Table 1. Wind power potential in Indonesia

| Resource Potential | Wind Speed at 50 m, (m/s) | Wind Power Density, at 50 m, ($W/m^2$) | Number of Sites |
|---|---|---|---|
| Lowest | <3.0 | <45 | 66 |
| Low (Small-Scale) | 3.0 – 4.0 | < 75 | 34 |
| Medium Scale | 4.1 – 5.0 | 75 – 150 | 34 |
| Large Scale | > 5.0 | > 150 | 19 |

## 4. Sidrap and Tolo Wind Power Plants

Wind farm Sidrap is the first utility-scale wind farm ever constructed in Indonesia. It marks an important milestone for renewable development in Indonesia. Having a total installed capacity of 75 MW, this wind farm is the biggest in Indonesia, even in South East Asia.

Located at Sidenreng Rappang, Southern part of Sulawesi Island, Sidrap wind power has 30 windmills with a tower height of 80 meters and a propeller length of 57 meters. Each propeller is connected to a 2.5 MW generator to generate electricity with total capacity of 75 MW.

Table 2.
Comparison of Sidrap and Tolo Wind Powers

| Item | Sidrap | Tolo |
|---|---|---|
| Location | Sidenreng Rappang South Sulawesi | Joneponto, South Sulawesi |
| No of unit | 30 | 20 |
| Height (m) | 80 | 133 |
| Blade length (m) | 57 | 63 |
| Output per unit (MW) | 2.5 | 3.6 |
| Total output (MW) | 75 | 72 |
| Price per kWh (sen USD) | 11 | 11,85 |
| Investment (Million USD) | 150 | 160.7 |

Another wind power plant is operating at Joneponto of Southern Sulawesi. It names Tolo Wind Power Plant. The number of windmills in Tolo wind power plant is 20 units. The height of its tower is 133 meters and the length of its propeller is 63 meters. Each turbine has a capacity of 3.6 Megawatts (MW), bringing the total capacity to 72 MW.

The electricity produced by the Tolo wind power plant will be connected to the existing PLN transmission system with a voltage of 150kV owned by State Electricity Company, PT PLN. Tolo wind power is also targeted to reduce greenhouse gas (GHG) emissions by 160,600 tons of $CO_2$ / year [5].

a. Sidrap Wind Power

b. Tolo Wind Power Plant

Figure 3. Sidrap (a) and Tolo (b) wind Power plants

Tolo Wind Power Plant is a new renewable energy power plant that is incorporated in the Southern Sulawesi system. Curently, Southern Sulawesi's total capacity is 1,499 MW, while this system has a peak load of 1,165 MW, thus its reserve margin is 334 MW or 28.62 %.

Tolo Wind Power Plant contributes to 7 % energy mix portion for renewable energy power plants in Southern Sulawesi. The largest renewable energy portion in Southern Sulawesi comes from hydropower plants by 22 % and geothermal power plants by 7.66 %. The construction of Tolo Wind Power Plant was a part of national 35,000 MW project.

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# TECHNOLOGY REVIEW

## Direct Current Integrated Charge Method (Q(t) Method) as an Evaluation Measurement Tool for Dielectric Properties of Polymer Materials

**Yoitsu Sekiguchi (Sumitomo Electric Industries, Ltd.)**

Recently, the importance of HVDC transmission technology has become greater and greater in the world. In the case of solid dielectric cables, as insulation material for cables is quite different for HVAC and HVDC, development of insulation material for HVDC cables has been a big issue in the field. Usually, as the properties of materials under high voltage DC, such as electric conductivity, permittivity and space charge accumulation behavior are evaluated by individually using suitable methods under different temperatures and electric fields, many procedures and a lot of time is required. The direct current integrated charge method (abbreviated to Q(t) method) also belongs to this category of methods, but it has more advantages compared to other methods from the point of view of simplicity, flexible usability for properties, and noise immunity. These features of the Q(t) method are described in this article.

### 1.1 Basic Theory[1]

Applying DC voltage to a dielectric material, extremely weak electric current flows within the material. Despite some components of current, such as displacement current, absorption current and conduction current which have the probability to become a parameter of physical phenomena, being included in the currents, it is usual for them to be evaluated separately using different methods. In the Q(t) method, charge Q(t) as the integration of the currents I(t) is accumulated and measured in an integrating capacitor that is connected in series to a sample as shown in Fig. 1 (a). Applying square wave voltage as shown in Fig. 1 (b), the current is responsible to the physical phenomena and is expressed by equation (1) and Fig. 1 (d). And the charge Q(t) as an integration of I(t) can be shown as in Fig. 1 (c). If a researcher measures the Q(t) from the beginning of application of square voltage to grounding, all components of current can be captured, and properties corresponding to physical phenomena can be obtained.

$$\mathrm{Q}(t) = \int I(t)dt \qquad (1)$$

$$= \mathrm{Q}(0) + \int I_{abs}(t)dt + \int I_{cond}(t)dt$$

Where, $\mathrm{Q}(0) = \int I_{disp}(t)dt = C_s \cdot V_{dc}$

#### 1.1.1 Capacitance and permittivity

When the square wave voltage of $V_{dc}$ is applied and the capacitance of the sample is $C_s$, a charge expressed by

