Electrical Insulation News in Asia

No.24 *December 2017*

IEEJ

CONTENTS

PREFACE

Prof. Naohiro HOZUMI

Maintenance and Condition Monitoring

Long time ago Japan experienced a very rapid economic growth. In order to catch up with rapidly increasing demand of electric power a large number of facilities were newly installed. At the same time, most of already aged facilities were automatically replaced in order to upgrade their power capacity. As the result ageing was not as serious as these days. In the middle of 1990s there happened an economic crisis that was called as collapse of the bubble economy. Although electric power consumption is still increasing, the investment to upgrade power capacity had shrunk. Nearly 30 years have passed since we had a massive growth in economy and installed new facilities. As they were typically designed to be operated for 30 years, some of them may be facing to the end of lifetime.

As the things are pretty probabilistic, failures do not happen at the same time when the designed lifetime has passed. At this moment number of failures in Japan is not so significant. Thanks to big effort of power-related companies, reliability in power supply is maintained extremely high comparing to any other countries. However we need to keep in mind that some unexpected failures after long term operation are being realized. If we recognize that these failures are just the head of statistical distribution, we may have to expect that a big wave of failure comes in the near future.

In order to maintain the reliability of the power infrastructure, what should be encouraged would be:

a) Establishment of asset managing strategy to simultaneously fulfill reliability and cost-effectiveness.
b) Survey on the failures and creation of database that can support the maintenance strategy.
c) Condition monitoring technology including measurement, diagnoses and residual life assessment.

More importantly we should appreciate those who are in charge of maintenance, which is not flashy but very essential.

Electrical insulation technology is the very core of electric infra-structure. Our knowledge is backgrounded by such as chemistry, physics, mathematics, informatics, and even economics. It is strongly expected that we make use of our high potential to avoid catastrophic power cut. In addition, for Asian countries that have grown up more rapidly, looking at what is going on in Japan is probably a good idea to avoid what may happen in the Asian countries in the near future. Technical exchange is strongly encouraged.

Dr. Naohiro HOZUMI
Professor of Toyohashi University of Technology, Japan

OUTLINE OF TECHNICAL COMMITTEES IN IEEJ

Dielectrics and Electrical Insulation (DEI)

Chairperson: Yasuhiro Tanaka (Tokyo City University)
Secretaries: Hiroyuki Nishikawa (Shibaura Institute of Technology)
Yoitsu Sekiguchi (Sumitomo Electric Co. Ltd.)
Assistant Secretaries: Norikazu Fuse (CRIEPI**)
Yuji Hayase (Fuji Electric Co. Ltd.)
**CRIEPI: Central Research Institute of Electric Power Industry

The Technical Committee on Dielectrics and Electrical Insulation (**TC-DEI**) has a long history from 1970, in which the former committee named as the Permanent Committee on Electrical Insulating Materials was established in IEEJ (the Institute of Electrical Engineers in Japan). The TC-DEI has started a new season from June 2016 with a chairperson, Prof. Y. Tanaka, who has continuously conducted the committee from the last season. The activity of the Committee has been covering mainly solid and composite dielectric materials and their technologies.

Organized events by TC-DEI

The important activity of TC-DEI is the annual domestic Symposium on Electrical and Electronic Insulating Materials and Application in Systems (**SEEIMAS**), formerly called Symposium on Electrical Insulating Materials, and the international symposium named "Symposium on Electrical Insulating Materials" (**ISEIM**), which is supposed to be held in every 3 years.

The 9th ISEIM (ISEIM 2017) was held at Toyohashi Chamber of Commerce & Industry, Toyohashi, from 12th to 15th September 2017, with technically cosponsored by IEEE DEIS, IEEE DEIS Japan Chapter, and financially supported by The Obayashi Foundation and Support Center for Advanced Telecommunications Technology Research Foundation. Totally 201 papers (new record) including 2 invited papers were listed in the symposium proceedings. There were 78 oral and 123 poster presentations (including demonstrations). During the conference, 257 participants (also new record) from working with industry, government, research and academic institutions shared their experiences and discussed the latest developments and future challenges confronting the field. The symposium covered the topics of diagnostic techniques, inverter surge and partial discharge phenomena, biological and organic electronics technology, and space and surface charge phenomena. Especially in this year's ISEIM, the special session featuring "Development of Electrical Insulation Evaluation of Inverter-Fed Motors for the IEC Standardizations" was held with a demonstration test sets for the Round Robin Test. In the next year, the 49th SEEIMAS is supposed to be held in Matsuyama, Ehime, in middle of September. The details are not fixed yet.

Investigation Committees run by TC-DEI

Adding to organize some events, the TC-DEI runs Investigation Committees (IC's) that organize several technical meetings every year. The investigation committees are categorized into three research areas:

New materials including nano-materials related

> Advanced Nanostructure Control for High-Performance Organic Devises and Life Science

Fig.1 Group photo in ISEIM 2017.

(07/2014 - 06/2017, Chairperson: K. Kato (Niigata University)). This committee has been already finished after publishing a technical report, and it has been succeeded by a new committee named "Advanced Nanomaterials and Nanostructure Control for Innovative Organic Devices and Life Science" (07/2017 - 06/2020, Chairperson: K. Kato (Niigata University)).

> Application to the Next-generation Electronics of the Study of Organic Dielectricity and Functionality of Electrical and Electronic Materials in the District of Asia (04/2014 - 03/2017, Chairperson: M. Iwamoto (Tokyo Institute of Technology)). This committee has been already finished after publishing a technical report.

> Advancing Tailor-made Composite Insulation Materials (07/2015 - 06/2018, Chairperson: T. Tanaka (Waseda University)).

Ageing and diagnosis of electric and electronic equipment related

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

Basic dielectric and breakdown phenomena related

> Electrical insulation technologies under cryogenic temperature (10/2015 – 09/2018, Chairperson: N. Hayakawa (Nagoya University)).

Space charge accumulation characteristics and standardization for measurement

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

Above committees are basically requested to publish the technical reports when the activity of them are expired. All reports are basically published in Japanese. However, recently, the Investigation R&D Committee on Advanced Polymer Nanoconposite Dielectrics (04/2010 - 03/2013, Chairperson: T. Tanaka (Waseda University)), had challenged to publish the technical report in English. The book entitled "Advanced Nanodielectrics -Fundamental and Applications-" edited by Toshikatsu Tanaka and Takahiro Imai, has been published in 2017 from Pan Stanford Publishing, Pte. Ltd. (Print ISBN: 9789814745024), and a tutorial organized by the authors of the book was held prior to ISEIM 2017. The tutorial was successfully carried out with participants of more than 50 persons. It means that the transmission of information from the technical committees of IEEJ DEI have a potential to attract the researchers all over the world. We would like to challenge to increase such activity gradually in the future.

Electrical Discharges(ED)

Chairperson:	Haruaki Akashi	(National Defense Academy)
Secretaries:	Akiko Kumada	(The University of Tokyo)
	Hiroshi Kojima	(Nagoya University)
Assistant Secretaries:	Yasushi Yamano	(Saitama University)
	Naohiko Shimura	(Toshiba Corporation)

The Technical Committee on Electrical Discharge (TC-ED) belongs to the Fundamentals and Materials Society of the IEE Japan. The origin of the TC-ED is the Expert Committee on Electrical Discharges, which was established in January 1954. That is, the TC-ED has supported the development of science and technologies on electrical discharges in Japan for a long time.

The purposes of the TC-ED are mainly the wide promotion of the research activities concerning to a variety of electrical discharges in vacuum, gas, liquid and on surfaces of materials and their applications to high technologies, especially aiming an environmentally sustainable technology for the next generation.

Investigation committees, which are the affiliates of the TC-ED, are established to survey the up-to-date research subjects. The activities of these committees usually continue for three years. Each committee generates very useful technical report at the end of the active period. Unfortunately, there is no investigation committee is currently active.

The TC-ED organizes about six domestic technical meetings on electrical discharges every year. In these meetings, nearly 200 papers are presented from both academic and industrial sides. The technical meeting is also useful to train and encourage young researchers including students. Every year, about 10 young researchers receive Young Researchers Prize from Technical Society of Fundamentals and Materials and IEEJ. The domestic technical meetings are sometimes co-organized by other Technical Committees such as Dielectrics and Electrical Insulation, Pulse Electromagnetic Energy, Plasma Science and Technology, High Voltage Engineering, and Switching and Protecting Engineering.

In order to promote the international activities, The 10th Asia-Pacific International Symposium on Basics and Applications of Plasma Technology (APSPT10) is co-organized by TC-ED which was held in Taoyuan, Taiwan on December 15 to 17. 6 Plenary speakers, 3 Tutorial speakers and 25 invited speakers + 172 contributed papers were presented.

The TC-ED 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. 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 for two days.

Pulsed Electromagnetic Energy (PEE)

Chairperson:	Koichi Takaki	(Iwate University)
Vice-Chairperson:	Jun Hasegawa	(Tokyo Institute of Technology)
Secretary:	Douyan Wang	(Kumamoto University)
Assistant Secretary:	Toru Sasaki	(Nagaoka University of Technology)

Pulsed electromagnetic energy produced by pulsed power, which refers to huge power within an extremely short period of time. The power level reaches 300 TW. The period of time goes down to sub-nanosecond range. Pulsed power is often focused in a narrow space to produce an extremely high power density. Pulsed power is basically produced by means of a rapid energy transfer from an energy storage medium to the load. The pulse power technology and the pulsed electromagnetic energy have greatly expanded their regimes in technological and application fields, based on the state-of-the-art technology of power devices. Trend of the device is shifted from a single-shot huge machine to highly repetitive compact devices.

The research field of the Technical Committee on Pulsed Electromagnetic Energy (TC-PEE) has 17 members from various fields on pulsed power science and technology in Japan. TC-PEE covers electric power engineering, plasma and discharge engineering, high energy density physics, accelerator engineering, bio-medical engineering. By the modification of pulsed electromagnetic energy, we can make an extremely high energy density (high temperature and/or high density) state with well-defined condition, which can be utilized for generations of high power lasers, intense radiation sources, high current particle beams and also for formation of new materials. The pulsed power technology is also capable of efficiently producing non-thermal equilibrium plasmas. A large volume, atmospheric pressure non-thermal plasmas is utilized for decomposition of toxic gases, ozone synthesis and sterilization. The pulsed power driven underwater discharge plasmas can be utilized for cleaning the water environment.

