Materials

Ceramic electret for electrostatic vibration power generation

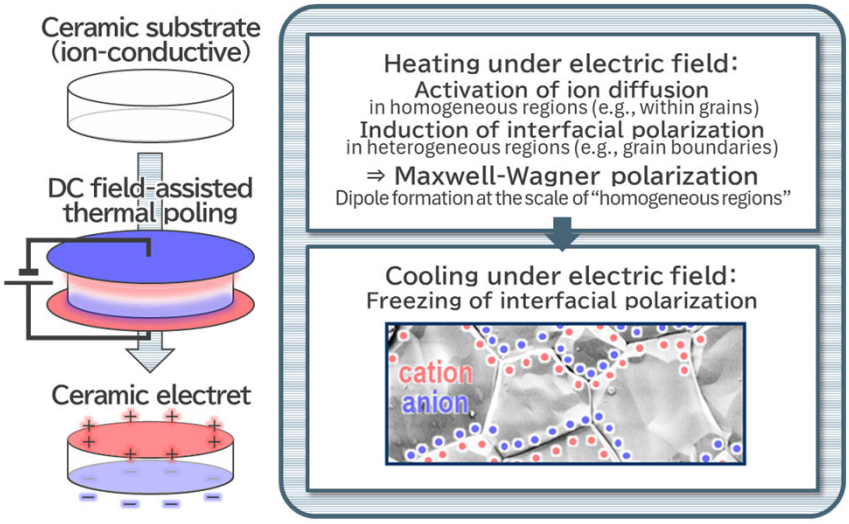
Yumi TANAKA (Associate Professor, Department of Industrial Chemistry, Faculty of Engineering, Tokyo University of Science)

Purpose of Research

To support future ICT systems, efficient energy harvesting for edge devices is essential. Among various approaches, electrostatic vibration energy harvesting, which converts ambient vibrations into electricity using electrostatic forces, has gained attention. In this system, electrets serve as key materials that provide a quasi-permanent electric field. This study aims to develop novel ceramic-based electrets with high surface potential, excellent charge retention, and MEMS process compatibility.

Summary of Research

This study focuses on developing ceramic electrets using weakly ion-conductive ceramics. A novel approach is employed: interfacial poling via ion diffusion is induced and frozen at heterogeneous interfaces such as grain boundaries. To achieve high-performance electrets, we systematically investigate how ceramic composition, crystal structure, and defects relate to electrical properties such as conductivity, permittivity, and charge storage.



Comparison with Conventional or Competitive Technologies

- High surface potential with long-term retention
- MEMS process compatible

Expected Applications

- Power source for edge IoT sensors and wearable devices
- Electrostatic functional substrates
- Microphones, motors, and sensors

Challenges in Implementation

- Clarification of poling mechanism
- Optimization of MEMS design and manufacturing process
- Evaluation of device performance

Points

- Successfully developed ceramic electrets with world-leading surface potential (7 kV/mm-bulk, 1 kV/μm-film)
- Achieved 80% retention at 200℃, 30min
- Successfully prototyped MEMS device

What We Expect from Companies

- Proposal of applications and performance specifications
- Collaboration on optimization of MEMS design and processing
- Support for demonstration in operational environments

Future Developments

Phase 1 (~FY2028)
Electret performance enhancement and MEMS power evaluation
Phase 2 (FY2029~)
Operational validation and production process development

■Associated System: JST CREST, KAKENHI
■Intellectual Property:
US Pat. 11,917,919 & 11,949,191 et al.
■Prototype: Available
■Sample: Bulk-type ceramic electret

June 2025

TOKYO UNIVERSITY OF SCIENCE Organization for Innovation and Social Collaboration
1-3, Kagurazaka, Shinjuku-ku, Tokyo, 162-8601, Japan E-MAIL: ura@admin.tus.ac.jp