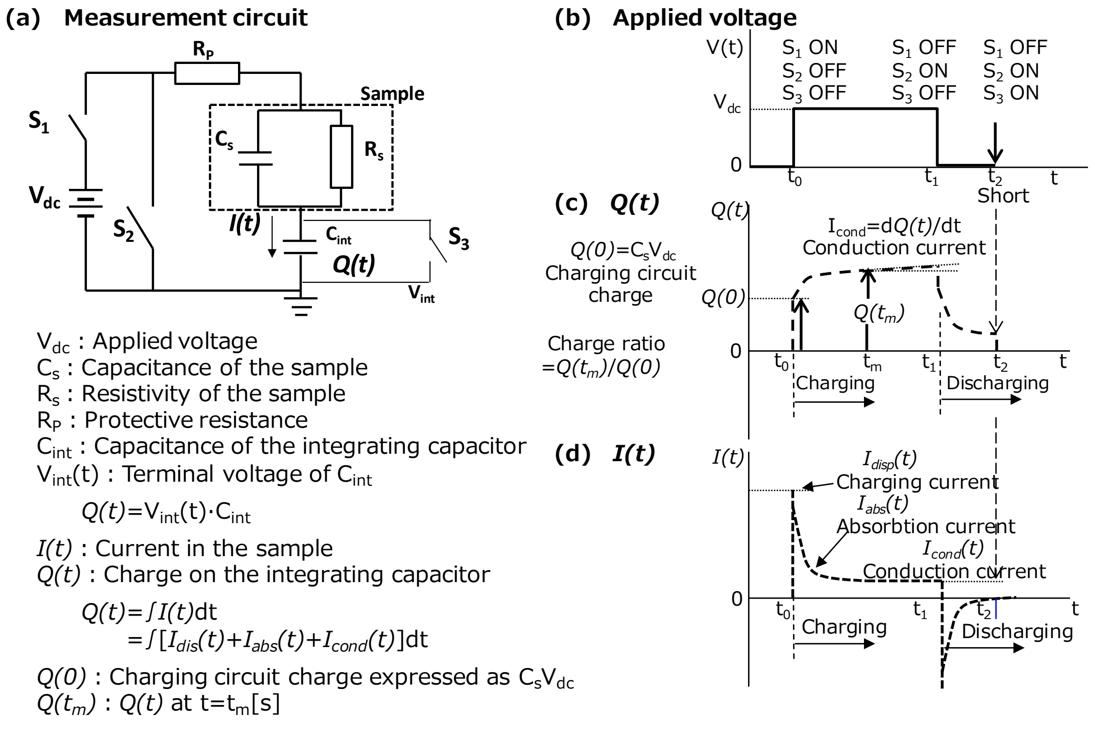


Fig. 1. Measurement circuit (a) and conceptual image of Q(t) and I(t) when a square wave voltage was applied ((b) to (d))

$Q(0)=C_s \cdot V_{dc}$ accumulates as an electrode charge. Q(0) is measured by the Q(t) method, and $C_s$ and $\varepsilon_r$ can be calculated by Eq. (2).

$$Q(0) = C_s \cdot V_{dc} = \frac{\varepsilon S}{d} \cdot V_{dc} = \varepsilon_0 \varepsilon_r \frac{S}{d} \cdot V_{dc} \qquad (2)$$

### 1.1.2 Space charges

Information about space charge can be obtained based on the behavior of the absorption current that is affected by the space charge accumulation and transfer. It should be noted that the *Q(t)* method does not provide information about the position of charge distribution, which is different from the PEA method. The *Q(t)* method only offers information about the total charge quantity. To calculate changes in the charge quantity, we evaluated the charge quantity ratio $Q(t_m)/Q(0)$ (i.e. the ratio of the charge quantity *Q(0)* immediately after startup and the charge quantity $Q(t_m)$ at $t_m$ seconds later) as shown in Eq, (3).

$$\frac{Q(t)}{Q(0)} = 1 + \frac{\Delta Q(t)}{Q(0)} \qquad (3)$$

Where, $\Delta Q(t) = Q(t) - Q(0) = \int I_{abs}(t)\mathrm{d}t + \int I_{cond}(t)\mathrm{d}t$

When charge quantity ratio *Q(t)/Q(0)* is 1, there is no injection or accumulation of charges into the sample.

### 1.1.3 Electric conductivity

Current can be calculated by differentiating the charge quantity in relation to time ($\mathrm{d}Q(t)/\mathrm{d}t = I(t)$). Thus, the gradient of the time dependence graph of *Q(t)* obtained in a steady state shows the conduction current. Electrical conductivity κ can be calculated from the conduction current as shown in Eqs (4) to (6). Here, J is the current density, S is the electrode area, and d is the sample's thickness.

$$\mathrm{J(t)} = \frac{1}{\mathrm{S}} \cdot \mathrm{I(t)} = \frac{1}{\mathrm{S}} \cdot \frac{\mathrm{dQ}}{\mathrm{dt}} \qquad (4)$$

Also,

$$\mathrm{J_{cond}} = \kappa \cdot \mathrm{E} = \kappa \cdot \frac{\mathrm{V_{dc}}}{\mathrm{d}} \qquad (5)$$

Therefore,

$$\kappa = \frac{\mathrm{d}}{\mathrm{S}} \cdot \frac{1}{\mathrm{V_{dc}}} \cdot \frac{\mathrm{dQ}}{\mathrm{dt}} \qquad (6)$$

These physical property values can be calculated by a single measurement. More general information about the dielectric characteristics of a material can be obtained by calculating the electric field dependence and temperature dependence while the applied field and measurement temperature are changed.