The major activity of TC-PEE is to collect the cutting-edge science and technology through the activity of the investigation committees and to organize several technical meetings every year to exchange information on pulsed power technology and its applications. Recent activities are as follows: In 2016, we had four technical meetings in January at National Institute for Fusion Science (NIFS) in Toki, in May at Iwate University in Morioka, in August at Tokushima University in Tokushima, and in October at Saga University in Saga. In 2017, three technical meetings were also held, in January at NIFS in Toki, in May at Kyoto Institute of Technology in Kyoto, and in October at Kumamoto University in Kumamoto. Each meeting usually has 20–40 oral presentations. The oral presentations by young researchers including undergraduate and graduate students are strongly encouraged, and they are nominated for young presentation award. Some of the technical meetings are jointly organized with the Technical Committees on Plasma Science and Technology (TC-PST) and Electrical Discharges (TC-ED).

In August 2017, TC-PEE co-hosted a 9th International Workshop on Plasma Scientech for All Something (PLASAS-9) at Kumamoto University, Kumamoto, Japan, together with the PLASAS International Organizing Committee, the TC-PST Committee (Fig.1). The PLASAS has ever been held every years in China and Japan to promote fundamental and applied plasma and pulsed power researches for scientists and engineers in Japan and China. The next PLASAS will be held in Dalian University of Technology, China, in August 2018.

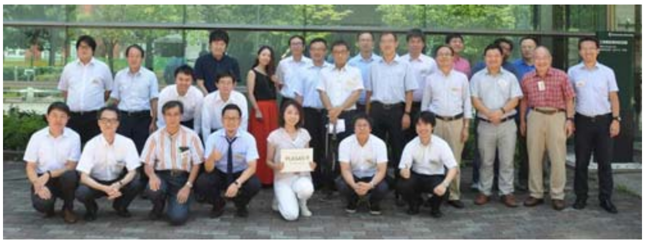

Fig. 1. Participants of PLASAS-9 at Kumamoto Univ.

TC-PEE is currently running two investigation committees. One is the committee on "Advanced Technologies in Highly Repetitive Pulsed Power Generators and Their Industrial Applications" chaired by Prof. Weihua Jiang of Nagaoka University of Technology. This committee covers the high repetition rate ranging to 1 MHz, semiconductor-driven voltage multiplier including Marx and Linear Induction Driver (LTD) circuits, FPGA-controlled smart pulsed power circuits as well as advanced power devices including SiC, GaAs and laser-triggered photoconductive devices. The other committee is on "Physics and Engineering of High Energy Particle Beams using Pulsed Power Technology" chaired by Prof. Takashi Kikuchi of Nagaoka University of Technology, which started in May 2016. This committee is investigating the recent progress on the inertial confinement fusion (ICF), the high energy heavy ion beam as the ICF driver, as well as accelerators and the related technologies based on pulsed power. Both committees have been carrying out their task actively and contributing to the community.

Plasma Science and Technology (PST)

Chairperson: Tatsuru Shirafuji (Osaka City University)

Secretaries: Nozomi Takeuchi (National Institute of Advanced Industrial Science and Technology)

Ryuta Ichiki (Oita University)

Assistant Secretaries: Takuya Kuwahara (Nippon Institute of Technology)

The Technical Committee on Plasma Science and Technology (TC-PST) in Institute of Electrical Engineers of Japan (IEEJ) was founded in April 1999. This committee is originally based on the plasma researcher's society that had organized technical meetings on plasma science and technology in IEE Japan several times a year since about 30 years ago. The activity field of this committee includes researches and investigations on fundamentals and applications of various plasmas over wide ranges of their density, temperature, ionization degree such as nuclear fusion, plasma processing, and plasma chemistry.

The TC-PST has 17 members from various fields on plasma science and technology in Japan. The major activity of this committee is to organize several technical meetings on plasma science and technology every year. Recent activities are as follows: In 2017, we had three technical meetings in May at Kyoto Institute of Technology in Kyoto, in August at Chubu University in Aichi and in October at Kumamoto University in Kumamoto. Each meeting usually has 20–40 oral presentations. The oral presentations by young researchers including undergraduate and graduate students are strongly encouraged, and they are nominated for young presentation award. In addition, some of the technical meetings are jointly organized with the technical meetings of Pulse-Power Technology (TC-PPT) and Electrical Discharges (TC-ED). In 2017, we have had two joint meetings with them.

Fig. 1 A photograph of an oral session in APSPT-10.

In August 18-20, 2017, the TC-PST co-hosted an international workshop of the 9th International Workshop on Plasma Scientech for All Something (PLASAS-9) at Kumamoto. In December 15-17, 2017, the TC-PST will co-host an international symposium of the 10th Asia-Pacific International Symposium on the Basics and Applications of Plasma Technology (APSPT-10) at Chung Yuan Christian University, Taoyuan, Taiwan, together with the APSPT International Organizing Committee, the TC-ED, the TC-PPT, and the JSPS 153 Committee. The APSPT has ever been held every two years in Taiwan over 16 years to promote fundamental and applied plasma researches for scientists and engineers in Japan and Taiwan. The previous APSPT-9 was held in Nagasaki, Japan, and the next APSPT-11 will be held in Japan again, in December 12-14, 2019 at Kanazawa. The chair of the APSPT-11 is Prof. Tanaka in Kanazawa University, who was the former chairperson of the TC-PST.

Recently, the TC-PST and TC-PPT had decided to unify these technical committees for further development of science and technology of plasma and pulse power, because recent research activities on plasma science and technology frequently utilize pulse power technology for obtaining low-temperature plasma under atmospheric pressure conditions. Low-temperature atmospheric pressure plasma is now utilized various applications such as environmental protection, agriculture, biology, and medicine. Thus, the integration of the TC-PST and TC-PPT is inevitable. This activity had been authorized by IEEJ in March 6, 2015. The TC-PST and TC-PPT will be unified as The Technical Committee on Plasma and Pulse Power (TC-PPP) in January 2018. The newly organized TC-PPP will hold the kick-off symposium during the period of the annual meeting of IEEJ which will be held in March 14-16, 2018, at Ito Campus, Kyushu University in Kyushu.

Electrical Wire and Cables (EWC)

Chairperson: Masayuki Hikita (Kyushu Institute of Technology)
Secretaries: Kenichi Furusawa (Sumitomo Electric Industries, Ltd.)
Hiroshi Nishino (Fujikura, Ltd.)
Kouji Miura (SWCC Showa Cable Systems Co., Ltd.)
Yoshihisa Nagoya (Furukawa Electric Co., 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 an opportunity to present technical achievements and to promote R&D activities in this field. Three technical meetings were so far held in March, 2017 on ‘Degradation diagnosis and judgement of wires, cables and power apparatuses’ held as a joint meeting of TC-DEI and TC-EWC, in October on ‘Products and accessories technology trend of cables and wires’, and in November on ‘Insulation performance and aging in cables and electrical properties of dielectric and insulating materials’.

The technical committee plans to hold 2 more technical meetings in Japanese FY2017, one of which will be jointly organized by TC-DEI and TC-EWC. The topics of the technical meetings will be

‘Technological trends in diagnostics and maintenance in cables and wires’ and ‘Technology trends in cable and wire systems (product technology, aging mechanism clarification, diagnostics, evaluation, judgement methods)‘.

The technical committee will hold a symposium on ‘Status Quo and Issues in Diagnosis and Evaluation Methods for Insulation Dignity of Distribution Wire and Cables’ in Annual Conference of IEEJ in March, 2018.

The Technical Committee will also hold a forum on ‘Status Quo and Issues in Environmental Responsiveness of Insulation Wires and Cables’ in March, 2018.

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 new investigation committees were started in April and July in FY2017 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’. The Investigation Committee for the Status Quo and Problems of Diagnosis and Evaluation Methods for Distribution Wire and Cables was finished in September, 2016. Then, a technical report of the investigation committee is scheduled to be published in March 2018.

The technical committee also organized a technical visit. This year the technical committee members visited Nippon Steel & Sumitomo Metal Corporation, Yawata Works in December 7th, 2017.

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 53 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, succeeding Prof. Tatsuki Okamoto of WG7, 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 September 25 to 29, 2017, IEC TC 112 Meeting was held in Delft, the Netherlands, and meetings of WGs were held during the weeks. 5 experts from JNC participated in the TC 112 meetings including the Plenary, Advisory group and WGs meetings.

The meeting in Delft was the first meeting for Mr. Bernd Komanschek as Secretary of TC 112, who has succeeded Mr. Bernd Goettert, after the TC 112 plenary meeting in October 2016. The meeting observed a minute of silence in remembrance of Mr. Tomiaki Sakano, a veteran expert in TC 112 JNC, who had passed away in November 2016. Also, Mr. Sakano received IEC 1906 Award 2017.

The next meetings of TC112 will be held in Vienna, Austria from September 17 to 21, 2018.

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.

IEC/TS 60216-7-1: Electrical insulating materials - Thermal endurance properties - Part 7-1: Accelerated determination of relative thermal endurance using analytical test methods (RTEA) – Instructions for calculations based on activation energy.

The convenor has been replaced by Mr. Roger Wicks, succeeding Prof. Gian Carlo Montanari.

There is a need to harmonize nomenclature on thermal endurance between WG1 and WG6, following up from the ‘TI expression’ meeting from Frankfurt. Therefore, a JWG is in progress to be established.

WG2: IEC/TR 61244-4: Effects of radiation under non-ambient environments; Effect of temperature.

WG3: IEC 61934 Ed.1: Electrical insulating materials and systems - Electrical measurement of partial discharges (PD) under short rise time and repetitive voltage impulses.

The plenary agreed to disband JWG12 with TC 2.

WG4: IEC 62631-2-1: Dielectric and resistive properties of solid insulating materials Part 2-1: Relative Permittivity and dissipation factor – Technical Frequencies (1 – 100 MHz), AC Methods.

