

Investigating R&D Committee on Advancing Tailor-made Composite Insulation Materials and Their Applications

Technical Committee on Dielectrics and Electrical Insulating Materials

1. Objective

Various characteristics and functions are required to insulate voltage-carrying conductors with materials used in electric power equipment, cables, and electronic equipment. Although polymer insulation materials are widely used in such equipment, polymer composite insulation materials containing dispersed inorganic fillers play an important role in addressing the insufficient performance and functionality of polymers alone. Recently, there has been active development of technologies to create polymer composite insulation materials on demand (tailor-made) to obtain the necessary material properties, or to simultaneously realize a plurality of functions. The IEEJ Dielectric and Insulating Materials Technology Committee published Technical Report No. 1455, "Advanced Tailor-made Composite Insulation Materials – Towards Innovative Composites to Meet Demand in Electric Power and Electronics Sectors -" (May 2019), summarizing the trends and issues noted in research and development.

Advent of Artificial Intelligence (AI) including Materials Informatics (MI) is just about to accelerate the tailoring of polymer composite insulation materials. Moreover, a multi-scale simulation connecting quantum, atomic, meso and micro-scale calculation is attracting attention to estimate physical properties in the polymer composite insulation materials. Thus, we wish to establish this investigation committee to explore the possible fusion of theory, experiments, computational science, and information science in the development of tailor-made composite insulation materials.

In addition, we hope that this committee will play a role in the advancement of tailor-made composite insulation materials (functionally gradient insulating materials, insulating prepared by additive manufacturing, nanocomposite insulation materials with controlled polymer/filler interfaces, polymer blended insulation materials, etc.). The committee will actively engage in identifying mechanisms, seeking out areas of application, and developing fields of applications. Moreover, the committee will act as intermediary between academia including research institute and industry.

2. Background and internal and external research activities

Previously, experience and intuition of researchers have an impact on the creation of polymer composite insulation materials and evaluation of their performance and function. However, as the "performance and function" are ultimately important, the process of "creating insulating material and then evaluating performance and function" should be switched to "creating insulating materials based on the required performance and function." It is considered that developing insulating materials based on informatics technology and simulation for efficient and optimal material development will be an important future trend.

Various projects related to informatics technology have been conducted domestically. For examples, excellent results have been reported in the fields of inorganic and metallic materials including electrode materials for lithium-ion batteries, materials for photovoltaic power generation, and thermoelectric conversion materials. The informatics technology is positively about to apply the development of polymer composite materials such as fiber-reinforced plastics (FRP). Besides, similar projects have been conducted in the world. In the USA, the Genome Initiative started in 2011. Furthermore, the Novel Materials Discovery (NOMAD) project has been undertaken in Europe, and similar projects have been launched in China and Korea. However, the informatics technology has yet to apply the development of polymer composite insulation materials. Therefore, the proposed committee will investigate these new techniques and their potential usefulness in polymer composite insulation materials. We believe that our committee's activities will help pave the way for their development.

In addition, the above-mentioned technical Report No. 1455 shows that the number of papers on tailor-made composite insulation materials including polymer nanocomposites in *IEEE Transactions on Dielectrics and Electrical Insulation* (IEEE TDEI), a typical journal focusing on dielectrics and insulation materials, has been increasing every year. In Japan, the industry-academia collaboration project "Development of innovative functional insulation materials for electric power apparatuses" has been proceeding, which is supported by New Energy and Industrial Technology Development

Organization (NEDO). The project tackles to create the high-performance and multi-functional polymer composite insulation materials that can be used in generators, industrial motors, and switchgears. On the other hand, the Technical Report No. 1455 indicates that the most papers on tailor-made composite insulation materials in IEEE TDEI are from China, followed by India, Japan, and the US. Therefore, it is crucial for Japan to recover and maintain its initiative in this field.