## 1.2 Measurement Example

The measurement result for XLPE (Cross-linked polyethylene) for AC power cables under DC high voltage is shown in Fig. 2 as an example. It is notable that the conductivity of XLPE varies greatly depending on the temperature during measurement.

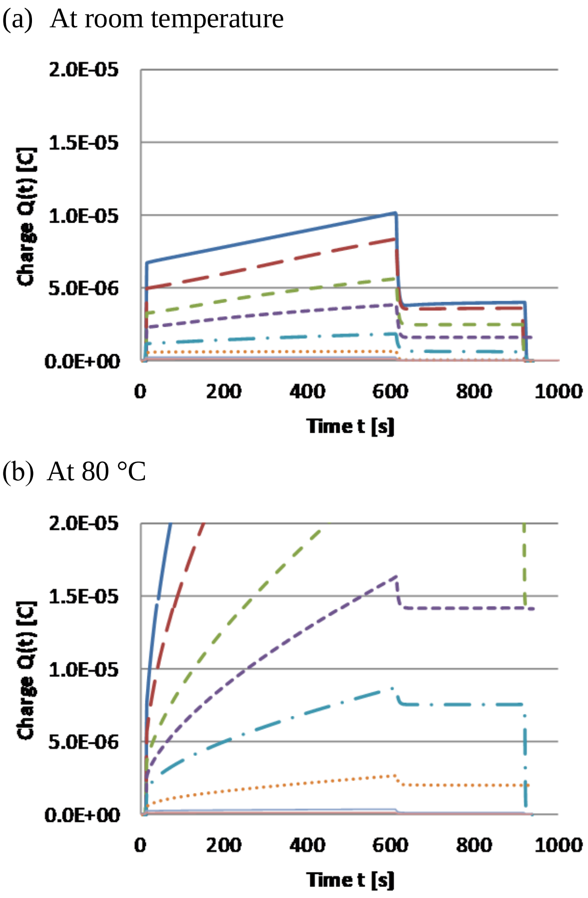


Fig. 2. Q(t) curves of AC-XLPE at (a) room temperature (r.t.) and (b) 80 °C

## 1.3 Application

The Q(t) method is expected to enable supplementary and general evaluation of materials and phenomena, since it is a simple measurement technique that can be used to evaluate various dielectric properties.. In addition, since noise can be canceled by integration in the Q(t) method, even electrodes of a smaller size can measure dielectric properties with high accuracy, and bundling up such electrodes leads to a "multichannel electrode Q(t) meter" which can measure a distribution of charges or currents in a particular area of a sample[2][3]. Newly developed measuring techniques using the Q(t) method are expected in the near future.

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# Progress in Terahertz Technology and Non-destructive Testing

## Investigating R&D Committee on Non-destructive Testing with Terahertz Waves

IEEJ Technical Report No. 1432 (in Japanese), published on July 25, 2018

Safety and security are among the key words drawing much attention to non-destructive testing. They spread from maintenance of buildings and public infrastructure to the manufacturing process of commercial products. This technology detects the hidden abnormalities in materials without opening or destroying them. Material identification is also an anticipated application of the technology. These expectations are not limited to industrial fields, but have spread to research and development.

Infrastructure, cultural properties, and certain industrial products are typically protectively coated for purposes such as protection. Ceramic and polymeric materials have shown good transparency in the frequency range of approximately 0.1–10 × $10^{12}$ Hz. Electromagnetic waves in this frequency range are called terahertz (THz) waves. They permit detection of rust in anticorrosion paints, inspection of drugs in capsules, and testing of base structures in cultural properties (Fig. 1) [1, 2]. Japanese THz technology has exhibited world-class excellence [3], and has been selected as one of the national critical technologies in MEXT Council for Science and Technology.

The Investigating R&D Committee on Non-destructive Testing by Terahertz Waves was established in April 2015 under the IEEJ Technical Committee on Instrumentation and Measurement. The aim of the committee was to survey the following items: the latest apparatus to generate and detect THz waves, THz wave application to non-destructive testing, and extraction of technological subjects for the application. After a three-year survey of activities was concluded, the results were published as IEEJ Technical Report No. 1432. This report provides examples of THz non-destructive testing on cultural heritage sites, turbine blades used in power stations, petroleum tanks, transmission power lines, and concrete structures. This report also introduces progress in THz material identifications for polymers, electrical insulating materials, pharmacological agents, dangerous drugs, as well as medical and bio sensing.