IEC 62631-3-4: Dielectric and resistive properties of solid insulating materials - Part 3-4 Method of test for electrical resistance and resistivity of insulating materials at elevated temperatures.

IEC 62631-3-11: Dielectric and resistive properties of solid insulating materials – Part 3-11: Determination of resistive properties (DC Methods) – Volume resistance and volume resistivity, method for impregnation and coating materials.

IEC 62631-3-12: Determination of dielectric and resistive properties of solid insulating materials – Part 3-12: Determination of resistive properties (DC Methods) – Volume resistance and volume resistivity, method for casting resins.

JNC suggested to revise IEC 62631-1, 62631-3-1, 62631-3-2 and 62631-3-3. The plenary agreed to revise IEC 62631-3-1 and IEC 62631-3-2 with Mr. Jun Haruhara (JP) as project leader.

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 61621: Dry, solid insulating materials - Resistance test to high-voltage, low-current arc discharges.

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

WG7: IEC/TR 60493-3: Guide for the statistical analysis of aging test data - Minimum specimen numbers at different test conditions with given experimental data.

The plenary approved Dr. Kudoh as the new convenor, succeeding Prof. Okamoto.

WG8: IEC/TR 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 electro-acoustic (PEA) measurement principle.

RESEARCH ACTIVITIES AND TECHNICAL EXCHANGES IN ASIAN COUNTRIES

Conference Records

1st IEEE International Conference on Electrical Materials and Power Equipment (ICEMPE 2017)

The first International Conference on Electrical Materials and Power Equipment (ICEMPE), co-sponsored by Engineering Dielectrics Committee of China Electrotechnical Society and IEEE DEIS, was held on May 14-17, 2017, in Xi'an, China (Picture 1). It was organized and technically supported by Xi'an Jiaotong University. ICEPME is a promotion of Chinese National Conference on Engineering Dielectrics (NCED), which was founded in 1983 as a biennial forum and has already been successfully conducted for 15 times. Shengtao Li (Xi'an Jiaotong University, China) chaired the conference (Picture 2).

Experts from industry and academic were invited to join Organizing Committee and International Advisory Committee and give invited talks. More than 200 participants, from 15 countries of both academia and industry, added color to the conference. Chen Jidan Award and Memorial Lecture was established and conducted in the 1st ICEMPE. This lecture is named in honor of Chen Jidan, a pioneer in the development of electrical insulation and dielectrics in China. Kai Wu (Xi'an Jiaotong University, China) won the 1st Chen Jidan Award (Picture 3) and he delivered the Memorial Lecture on "Space Charge Behavior under Temperature Gradient and Its Effects on Material Aging". 5 oral sessions including Power Cables, Transformers, GIS and Circuit Breakers, Capacitors, Electric Motors and 3 poster sessions (Picture 4-5) were scheduled in the conference. 12 invited speeches were given (Table 1). In particular, a "China Session" was organized in dual language of English and Chinese, to help improve communication of engineers in China (Picture 6).

Prior to the conference, Workshop on Advanced Power Equipment was held. A group of leading scientists and engineers were invited to talk on fundamentals and applications of dielectrics and electrical insulation. The attendance was extremely good and the workshop attracted many young researchers. The feedback from many attendees was positive.

It is believed that the 1st ICEMPE is a great success. During the conference, the 2nd and 3rd ICEMPE venues were decided. It will be held in Guangzhou and Chongqing of China in years 2019 and 2021 respectively.

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Table 1 Presenters and titles of invited speeches.

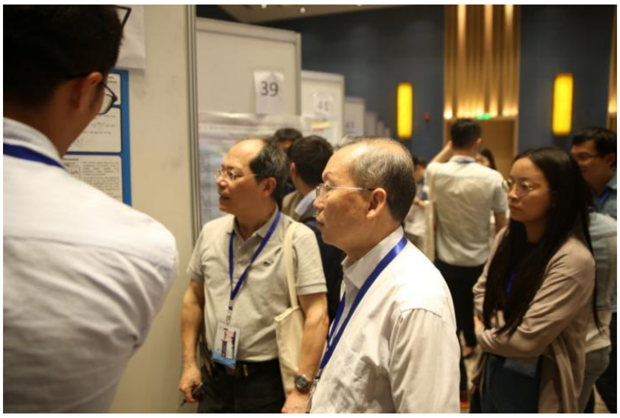
No.	Name of Speaker	Title of Presentation
1	Chen Jidan Memorial Lecture -- Kai Wu (Xi'an Jiaotong University, China)	Space Charge Behavior under Temperature Gradient and Its Effects on Material Aging
2	Prof. Stéphane Holé Université Pierre et Marie Curie, France	Space charge distribution measurements and industrial uses
3	Prof. Xingyi Huang Shanghai Jiao Tong University, China	Ultrahigh Thermal Conductivity Enhancement in Polymer Insulating Materials by Constructing 3D BN Nanosheet Networks
4	Prof. Zhongdong Wang University of Manchester, UK	Methanol and Ethanol as Alternative Transformer Paper Ageing Indicators
5	Prof. Ahmed Abu-siada Curtin University, Australia	Correlation between Dissolved Gases and Oil Spectral Response
6	Dr. Hajime Urai Hitachi, Ltd., Japan	Simulation and Measurement for Development of High-voltage Circuit Breakers

6	Dr. Hajime Urai Hitachi, Ltd., Japan	Simulation and Measurement for Development of High-voltage Circuit Breakers
7	Dr. Henri Bonhomme ABB, Belgium	The Dilemma of the Capacitor: a Commodity or a High Tech Component
8	Prof. Alun Stuart Vaughan University of Southampton, UK	Molecular Design of Next-generation Dielectric: Powering the Future through Designer Materials
9	Prof. Alistair Duffy De Montfort University, UK	Transmission Line Matrix (TLM) Simulation of the Propagation of Partial Discharge Phenomenon in Transmission Lines
10	Mr. Wen Wang Suzhou Jufeng Electrical Insulation System Co., Ltd, China	Developing a Novel Environment Friendly Epoxy Solventless Impregnating Resin without Anhydride for High Voltage Motor
11	Prof. Ping He Nanjing Electric (Group) Co., Ltd, China	HV Bushing and Insulation Materials
12	Prof. Rongsheng Liu ABB, Sweden	Progress of Long-Distance DC Electrical Power Transmission

Picture 1 Group photo of the 1st ICEMPE

Picture 2 Shengtao Li, Conference Chair

Picture 3 Kai Wu accepting Chen Jidan Award



Picture 4 LishengZhong and Yewen Zhang


Picture 6 John Fothergill asking questions

Picture 5 At the Poster Session

2017 International Symposium on Electrical Insulating Materials (ISEIM 2017)

The eighth International Symposium on Electrical Insulation Materials (ISEIM) was conducted from Sept. 11 to 15, 2017 in the Toyohashi Chamber of Commerce & Industry, Toyohashi, Japan. It was hosted by the Technical Committee on Dielectric and Electri- cal Insulation of the Institute of Electrical Engineers of Japan (IEEJ). The ISEIM intends to introduce an annual domestic Symposium on Electrical and Electronic Insulating Materials and Applications in Systems to the international audience.

The ISEIM conference covered nanotechnology, material aging, phenomena under inverter surge, and several other fundamental material research topics. The conference had accepted 201 research papers and had invited nine lecturers for the workshop. The papers accepted include 78 oral presentations, 104 poster presentations, 11 industrial exhibitions, and 8 device demonstrations. The category-wise statistics for the selected papers based on their abstracts is summarized in Fig. 1. It can be observed that there were more than 11 topics. During the conference, 256 participants from twenty different countries (Table 1), who were collaborating with the industry, government, and research and academic institutions shared their experiences and discussed the latest developments and future challenges that are confronting them in their research fields. Figure 2 illustrates a group photo that was captured at the end of the conference banquet.

The conference commenced with opening remarks from Prof. Y. Tanaka of Tokyo City University, who was the general chair of the symposium. Dr. Christian Laurent of Université de Toulouse delivered the Inuishi memorial lecture. His presentation that was titled “Energetics of Charge Transport in Insulating Polymers” described the research that was conducted to understand the aging and breakdown mechanism from an electronic viewpoint. Electroluminescence was introduced to identify the critical transport regime in which energy release would result in degradation of the material (Fig. 3).

A special session was organized to present the development in electrical insulation evaluation of inverter-fed motors. The corresponding investigating R&D committee in IEEJ arranged the session to present the recent development in the qualification procedure of random-wound motors by detecting partial discharges that are arising from high-voltage and high-repetition surges. A plenary lecture was presented by Dr. Andrea Cavallini from the University of Bologna (Fig. 4). Various other digest reports were also presented by the R&D committee members to depict how the round-robin test results have contributed to the IEC standards. The device that was used to perform the test was also exhibited during the demonstration session.

Another separated special session was also conducted on numerical simulation to disseminate knowledge about band energy structures, charge storage, charge transportation, and conformational structure analysis. This session was titled APIANS,

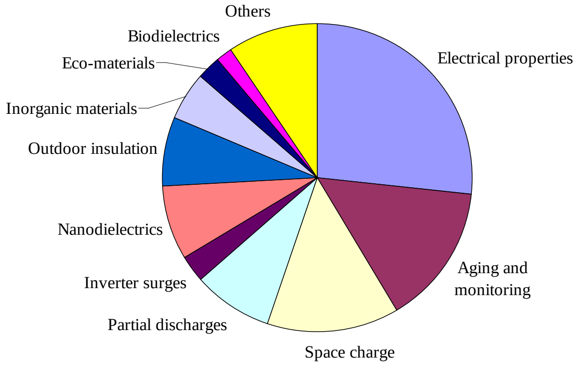


Fig. 1. Types of presentations

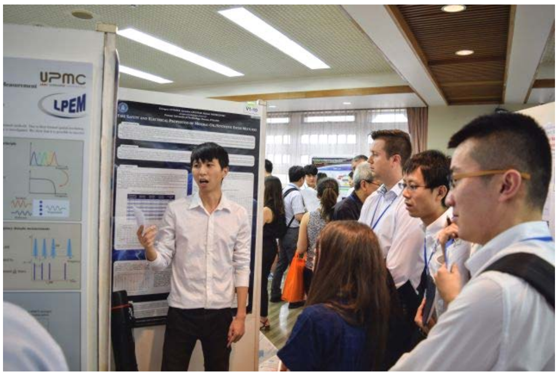
Table 1. Country-wise distribution of participants.