3. Investigative matters

Tailor-made composite insulation materials will be investigated based on the following considerations:

- (1) Possibility and usefulness of new design techniques in the development of polymer composite insulation materials (Materials Informatics, etc.)
- (2) Tailor-made composite insulation materials and the mechanism through which their characteristics evolve (functionally gradient insulation materials, insulating materials prepared by additive manufacturing, nanocomposite insulating materials with controlled polymer/filler interfaces, polymer blended insulating materials, etc.)
- (3) Development of applications in electric power and electronics sectors

4. Expected effects

Composite insulation materials based on informatics technology have the potential to transform existing development techniques. The research activities of this committee will be a starting point for trendsetting in this field and can enable the development of hitherto nonexistent innovative composite insulation materials. In addition, sharing of technical information on tailor-made composite insulation materials will clarify current problems toward practical application and promote practical feedback from industry to academia. We believe that our activities play an initiative role on researches of polymer composite insulation materials in the world as well as in Japan.

5. Term of investigation

January 2020 to December 2022 (3 years)

6. Committee members

Position	Name	Affiliation	Member/Non-member category of IEEEJ
Chairperson	Takahiro Imai	Toshiba Infrastructure Systems & Solutions Corporation	Member
Member	Nobutaka Araoka	Fukuoka University	Member
"	Tomonori Iizuka	Waseda University	Member
"	Takeshi Igarashi	Showa Denko K.K.	Non-member
"	Teiichi Inada	Showa Denko Materials Co., Ltd.	Non-member
"	Shinya Iwata	Osaka Research Institute of Industrial Science and Technology	Member
"	Takeo Ebina	National Institute of Advanced Industrial Science and Technology	Non-member
"	Yoshimichi Oki	Waseda University	Member
"	Takashi Ota	Panasonic Corporation	Member
"	Naoki Kasamatsu	Nagase ChemteX Corporation	Member
"	Akiko Kumada	The University of Tokyo	Member
"	Norio Kurokawa	He retired from Japan Electrical Insulating and Advanced Performance Materials Industrial Association.	Non-member
"	Masahiro Kozako	Kyushu Institute of Technology	Member
"	Keita Sasaki	Meidensha Corporation	Non-member
"	Masahiro Sato	The University of Tokyo	Member
"	Asuka Shimozato	Takaoka Toko Co., Ltd.	Member

Position	Name	Affiliation	Member/Non-member category of IEEEJ
Member	Shoma Suzuki	Sumitomo Electric Industries, Ltd.	Non-member
"	Toshikatsu Tanaka	Waseda University	Member
"	Yasuhiro Tanaka	Tokyo City University	Member
"	Kazuyuki Toyama	National Institute of Technology(KOSEN), Numazu College	Member
"	Masayoshi Nagata	University of Hyogo	Member
"	Tomoki Hasegawa	Fuji Electric Co., Ltd.	Member
"	Naoki Hayakawa	Nagoya University	Member
"	Michitomo Fujita	SWCC Showa Cable Systems Co., Ltd.	Member
"	Nobutaka Fujimoto	Sumitomo Seika Chemicals Co., Ltd.	Non-member
"	Takahiro Mabuchi	Mitsubishi Electric Corporation	Non-member
"	Kenji Miyata	Denka Co., Ltd.	Member
"	Yoshinobu Murakami	Toyohashi University of Technology	Member
"	Yu Yamashita	Toshiba Mitsubishi-Electric Industrial Systems Corporation	Member
"	Tetsuo Yoshimitsu	Nippon Rika Industries Corporation	Member
Secretary	Muneaki Kurimoto	Nagoya University	Member
"	Hideki Misaka	Central Research Institute of Electric Power Industry	Member
Assistant secretary	Ryotaro Shimada	Hitachi, Ltd.	Non-member

7. Activity schedule

Committee meetings: 4 times/year; Secretariat: 1 time/year; Technical meetings: 2 times/3 years

8. Reporting format

A technical report shall be prepared to present the results.