Several THz technologies highlighted recently relate to downsizing, power saving, and low-cost production. Electronic devise modules that directly emit generate and detect THz waves are considered promising for such purposes. Resonant tunneling diodes (RTD) can operate both for generation and detection of THz waves at room temperature. Brown reported on this epoch technology in oscillating 420 GHz waves at room temperature [4]. In recent years, Asada reported the oscillation of 1.92 THz waves [5]. The pile-up laminated structure of quantum wells and their barriers on semi-insulating indium phosphide substrate is the key factor allowing RTD to form a resonance state in the well layer. THz waves in single frequency are continuously oscillated under the voltage range where the RTD shows negative I-V correlation. The I-V correlation also shows non-linear characteristics to realize high-sensitivity detection of THz waves.

Pioneer Inc. manufactures the catoptric system shown in Fig. 2, which contains an RTD devise in its scanning head to fit several sample shapes. RTD devises are used both as an emitter and receiver of THz waves to standardize the control circuit. Simple circuit

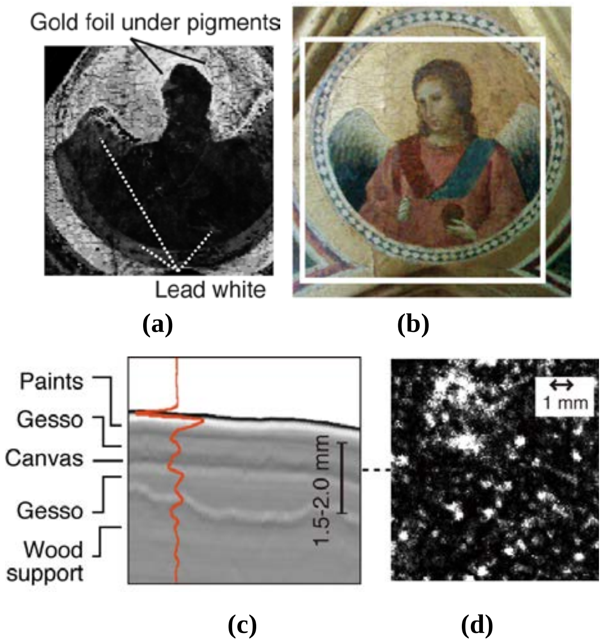



**Fig. 1. (a) THz reflection and (b) visible images of a part of Giotto's masterpiece, Polittico di Badia (c.a. 1300). (c) Gray scaled cross-sectional image, and (d) the existence of a regularly-patterned layer under the paint and gesso layers is revealed by extracting the pulse signal from the canvas layer. [1], [2].**

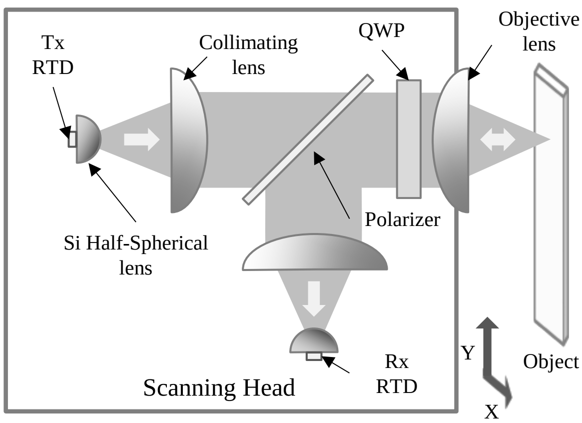


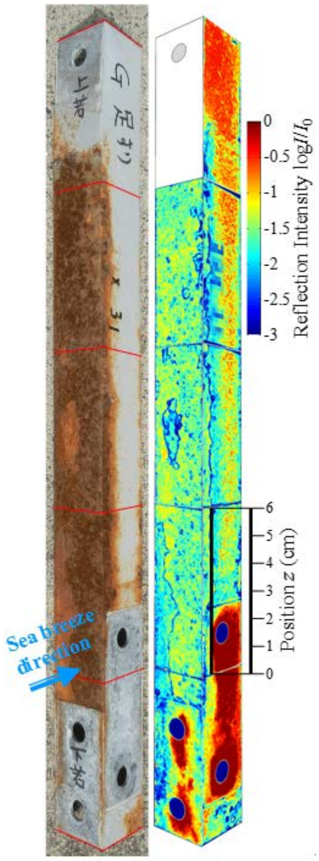

**Fig. 2. Scanning head of the RTD catoptric system.**

**Fig. 3. The RTD system.**

structures can also accommodate signal processing such as lock-in detection. 0.3 THz waves are oscillated in this system via a bias tee device by applying a 500 Hz modulated signal and DC bias voltage to RTD. The voltage induced by another RTD receiving the reflected THz waves is modulated and detected by the lock-in amplifier. The system also consists of coaxial optics to utilize the polarization characteristics of the RTD. The efficiency of THz waves is superior to that of optics that uses a half mirror for the beam splitter to separate emitter and receiver. The coaxial system also prevents the return of the reflection waves to the emitter, thus securing its stable operation. Raster scanning is used for the RTD catoptric system head (Fig. 3). Array configuration is necessary for faster scanning speed, which is especially demanded in imaging measurement. Such multiple devise arrays are promising for incoherent illumination emitters by simultaneous oscillation, and also for high-sensitivity line receivers.