Japan	126	China	44
Korea	23	France	18
India	6	Thailand	6
Italy	5	Australia	4
Sweden	4	U.K.	4
Malaysia	3	Vietnam	3
Germany	2	The Netherlands	2
Canada	1	Indonesia	1
Kazakhstan	1	Poland	1
Singapore	1	Switzerland	1
		Total	256

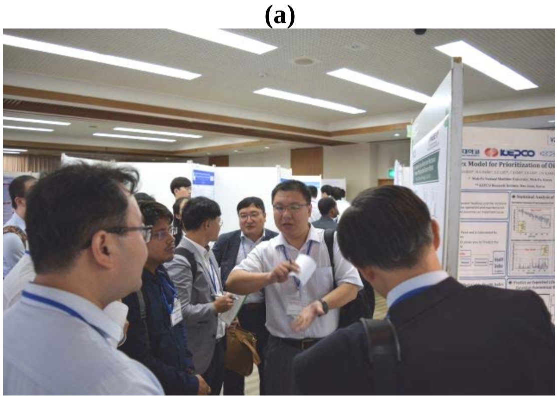
Fig. 2. Group photo

Fig. 3. C. Laurent during his Inuishi memorial lecture

Fig. 4. A. Cavallini during his plenary lecture



(a)



(b)

Fig. 5. Pictures of the MVP session

which means Analysis for Polymeric Insulating Materials Using Advanced Numerical Simulation. The 2017 symposium was conducted to follow the huge success of the 2014 symposium and various other conferences. The presentation by Dr. Michel Unge of

Table 2. Invited lectures on the sessions

Speaker	Affiliation	Title
Christian Laurent	Univ. Toulouse, France	Energetics of Charge Transport in Insulating Polymers
Andrea Cavallini	Univ. Bologna, Italy	Reliability of Low Voltage Inverter-fed Motors. What Have We Learned, Perspectives, Open Points
Stefan Kornhuber	Univ. Appl. Sci. Zittau/Görlitz, Germany	Evaluation of the Influence of Low Molecular Weight Components to the Retention of the Hydrophobicity of Silicones by Using the Dynamic Drop Test
Gilbert Teyssèdre	LAPLACE, France	Impact of Press-Molding Process on Chemical, Structural and Dielectric Properties of Insulating Polymers
Ramanujam Sarathi	Indian Inst. Tech. Madras, India	Understanding Corona Activity in Nanoparticles Dispersed Transformer Oil under Harmonic AC Voltages
Stéphane Holé	LPEM/UPMC, France	PPLP and Kraft Paper Under High Voltage in Liquid Nitrogen
Toshikatsu Tanaka	Waseda Univ., Japan	A Quantum Dot Model for Nanoparticles Dispersed in Polymers: How does it work?
Michel Fréchette	Hydro-Québec's Res. Inst., Canada	Fabrication and Characterization of LDPE Si/SiO_2 Core/shell Nanocomposites
Hiroyuki Muto	Toyohashi Univ. Tech., Japan	Nano/Micro-Composite Particles. Preparation Process and Applications
Ken Kimura	Nara Nat. Inst. Tech., Japan	The Role of IEC 60034-27-5 for IEC 60034-18-41. Offline PD Test Methods with Repetitive Impulse Voltage
Gian Carlo Montanari	Univ. Bologna, Italy	Partial Discharge and Aging Phenomena in Insulation Systems of Rotating Machines Fed by Power Electronics
Yi Yin	Shanghai Jiao-tong Univ., China	Space Charge Measurement of Cross-linked Polyethylene at Low Temperatures
C. C. Reddy	Indian Inst. Tech. Roper, India	Investigation on Nanocomposite Materials for Power Cable Insulation
Shengtao Li	Xi'an Jiaotong Univ., China	Study on Short-term DC Breakdown and Corona-resistance Mechanism of Polyimide
Mitsuyoshi Onoda	Univ. Hyogo, Japan	Detection of Environmental Pollutants with Oxidoreductases
Mikael Unge	ABB Corporate Research, Sweden	High Field Ion Mobility in Dielectric Polymers. A Molecular Dynamics Study of Water in Poly(dimethylsiloxane)
Kai Wu	Xi'an Jiao Tong Univ., China	A Numerical Simulation Model for Oil Flow Electrification under DC Voltage
Suwamo	Inst. Tek. Bandung, Indonesia	Effects of Thermal Aging on Paper Characteristics in Paper-Mineral Oil Composite Insulation

ABB Corporate Research was an invited lecture in this session. In addition to his presentation, eleven other lectures were selected to be 'session invited' to encounter in various key fields. Table 2 lists the speakers and the titles of their lectures.

A special poster session that was titled "mutual visiting-type poster (MVP) session" was organized to remain faithful to the ISEIM tradition of encouraging young researchers to expand their horizons. Presenters were instructed to exhibit their abilities using their posters. They were required to give their own results to the remaining members of the group. The remaining group members asked questions to the presenter after the short presentations. This encouraged all the participants to engage in meaningful and productive discussions and to overcome language barriers (Fig. 5). Eleven outstanding presenters who are listed in Table 3 were recognized with awards during the conference

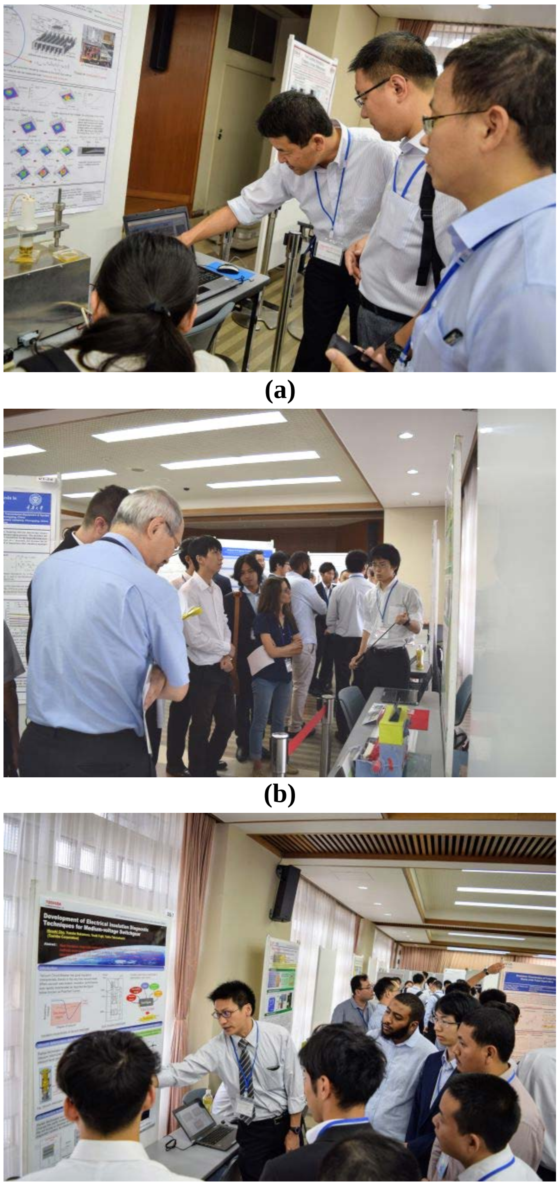
Table 3. Papers that were awarded for valuable presentations during poster sessions

Speaker	Affiliation	Title
Daomin Min	Xi'an Jiaotong Univ., China	Trap and Carrier Transport of Pristine and Aged Silicone Rubber by Surface Potential Measurements
Louiza Hamidouche	LPEM, France	Electro-Acoustic Reflectometry: Reaching High Spatial Resolution and High Sensitivity for Space Charge Measurements
Salem Mgammal Awadh Nasser Al-Ameri	Univ. Tun Hussein Onn Malaysia	Examining Faulty Transformer Tap Changer using Frequency Response Analysis
Tsuyoshi Tohmine	Tokyo City Univ., Japan	Measurement of Space Charge Accumulated in Multi-layered Samples Composed of Different Insulators Used in the Joints of DC Transmission Cables
Masahito Miyoshi	Tokyo City Univ., Japan	Charge Accumulation Characteristics of Fluorine Insulating Materials under Electron Beam Irradiation
Yuki Fuchi	Kyushu Inst. Tech., Japan	Permittivity Estimation of Hydrocarbon-based Thermosetting Resin Using Quantum Chemical Calculation
R. Sarathi	Indian Inst. Tech. Madras, India	Analysis of Incipient Discharge Activity in Nano Particles Dispersed Ester Oil Insulation
Yu Gao	Tianjin Univ., China	Effect of Elastomer Type on Electrical and Mechanical Properties of Polypropylene/ Elastomer Blends
Norikazu Hamasaki	Toyohashi Univ. Tech., Japan	Influence of Filler Orientation and Molding Temperature on Electrical and Thermal Properties of PMMA/h-BN Composite Material Produced by Electrostatic Adsorption Method
Takuya Kaneko	Waseda Univ., Japan	Terahertz Absorption Spectroscopy of Poly(ether ether ketone) Comparative Study of Mechanical and
Mrutyunjay Maharana	Indian Inst. Tech., Guwahati, India	Electrical Strength of Kraft Paper in Nanofluid Based Transformer Oil and Mineral Oil

banquet. T. Tohmine of Tokyo City University won "the most valuable presentation" award, which enabled the researcher to participate in the Korea–Japan Young Researcher Exchange Program. This symposium also carried out this program to receive a presentation from Mr. Chul-Ho Kim of Hoseo University, who won the same award for his presentation at the Korean conference.