One of the more promising fields for THz non-destructive testing is evaluation of rusting in infrastructure. Approximately 250,000 electric transmission towers are installed in Japan, with 70% having been in service for more than 30 years. Diagnostic techniques for rust detection are especially in demand for coated steels, since corrosivity under opaque anticorrosion film cannot be evaluated by visual inspection. THz time-domain spectroscopy was applied to coated angle steel used as a cross-arm in a transmission tower at a site on the Pacific coast [6]. Its appearance, as depicted in Fig. 4(a), indicated that corrosion was intense, and that most of the coating was lost on the surface facing the sea breeze, whereas the coating on the other surface remained intact. The three steel-like areas with one or two holes at the top and bottom are joint parts. Reflected THz waves became weak due to strong absorption by the steel rust. The THz wave intensity distribution depicted in Fig. 4(b) then showed the rust distribution. The intensity was particularly strong in the galvanized areas with no rust. The rusted areas showed weak reflection, even in areas where the coating remained intact. Rust fluid appeared to be transfused at the steel/coating interface to enhance the under film corrosion.

Fig. 5 shows THz spectra observed for coated zinc




**(a) (b)**

**Fig. 4. (a) Appearance and (b) THz reflection intensity distribution of a cross arm used in a transmission tower. The sample was cut along the red lines shown in (a). *I* and $I_0$ at the color bar caption in (b) are the incident and reflected intensities of THz waves, respectively [6].**

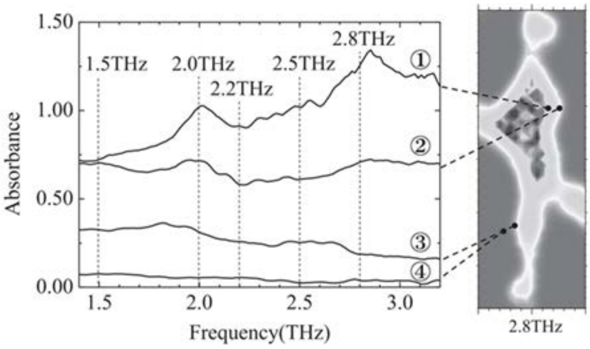



**Fig. 5. THz imaging result beneath the scribe and observed absorption spectrum [7].**

samples with cross scribes, after subjected to a salt spray corrosion acceleration test [7]. Weak reflection intensity distribution observed beneath the scribe showed that the rust spread from the scribe. Progress of such rusting can be continuously observed by additional acceleration tests as THz imaging is a non-destructive test. In contrast, conventional methods generally destroy the sample when analyzing its cross- section. THz spectra obtained in imaging measurement also enable material analysis by matching with the database. In this example, the 2.0 THz peak observed was ascribed to the presence of zinc oxide or a basic zinc. Another absorption peak observed around 2.8 THz was due to chloride zinc. Such material identification sometimes cannot be achieved even with X-rays. Expectations for THz wave measurement are now speeding into dynamical analysis of corrosion materials.

Research into THz (far-infrared) spectroscopy of organic materials started in the 1960s. THz absorption spectra of various materials have been investigated. Currently, many THz spectra are summarized and found in the “THz spectrum database” developed by RIKEN and NICT [8]. Low-frequency vibrational spectroscopy in the THz frequency range by the spectra of poly(hydroxybutyrate) (PHB) is demon- strated herein. Fig. 4 shows the absorption spectra of (a) amorphous and (b) crystalline PHB [9]. The characteristic bands at 2.5 and 2.9 THz observed in crystalline PHB are not shown in the spectra of amorphous PHB, suggesting that those vibrational bands originate from a crystalline structure. Thus, the THz absorption bands mainly reflect intermolecular structures. For assignment of the intermolecular vibrational bands, polarization spectroscopy was used, which gave detailed information about the direction of the vibrational dipole moment. Fig. 4 (c) and (d) displays the polarization spectra of PHB (c) parallel, and (d) perpendicular to the crystalline *c* axis. To obtain the polarization spectra, the sample was stretched to align the crystal axis and the spectra were measured with linearly polarized THz light. It is known that crystalline PHB forms a lamellar crystal structure, in which helical polymer chains in the *c* direction align on an *ab* plane with weak hydrogen bondings between CH and CO. The vibrational bands at 2.9 and 2.4 THz in Fig. 4(c) had a dipole moment along the *c* axis, suggesting that those bands were skeletal vibrational bands of the polymer chain. On the other hand, the band at 2.5 THz in Fig. 4(d) was due to the hydrogen bonding, which was perpendicular to the *c* axis.

For a more detailed assignment of the vibrational bands, quantum mechanical calculation was used. Software used for this purpose must consider the crystalline structure of the sample to include intermolecular vibration modes. In Fig. 4 (e) shows a result of the “Cartesian coordinate tensor transfer method, [10]” which is the quantum mechanical calculation including crystalline structure for the calculation model. The result successfully reproduced the parallel and perpendicular vibrational modes observed in the polarization spectra.

Since THz spectra give rich information about higher order structures of macromolecules, it might become a novel inspection tool for polymers. The physical and chemical properties of polymers change with their higher order conformation. For example, the crystalline structure of polymers changes with degradation. The key advantage of THz spectroscopy is its non-destructive measurement of spectra, which is its biggest

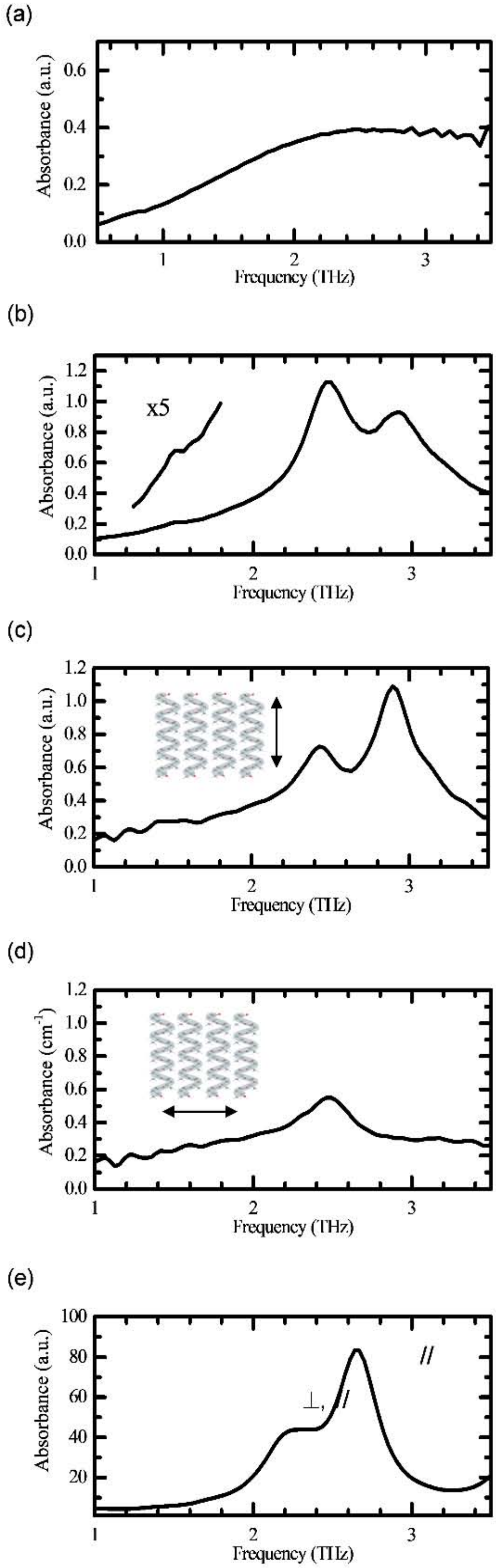



**Fig. 4. THz absorption spectra of (a) amorphous PHB and (b) crystalline PHB. Polarized absorption spectra of stretched PHB (c) parallel and (d) perpendicular to the crystalline *c* axis. (e) THz absorption spectra simulated by the CCT method.**

advantage over conventional analytical methods such as X-ray diffraction, nuclear magnetic resonance, and differential scanning calorimetry.

THz waves can be applied to non-destructive testing in combination with material identification, which cannot be achieved even with radio waves or X-rays. R&D activities throughout the world are summarized in the technical report with the following conclusions:

1) Material analysis field: Far-infrared systems are used in the food and semiconductor manufacturing fields. THz wave technologies are expected to elucidate the dielectric responses in the frequency regions from far-infrared to microwave. Wide frequency and high-accuracy analysis equipment is expected to evaluate the validity of such measurements.
2) Inspection and industrial application: Monitoring techniques are expected to be developed to inspect component change and allotrios in production processes. Imaging measurement is needed in such inspections. Techniques of high-sensitivity measurement and high speed data acquisition have helped in the development of THz wave fast-scanning methods. Line sensor systems are attracting much attention. Optical fiber systems are also expected to be adaptable to several structural shapes. Further R&D is also expected in data analysis algorithms and software to conduct cross-sectional diagnosis and material identification.
3) THz semiconductor devises: Modular development is expected to realize the direct emission and detection of THz waves using semiconductor devises. High-powered and wide-operation frequency RTD devices are in vigorous development. New components are also being developed for applications such as wider bandwidth Schottky barrier and low noise operation heterobarrier diodes.

The committee members dedicate this technical report to the late Dr. T. Fukuchi. The committee was established to honor his great passion. His commitment to THz technology prompted the realization of the industrial application of non-destructive testing.

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# BOOK REVIEW

## Advanced Tailor-made Composite Insulation Materials

### - Towards Innovative Composite Materials to Meet Demand in Electric Power and Electronics Sectors -

**IEEJ Investigation Committee on Advanced Tailor-made Composite Insulation Materials**

**Chairperson: Toshikatsu Tanaka, Waseda University**

IEEJ Technical Report No. 1455 (in Japanese), Published on May 10, 2019

IEEJ Investigation committee on advanced tailor-made composite insulation materials published the technical report No. 1455 as shown in Figure 1, on May 10th, 2019. The committee consists of 33 experts who work in academia including research institute and industry. Various committee members enable the technical report to cover new polymer composite insulation materials from fundamentals to applications.