Another continuous objective of the symposium was to provide the researchers with an opportunity to meet other researchers from across the world. Recently, efficient communication between researchers from the industry and academia has become increasingly important. The session introducing industrial R&D topics was entitled the "sun-shine" session - the title originates from a Japanese pun. The session helped to foster mutual understanding among researchers in both the industry as well as the academia who are working in the field of electrical insulation materials. This session and the aforementioned instrumental demonstrations were conducted along with the MVP session to improve collaboration (Fig. 7).

Additionally, the symposium conducted a workshop on the recent industrial development of nanodielectrics in Japan. An English book named "Advanced Nano-dielectrics - Fundamentals and Applications" was



(a)

(b)

(c)

Fig. 7. Pictures captured during the demonstration and industry sessions

published by the Investigating R&D Committee on Advanced Polymer Nanocomposite Dielectrics, which was chaired by Prof. T. Tanaka from 2010 to 2013. The book illustrates the investigations that were conducted by renowned Japanese expert committee members. The workshop introduced an outline of this book to assist researchers in this field (Table 4).

The local organizing committee arranged two kind of technical tours. The first group went to Hamamatsu Photonics, a Japanese optical sensor manufacturer (Fig. 8). The factory visited was the electron tube division for photomultiplier tubes, renowned for the Super-Kamiokande neutrino facility for which the Nobel Prize was awarded in 2015. The second group visited Honda Electronics and TUT Hozumi Lab. Both these places are renowned for the usage of ultrasonic technology. The second group also went to a historical venue called Futagawa-syuku Honjin Museum.

Table 4. List of lectures that were conducted in the workshop on nanodielectrics

Speaker	Affiliation	Title
Takahiro Imai	Toshiba Co., Japan	Applications Part I–Switchgears and Motor Windings
Takanori Kondo	NGK Insulators, Ltd., Japan	Applications Part II–Outdoor Insulations
Takashi Ohta	Panasonic Co., Japan	Applications Part III–Insulating Substrates and Electronic Devices
Kenji Okamoto	Fuji Electric Co., Ltd., Japan	Applications Part IV–LSI and Power Electronics
Yoshiyuki Inoue	Sumitomo Electric Industries, Ltd., Japan	Applications Part V–dc Power Cables
Yasuhiro Tanaka	Tokyo City Univ., Japan	Fundamentals Part I–Space Charges
Muneaki Kurimoto	Nagoya Univ., Japan	Fundamentals Part II–Permittivity, Water Tree, etc.
Toshikatsu Tanaka	Waseda Univ., Japan	Fundamentals Part III–Electrical Teeing and Partial Discharges
Masahiro Kozako	Kyushu Inst. Tech., Japan	Theoretical Aspects–Characterization, Computer Simulation, etc.

The local committee invited all the conference participants to a banquet and an award ceremony, which was followed by a cultural evening. A dance performance wearing a traditional samurai costume was presented after a short introduction by Prof. Hozumi, the honorary chair, and his student. Socialization among the researchers was encouraged using a sake tasting event (Fig. 9).

ISEIM 2017 has concluded on a successful note with record-breaking number of participants. The International Advisory Committee met to summarize the status of the conference. The next ISEIM would be conducted in Tokyo in 2020. We hope that all the participants and their families enjoyed a delightful time that was filled with friendship and kindness. The organizing committee is proud to have had an opportunity to organize this symposium.

Finally, we would like to sincerely express our gratitude to all the participants and members of the organizing committee for their contributions to the symposium. As a member of the secretariat, the author of this article would further like to appreciate the students who volunteered to conduct the conference smoothly by helping at the registration desk as well as during the presentation sessions. It has to be noted that the background work performed by these students was invaluable and that these sessions would not have been successful without their help. We hope that all the participants will return to Japan for ISEIM in 2020.

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Fig. 8. A picture that was captured during the technical tour

(a)

(b)

(c)

(d)

Fig. 9. Pictures that were captured during the banquet

International Conference to be held in Asia

ICPADM 2018 (International Conference on the Properties and Applications of Dielectric Materials)

Dates: May 20-24, 2018
Venue: Paradise Resort Hotel, Xi'an, China
Sponsored by:
The IEEE Dielectrics and Electrical Insulation Society
Organized by: Xi'an Jiaotong University
Chairman: Prof. Shengtao Li,
Xi'an Jiaotong University, China
URL: www.icpadm2018.org

ICPADM started in Xi'an in 1985 with the initial aim to provide a venue for Chinese electrical insulation and dielectrics researchers to communicate their research activities with the rest of the world. Actually ICPADM attendees are from many countries outside the Asia-Pacific region. The conference venues are: Xi'an China (1985), Beijing China (1988), Tokyo Japan (1991), Brisbane Australia (1994), Seoul Korea (1997), Xi'an China (2000), Nagoya Japan (2003), Bali Indonesia (2006), Harbin China (2009), Bangalore India (2012), Sydney Australia (2015). ICPADM 2018 will go back to Xi'an, China again.

Liu Ziyu Memorial Lecture was established in ICPADM 1994, to commemorate the contribution of Prof. Liu Ziyu to the conference. Prof. Liu was the General Chairman of the first ICPADM conference. The previous speakers are Masayuki Ieda (1994), A.H.Cookson (1997), Kwan C. Kao (2000), W. Boeck (2003), G. C. Montanari (2006), Christian Laurent (2009), J Keith Nelson (2012) and Shengtao Li (2015). In 2018, Liu Ziyu Memorial Lecture will be delivered by Prof. Yasuhiro Tanaka from Japan.

The technical program will consist of papers presented in regular, poster and plenary sessions covering a broad range of areas such as:

- Ageing and life expectancy of HV insulation
- Conduction and breakdown in dielectrics
- Dielectric phenomena and applications
- Eco-friendly dielectric materials
- Electrical insulation in high voltage power equipment and cables
- Gaseous electrical breakdown and discharges
- High voltage insulation design using computational analysis
- Nano-technology and nano-dielectrics
- New functional dielectrics for electrical systems
- Space charge and its effects

Important Dates:

Abstract Submission:	5 October 2017
Acceptance Notification:	30 November 2017
Manuscript submission:	5 January 2018
Notification of final acceptance:	5 February 2018

ICPADM 2018 Secretariat:
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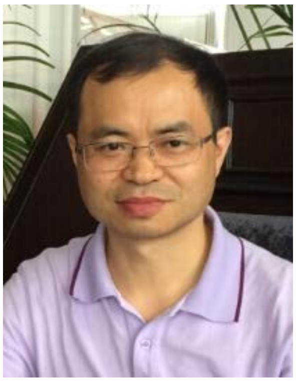
China Corner

Recent Progress on Extruded High Voltage Direct Current Power Cable Systems in China

Shengtao Li, Jinghui Gao, Lisheng Zhong



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1. Overall

Because of the unbalanced geographical distribution between natural resources (coals, natural gas, wind, solar and water powers, mainly located in western China) and power consumption centers (mainly in eastern China), it is an urgent necessity in China to design and construct an efficient energy transport system to solve the problem and support the high speed economic development. For electrical engineering, it involves an ongoing plan constructing a framework of ultrahigh power transmission lines, which includes 7 AC transmission lines with 1000 kV (or above) rating voltage and total capacity about 60.5 GW, 14 DC transmission lines with ±800 kV (or above) rating voltage and total capacity about 110.6 GW. The ultrahigh voltage (UHV) project not only mitigates the increasing energy pressure, but also helps relax the serious environmental problem via using clean energy. In addition, with the new trend of SMART grid concept, the UHV, especially the High Voltage Direct Current (HVDC) power system has attracted much attention in both academia and industry.

As a state strategy, China has initiated a research guideline on "Large Power Grid and its Flexible Interconnection", which belongs to the "National Key R&D Plan". As one of the projects in this direction, much effort has been dedicated to the extruded power cable used in HVDC system, which is still under intense study by both scientific institutes and giant domestic manufacturers. The motivation for studying the extruded DC power cable system lies in its obvious advantages over traditional oil-paper insulated DC power cable system. Firstly, oil-paper cable systems have practical limitations in operation that affect both service temperature and installation lengths. Secondly, environmental issues associated with the use of oil-paper cable systems could not be ignored. Thirdly, oil-paper insulated cable systems have a rather complex and expensive manufacturing process, which needs more labor works and special techniques in maintenance. Therefore, to develop high voltage rating and reliable HVDC extruded power cable is of importance.

Nowadays, the voltage level of recent operational extruded HVDC power cables was raised to ±320 kV (±320 kV/1000 MW project, Xiamen, 2015). On the other hand, ±525 kV DC cable has passed the type test and prequalification test. Nevertheless, for higher voltage rating, there are still a number of technical challenges to be solved before practical application.

2. Progress of the extruded HVDC power cable systems in China

2.1 Application of the extruded HVDC power cable systems in China

Up to now, there are three HVDC transmission power projects with extruded power cables as shown in Fig. 1. All those cables are manufactured and assembled in China. Some parameters of those cables are listed in Table.1. In the following, the three projects are briefly introduced.

Commissioned in Dec. 2013, Nan'ao ±160 kV transmission project is the first three-terminal flexible

Figure 1. Development of Chinese HVDC transmission projects

DC transmission system in the world, and adopts the first HVDC submarine cable in China. Nan'ao project consists of 3 converter stations, overhead line and cables, which has well solved the problem of wind power connection. It is the first time that combination of overhead line and cables is adopted. In the project, the length of overhead line is 20.6 km, land cable 9.5 km and submarine cable 10.6 km.

Zhoushan ±200 kV transmission project is the world first five-terminal flexible DC transmission system, and is also a project with the longest submarine cable in China, which has been put into operation since June 2014. The project includes five converter stations and DC cables. The length of submarine cable is 137.2 km, and land cable 9.2 km.

Xiamen ±320 kV transmission project is now a real bipolar project with the highest voltage in the world, which was commissioned in Dec. 2015. The transmission line includes 320 kV DC polar land cable with the length of 23 km, 10kV DC return cable with the length of 11.5 km, and its transmission capacity is 1000 MW.