"Tailoring" is the keyword of the technical report. Polymer composite insulation materials are essential in electric power and electronics sectors. Technologies, called "tailoring of composites", are being developed for making composite materials with desired dielectric and insulation properties as shown in Figure 2. The technical report focuses on the following technologies.

1) Tailoring of permittivity and conductivity to enable innovative functions.
2) Tailoring of interfaces between polymers and fillers to enable multi-functions.
3) Computer simulation to tailor new composites and to clarify their characteristics.

Cutting-edge research on tailoring composites are summarized from the material aspects such as combinations of polymers and fillers, second-generation nanocomposites, functionally graded composites and composites made by using additive manufacturing processes. For example, Figure 3 shows the insulation spacer model by the additive manufacturing, which is provided in the technical report.

Moreover, the review of necessary properties for insulation materials in rotating machines, switchgear, transformers, power cables and power modules implies directional movement of research and development. Besides, there is demand for various applications of tailor-made composites to these apparatuses and devices.

I hope that this technical report will contribute to advancement of polymer composite insulation materials so that this material technology will enable high performance and downsizing in electric power and electronics sectors.

**Dr. Takahiro Imai**
Toshiba Infrastructure Systems & Solutions Corporation, Japan




Figure 1. IEEJ Technical report No. 1455.

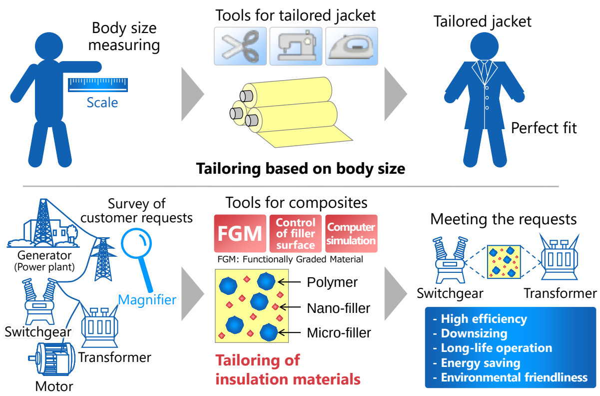


Figure 2. Concept of tailor-made composite materials.

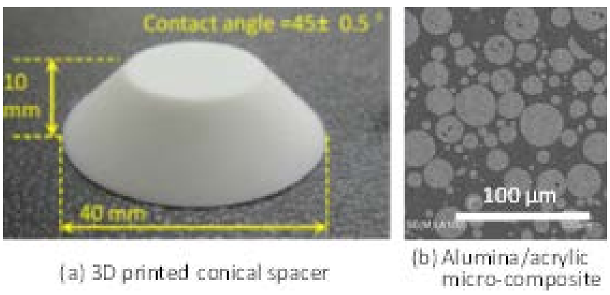


Figure 3. Insulation spacer model by additive manufacturing.

Reference: IEEJ Technical Report No. 1455, p. 59, Figure. 5-4-3 (2019)

# MISCELLANEOUS

## Photos on Front and Rear Covers

## Front Cover

### New Hokkaido-Honshu HVDC Link

The Hokkaido grid and the Honshu grid had been interconnected by Hokkaido-Honshu HVDC Link with a 600 MW LCC-HVDC.

In order to ensure reliable power supply of Hokkaido power system, Hokkaido Electric Power Co., constructed the New Hokkaido-Honshu HVDC Link (New Kitahon) by 300 MW and the New Kitahon was operated in March 2019.

For the new HVDC Link, the first Voltage Sourced Converter (VSC) - HVDC system in Japan was applied. The undersea tunnel (Seikan tunnel) constructed for railway was opted for the DC cable route to cross the Tsugaru Straits. The cable is the longest straits tunnel cable in the world as an EHV-cable. Moreover, the New Kitahon is one of very few VSC-HVDC types in the world that has both DC cable and overhead line sections with a total length of 122 km.

New Kitahon contributes to activation of the electricity trading between Hokkaido and Honshu, and expansion of renewable energy in Hokkaido.

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## Rear Cover

### Current Distribution Measurement under Non-uniform Electric Field by Current Integration Meter

In a space charge measurement, three-dimensional (3D) measurement techniques have been developed by using the PEA method in insulating polymer materials. As a result, space charge distribution and electric field distribution of insulating polymer can be measured even under non-uniform electric field. On the other hand, a current distribution measurement in an insulating polymer cross section has not been realized yet.

We have assembled a two-dimensional (2D) current integration meter (CIM) by using the DCIC-Q(t) method experimentally. And a current distribution I(x,y) of insulating polymer under a non-uniform electric field was measured.

The figure shows the sample structure and I(x,y) of the epoxy resin sample with 1 mm gap needle-plate electrode under 3 to 9 kV dc voltage application. The I(x, y) shows a mountain shape in which the position of the needle electrode is the top of the mountain under 5 kV or more. From these experimental results, the measurement accuracy of I(x, y) is considered to be around 10 pA.