Table 1. Extruded HVDC power cable systems in China

Project	Rating Voltage (kV)	Power Capacity (MW)	Length (km)	Conductor cross section (mm^2)	Insulation thickness (mm)
Nan'ao	±160	200	9.5 (Land cable) + 10.7 (Submarine cable)	500	16
Zhoushan	±200	400	9.2 (Land cable) + 103 (Submarine cable)	1000	16
Xiamen	±320	1000	23 (Land cable)	1800	26

2.2 Key techniques of extruded DC power cable systems

The benefits of extruded HVDC power cable systems together with the increasing practical needs predict a boom in related R&D activities. To fully explore the potential of the system, some key techniques that lay the foundation for application should be developed, matured and implemented, which are briefly discussed in the following.

(1) Material selection and evaluation technology for extruded DC cable systems, which includes both insulation materials and screen materials.

(2) Design technology for extruded DC cable systems.

(3) Test methods for extruded DC cable systems.

(4) Strategies of operation and maintenance for extruded DC cable systems.

To fulfill the goals of the National Key R&D Plan, Chinese cable manufacturers, research institutes, utilities and universities have been closely collaborating with each other to develop material analysis, structure design simulation, test methods, product manufacture, and maintenance strategies and so on. The research topics include DC cable insulation design fundamentals, insulation material and shielding material for DC cable, design and manufacture of DC cable and accessories, DC cable application and environmental compatibility as well as DC cable system tests and maintenance technologies. Figure 2 shows an example for cable testing of extruded HVDC cable in China.

Figure 2. Type test for ±320 kV extruded HVDC cable in Zhoushan, China.

3. Vision of extruded HVDC power cable systems

For higher voltage levels as in UHV systems, it is necessary to develop higher voltage level of extruded HVDC power cable systems, i.e., from ±320 kV to ±525 kV and even to ±800 kV. However, under those conditions, it faces various challenges, such as withstanding higher electrical field, transmitting more power and manufacturing larger size of cable systems. Consequently, the following issues should be carefully considered and properly solved: cable system insulation design under high electrical field and high temperature gradient, development and mass production of material with stability of high electrical field and high temperature, electrical field design with multi-physics and manufacturing progress of cable systems with large scale, effective test methods and maintenance strategies of extruded DC power cable.

The above mentioned issues are rather challenging and covering various knowledge, techniques and practical obstacles, which implies that the whole community around the world should be actively cooperated. As one of the main energy consumption countries in the world, China has the great determination as well as real actions to invest more on "Large Power Grid and its Flexible Interconnection". It can be expected that extruded HVDC power cable systems in China will provide a promising solution to today's energy problem. Furthermore, our experience could be of help to other countries with similar problems as well.

4. Summary

In recent years, China has been experiencing fast progress in extruded HVDC power cable systems. Three HVDC power transmission projects has been completed and in operation up till now. The associated theories and technologies of extruded HVDC power cable systems have been a frontier topic on SMART Grid technology and equipment, including cable system materials, cable system design, cable system test and maintenance. The extruded HVDC power cable systems has been advancing towards much higher voltage, larger capacity and more reliable, which involves numerous science and technology challenges that need to be solved. With the new breakthroughs in the field, we believe that the electrical engineering especially the electrical insulating industry in China will thrive to fully meet the increasing demands for efficient, sustainable and clean energy, which definitely benefits both China and the world.

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India Corner

Technological Development for Pulsed Power Application

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Dr. Archana Sharma

1. Introduction

Conventionally, Pulsed power science and technology deals with the physical and technical foundations for the production and application of high voltage pulses with very high power and relatively moderate energies (>1 kJ). A generator scheme for the production of high power electric pulses is always based on an electrical energy storage capacitor that is charged slowly at relatively low charging power and – by activating a switch – is discharged rapidly. To achieve the desired power multiplication this process can be repeated in several sequential stages if necessary, by shortening the charge and discharge period after every subsequent stage. Several pulsed power systems are designed, developed and commissioned in the group for various applications and are discussed in the article.

2. Electromagnetic Manufacturing Machine (EMM)

Electromagnetic Welding (EMW) technology is a promising and new manufacturing technology for welding alloys for nuclear applications. EMMs are made for EMW activity. The main components ofEMM are capacitor bank, capacitor bank charging supply, closing switch for energy transfer, welding coil and the work piece. EMM systems are designed and developed for expansion and compression welding joints of aluminium and stainless steel alloys. Several EMMs for welding of similar and dissimilar metals and also for metal forming have been developed based on synchronously switched capacitor bank technology. It is done in order to increase the life of each switch used, as coulomb handling transfer capacity of electrode materials of switch are limited. In this process, synchronisation of spark gaps (for 40kJ Capacitor bank), ignitrons (for 400kJ Capacitor bank) and rails gap (for 800kJ Capacitor bank) switches have been achieved consistently.

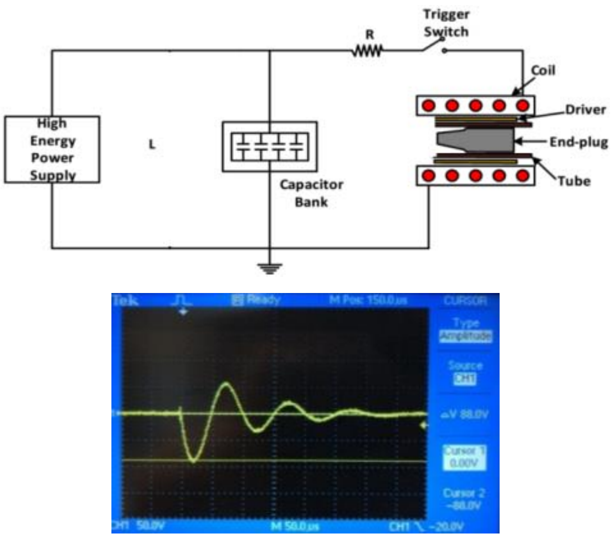

Figure 1. Schematic of Electromagnetic Joining setup and typical discharge current waveform

Use of Cu-W electrode has helped in increasing the life of electrode during switching of high current (~100kA). The discharge frequency in these EMMs are ranging from 10-15kHz. The magnetic field is generated between coil and job piece due to induced current in the job piece. This magnetic field should not diffuse through the flyer tube (job piece), hence if skin depth is more than the thickness of the tube, suitable highly conducting driver is used over the flyer tube. Angle of the inner plug is optimized to give required standoff distance between the flyer tube and the target so that the impact velocity reaches to the required velocity range (200-400m/s) for inter metallic metallurgical bonding. The schematic of the experimental setup is shown in Fig.1 and system photograph is shown in Fig.2. These systems are used for various expansion and compression welds/joints and being analyzed.

Figure 2. 800kJ, 1MA EMM with Synchronized rail gap switches

Post welding samples are first tested for helium leak detection and thereafter sample preparation for metallographic study, is done. Pull-out and peel-off tests are also recommended to characterize the weld quality. Various tool-coils have been designed to get typically 20-50T magnetic field for specified different jobs. As the strain rate increases, extent of deformation also increases before the rupture of the tube takes place is shown in Fig.3.

Figure 3. Deformation of Al 6061 tube

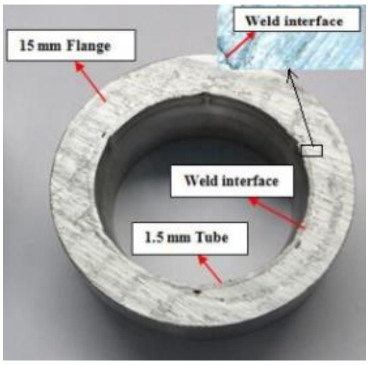

Figure 4. Welding of Al6061 tube to block

A good quality weld is obtained when the flyer tube velocity is > 300 m/s. The weld results of such flyer tube velocity is shown in Figure 4. Welding achieved with notched flanges and tapered angle was found of good quality in comparison to the smooth surface flanges. Moreover, the weld interface of the welded tube-flange sample was found to be wavy in nature in line with explosive welding.

3. High Frequency Electromagnetic Radiation

Various pulsed power systems are designed and developed to generate high frequency electromagnetic radiation. With the design of high gain antennas and efficient microwave devices these high power microwave (HPM) pulses can damage the electronics at large distances.

Personal Computer (PC)-reset has been demonstrated at 125m using Linear Induction Accelerator LIA-400 driven relativistic magnetron which is shown in figure 5. The typical power density pattern of LIA-400 is shown in fig.6. Other developed microwave devices are axial Vircator, reflex triode and axial magnetron. Shielding effectiveness of different materials also can be studies with these systems in S-band.

Figure 5. LIA 400 system

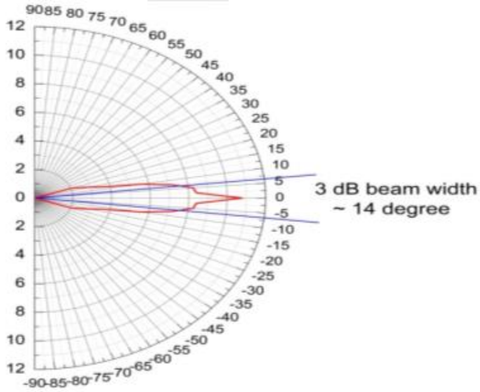

Figure 6. Power pattern of LIA-400

4. Flash X-Rays Generators:

There are two types of pulse power sources used for these applications. One is conventional tesla transformer followed by pulse forming line and REB diode i.e. Kilo-Ampere Linear Injector (KALI)-1000 as shown in Fig.7. The system generates 300 kV output voltage and 30 kA of load current across matched load. At 1 meter distance, X-ray dose of 350 mR has been measured with rated charging voltage and when the system operated with rod pinch diode in X-ray mode. It is illustrated in Figure 8. The spot size of the generated X-ray is measured by various methods like Pin Hole Camera & Rolled Edge arrangement and it is nearly 1-2 mm. In future it is planned to operate the system as a source of microwave by changing the diode arrangement. Several other pulsed power

Figure 7.KALI-1000 Pulse Power system

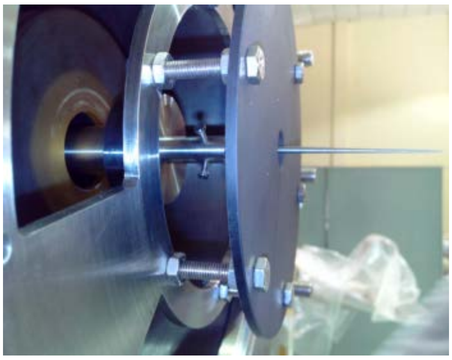

Figure 8. Rod Pinch Diode setup

systems are also designed for high power microwave generation studies.

Another topology for Flash X-rays is based on Linear Transformer Driver (LTD). It is relatively compact and produces nano second pulse at each stage. The schematic of LTD 1 is shown in figure 9. Here C is the capacitance of all the bricks of the cavity. S are the switches of the bricks. L3 is inductance of the vacuum coax. L4 is primary inductance. L1 represent parasitic inductance of the primary brick circuit and L2 is the parasitic inductance of the convolute between switch and vacuum coax. R is the resistance of the circuit. For proper LTD operation, L4 should be much higher compared to (L2+L3). Also L1 & L2 should be as low as possible compared to L3.

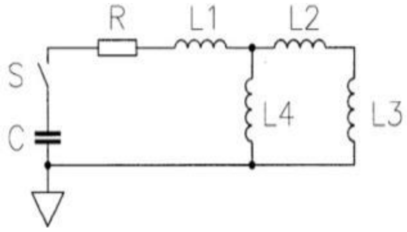

Figure 9. Schematic of LTD brick

Figure 10. Assembly of in LTD-1

After successful operation of LTD-1 as shown in Fig.10, three stage assembly (LTD 2) is being taken up. It will have modular assembly and bipolar charging to give 300kV output pulse as a substitute of KALI-1000 described above.

5. Pulsed neutron source

A dense plasma focus ~~device~~ based intense pulsed neutron source with efficient and compact pulsed power system is commissioned as shown in Figure 11. It's high current sealed pseudo spark switch based low inductance capacitor bank with maximum stored energy of ~10 kJ is segregated into four modules of ~2.5 kJ each and it cumulatively delivers peak current in the range of 400 kA–600 kA in a quarter time period of ~2 μs. The neutron yield performance of this device is in the order of $\sim 4 \times 10^9$ neutrons/pulse at ~7 kJ/8.5 mbar operation [6]. The average forward to radial anisotropy in neutron yield is found to be ~2. The entire system is contained on a moveable trolley having dimensions 1.5 m × 1 m × 0.7 m and it is operated from ~6 m distance from the device through optically isolated handheld remote console. The major intended application objective of this high neutron yield dense plasma focus device development is (i) testing of neutron shielding ability of different shielding materials, (ii) for neutron radiography of objects, (iii) identification of elements by prompt gamma neutron activation analysis (PGNAA), (iv) quantitative analysis of elements by delayed gamma neutron activation analysis.

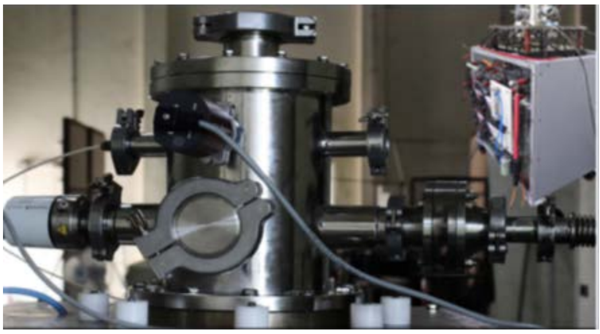

Figure 11. High Flux Neutron generator

Figure 12. Compact pulsed neutron generator

A miniaturized plasma focus DD neutron source (fig. 12) of 10^5 -10^6 neutron yield has also been developed with all the indigenous components and capable of repetitive operation. It is developed for detector testing and nuclear grade materials analysis.

6. Nanoparticle Production

Experiments have been performed on the explosion of copper wire at a discharge voltage of 9kV using 7.1 μF capacitor bank for the generation of Cu nano-particles in nitrogen environment at different pressures. Nano-particles generated by the electro exploded wire method were characterized by both optical microscopy and transmission electron microscopy. Experiment shows that the variation of pressure of nitrogen gas inside the exploding chamber determines the size of the particles formed during the explosion of the copper wire. It is observed that for a pressure of less than 230 mbar of nitrogen gas, the wire does not explode and the copper wire remains intact. Micro particle generation occurred at a pressure of 2.3×10^{-2}mbar of nitrogen gas and nano-particles were formed when the pressure was further increased to $1\times10^{-}3$ mbar. Transmission electron microscopy reveals the size of the nano-particles to be in the range of 35 to 75 nm.

7. Diagnostics for Pulsed Power experiments

Optical diagnostics like optically isolated magnetic field and current measurement using Faraday rotation principle is developed and implemented in various setups in the laboratory. The schematic of Faraday rotation is shown in figure 13. A magnetic field of 41Tesla, a current turn product of 4.5MA has been successfully measured by such systems developed in the laboratory. The velocity measurement suing fiber cut method (FCM) (by moving projectile) is implemented for Rail gun (velocity 260m/s), Electric gun (velocity ~2km/s) and Electromagnetically Expanding liner (310m/s) experiments (Figure14). Velocity interferometer system for surface of any reflection (VISAR) is built in the laboratory with 260m/s/fringe, fringe constant using 20 cm long etalon and 5 Watt highly coherent (60m coherence length) laser (Figure 15).

A Fabry Perot Velocimeter has also been developed in the laboratory for the velocity measurement of flyer plate. The sensitivity of the velocimeter is ~4km/s per every new fringe. With the help of a streak camera and 6 mm length of Fabry-Perot etalon high velocity measurement system has been developed.

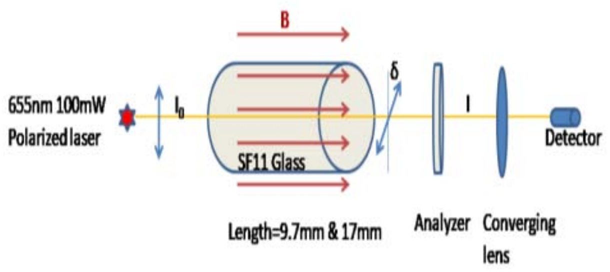

Figure 13.Schematic for Faraday rotation

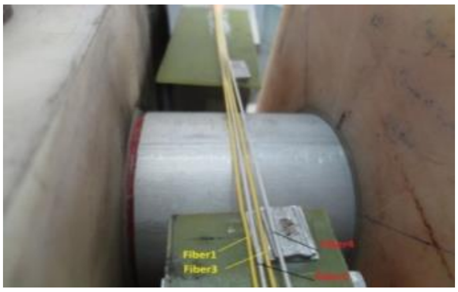

Figure 14. Velocity measurement by FCM

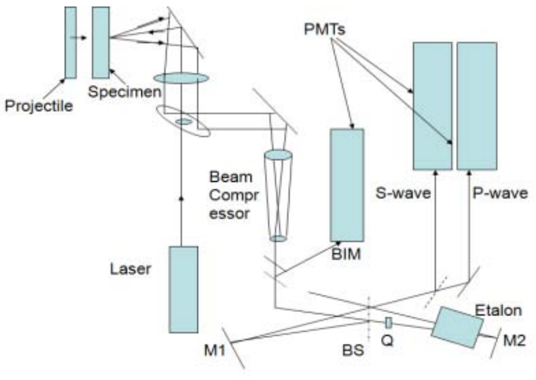

Figure 15. VISAR Schematic

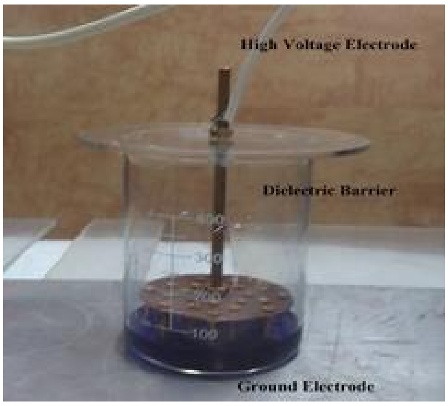

Figure 16. Discoloring using plasma discharges

8. Environmental application of pulsed power

Wastewater remediation has become a global concern, the development of innovative advanced oxidation processes for wastewater treatment is still a major challenge with regard to its fast removal rate and environmental compatibility, plasma technology is considered as a promising remediation technology for water remediation. A compact 45kV, 50 kHz power supply is designed and developed to generate pulsed plasma discharges for wastewater treatment. The pulsed plasma discharges can produce ultraviolet light and hydroxyl radicals in order to treat the water waste. The experimental studies are carried out for the breakdown of complex phenol and decolouring of water as shown in Figure 16. Also in bigger scale, setups with higher through put can be developed with higher power source.

Acknowledgement

The author wish to express thanks to Dr.Surender Kumar Sharma, Dr M V Suryanarayana, Dr M ShankariDr. Rishi Verma, Dr.Rohit Shukla, Shri Partha Banerjee and all members of Pulsed Power & Electromagnetic Division for the development of pulsed power systems and experiments. The author also would like to thank Shri R K Rajawat, Associate Director BTDG and Shri D Venkateshwarlu, Regional Director, BARC Visakhapatnam for the motivation and support to carry out pulsed power research.

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TECHNOLOGIES FOR TOMORROW

Repetitive Impulse Voltage Supply and Automatic RPDIV Measuring System

Two International Standards of IEC60034-18-41 and -42 (hereafter -41 and -42) are newly published to approve electrical insulation systems for use in rotating electrical machines fed by voltage converters. The machine manufacturer may derive an IVIC (Impulse Voltage Insulation Class) according to the Standards in the future.

-41 deals with Type I insulation systems, which tend to have random-wound coils generally used at less than 700 V rms. On the other hand, -42 has been published for Type II insulation systems which generally have form-wound coils above 700 V rms. The waveform shape parameters of repetitive impulse voltages needed for the IVIC qualification tests are inevitably different between the two standards and also depend on the impedance of the testing objects. For example, the higher voltage is usually needed for the IVIC qualification of Type II than Type I.