In the needle-plate electrode system, the prediction that I(x, y) becomes a mountain shape when a dc voltage is applied is experimentally clarified for the first time by using the 2D-CIM.

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# Journals of IEEJ

A Journal which is edited by the headquarters of the Institute and five transactions which are edited by five technical societies* A to E are monthly published.

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An English journal "IEEJ Journal of Industry Applications" is edited by the society D and published bimonthly. The papers can be downloaded free at present.


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https://onlinelibrary.wiley.com/journal/19429541
/(ISSN)1942-9541, (SCI registered)

Left: Electrical Engineering in Japan
https://onlinelibrary.wiley.com/journal/15206416
/(ISSN)1520-6416, (SCI registered)

They can be accessed from the website above:
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(*) Five technical societies in IEEJ are as follows:

**A: Fundamentals and Materials Society** (This magazine is published from EINA Committee under this society.)
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C: Electronics, Information and Systems Society
D: Industry Applications Society
E: Sensors and Micromachines Society
(please visit Portal site of IEEJ > English Top > Technical Societies)

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The A4 size technical reports listed below were prepared by investigation committees in technical societies A to E in IEEJ and published from November 2018 to November 2019. The extended summaries can be browsed in English on the web site below but the texts of technical reports are described in Japanese

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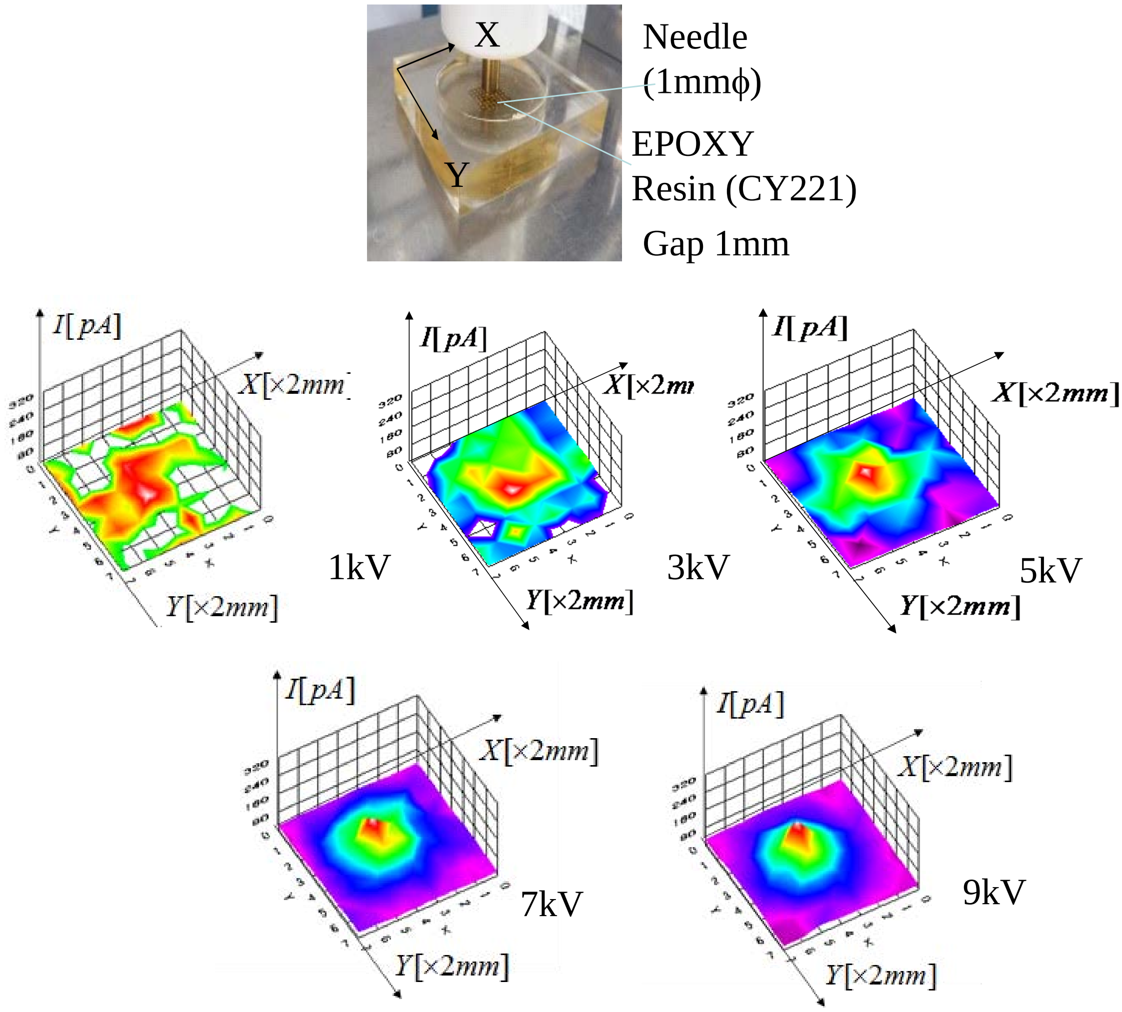


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