An all-purpose apparatus that can supply various kinds of repetitive impulse voltages according to the two standards has been developed. The principle circuit diagram is shown in Figure 1. A high-voltage, direct-current energy source is used to charge the capacitor. After charging the capacitor, an impulse voltage is generated through turning on a semiconductor switch using an external trigger from a function generator. In this circuit, a maximum output voltage of 10 kV is available. The peak to peak impulse voltages and the repetition ratio are controlled by a DC power supply and the electric trigger unit, respectively. The rise time of the impulse voltage can be adjusted through the circuit parameters of R_1, R_2 and C. The fall time can be adjusted through R_3. A power diode (D) is used when perfect unipolar repetitive impulse voltages are required.

Figure 2 shows an outlook of one apparatus developed for actual IVIC qualification tests. A right-hand rack lodges a controller system to change the impulse voltage waveform parameters and an automatic RPDIV measuring system. The left one includes the generator which safely provides various kinds of repetitive impulse voltages.

Table 1 shows specification of generated impulse waveform parameters the supply can produce.

Figures 3 shows typical repetitive impulse voltage waveforms and PD signals measured by the automatic RPDIV measuring system for a motorette model specified in -41. Figure 4 shows example of the repetitive impulse voltages for the form-wound coil with the capacitance of 4nF specified in -42.

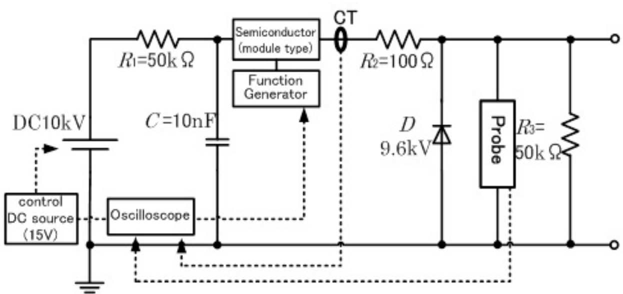

Fig. 1 Principle circuit diagram of repetitive impulse voltage supply

Fig.2 Outlook of apparatus

Table-1 Parameters of impulse voltage waveform

Term	Range	Note
Polarity	Positive or Negative	Bipolar is possible.
Output Voltage	~ 20 kV	Peak to Peak for Bipolar
Wave Width	~ 5 μs	Controllable
Frequency	~ 6 kHz	Controllable
Rise time	100 ns	without Load
Load	~ 4 nF	–

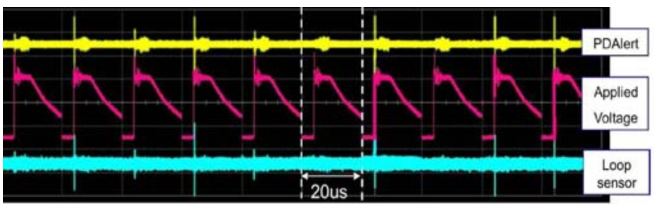

Fig.3 Applied repetitive impulse voltage with 1 kHz and PD signals for a motorette model specified in -41

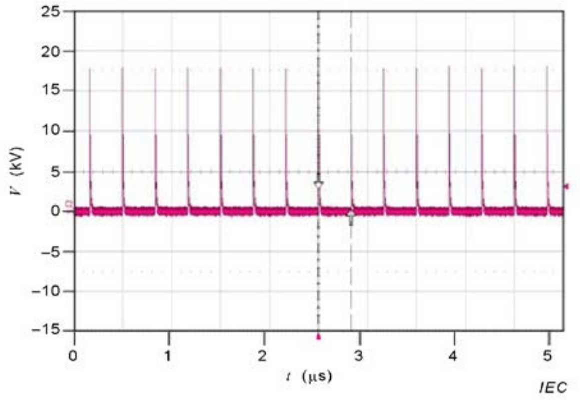

Fig.4 Typical wave form for a -42 form-wound coil with 4nF (f: 1.5kHz, Vp:17kV, Rise time:250ns)

Acknowledgment：

This technology development was collaborated with the National Institute of Technology Oita College, Toshiba Corporation, and ECG-Kokusai Co. Ltd.

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MISCELLANEOUS

Photos on Front and Rear Covers

Front Cover

NAS Battery

NAS battery system is the grid-scale energy storage system and has been commercialized only by NGK in the world. The NAS battery is characterized by long life, high energy density, and very compact and space efficient compared to other stationary batteries.

NGK has delivered NAS battery systems with a total output of 530MW and storage capacity of 3.7GWh at approximately 200 sites around the world such as the power grid of Italy and the United Arab Emirates.

The NAS battery system delivered to the Buzen Substation is one of the world's largest energy storage systems with an output of 50MW and a storage capacity of 300MWh and NGK has installed it in about six months thanks to the new containerized design that requires only about one third of the installation time compared with the conventional design. The NAS battery system is being used for improving the balance of supply and demand by utilizing its storage capacity, equivalent to a pumped hydroelectric power generation facility.

Tomio Tamakoshi
NGK INSULATORS, LTD.
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NAS Battery Division
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Rear Cover

Nano-Micro assembly technique for designing of composite materials

Nano-micro composite materials are being widely used in many areas for their remarkable performances. Many nano-micro composite materials are prepared for mixing the additive and matrix powders. For now, conventional mechanical mixing process such as ball milling technique is the most common way to obtain mixed powder. However, the mechanical milling process is not enough to obtain "well-mixed" powder on nanoscale. Besides, during the process, the strong force would destroy the original crystallinity and sharp of the particles such as nano-fibers and nano-rods. To solve those problems, a new method to prepare nano-micro composite particles has developed, so call the electrostatic adsorption assembly method proposed in our laboratory. The nanocomposite particles with different sizes and sharps can be easily assembled by the proposed electrostatic adsorption assembly method.

Figure is showing PMMA (polymethyl methacrylate) spherical matrix particles covered with plate-like h-BN (hexagonal boron nitride) additive particles. This is expected to fabricate functional composite materials with high thermal conductivity.

This study was supported by Cross-Ministerial Strategic Innovation Promotion Program (SIP) of Council for Science, Technology and Innovation (CSTI), Japan.

Prof. Hiroyuki MUTO
Toyohashi University of Technology
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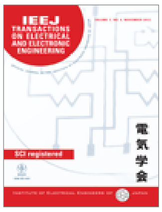
Journals of IEEJ

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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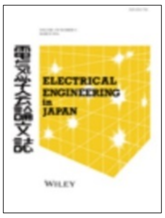

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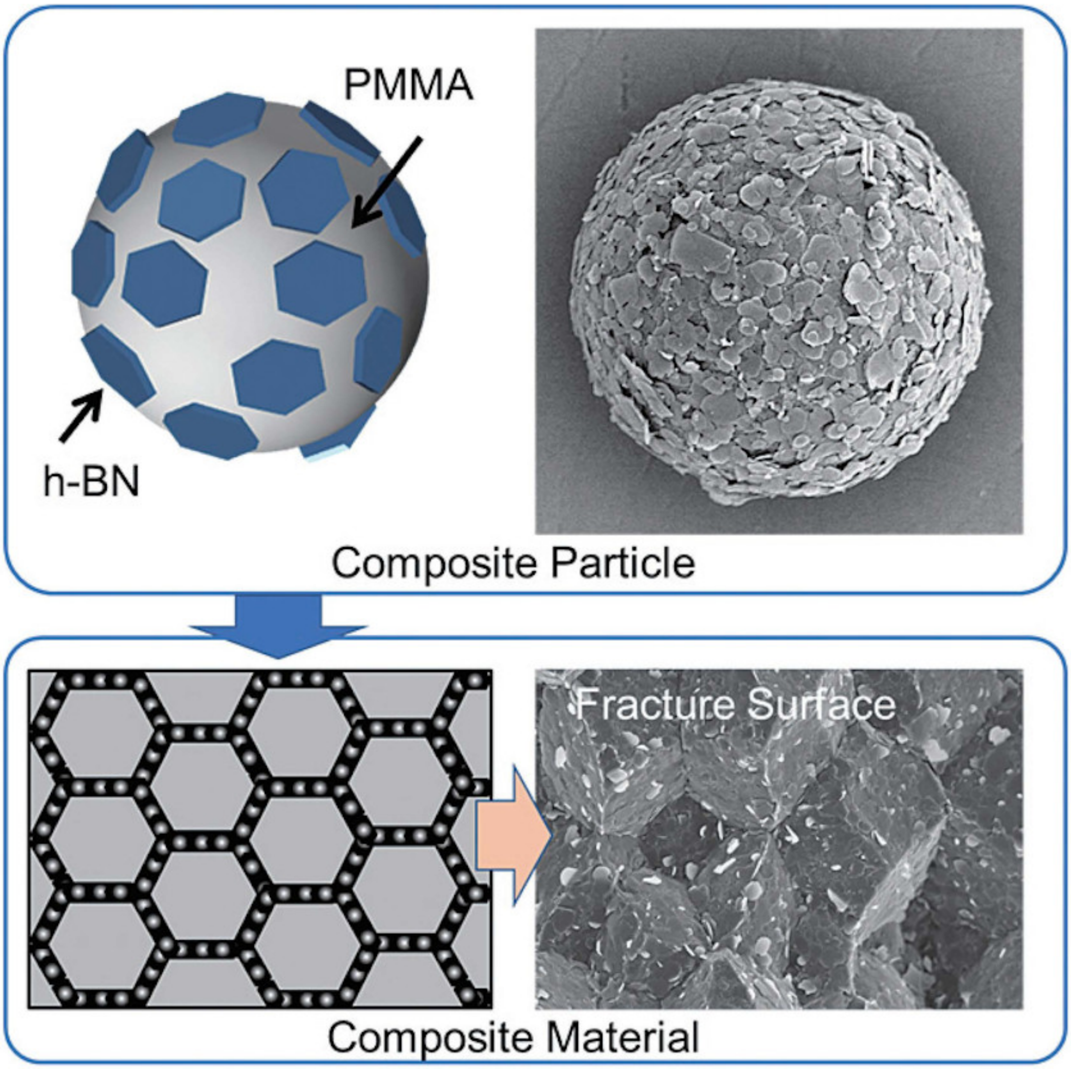

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