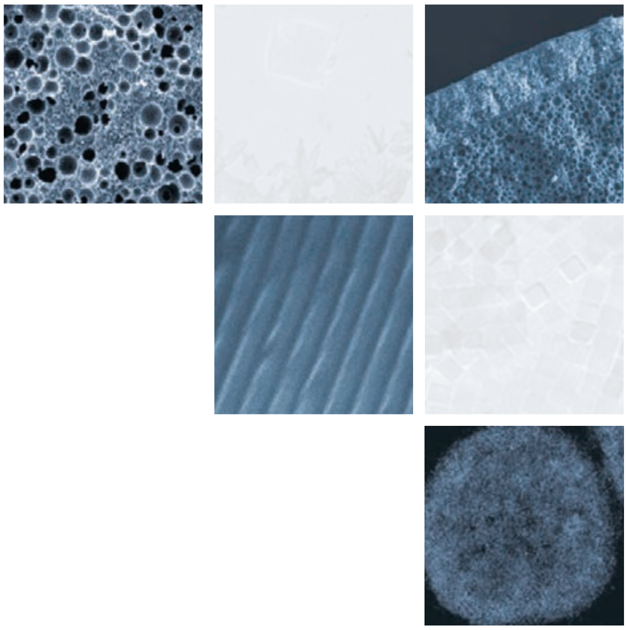


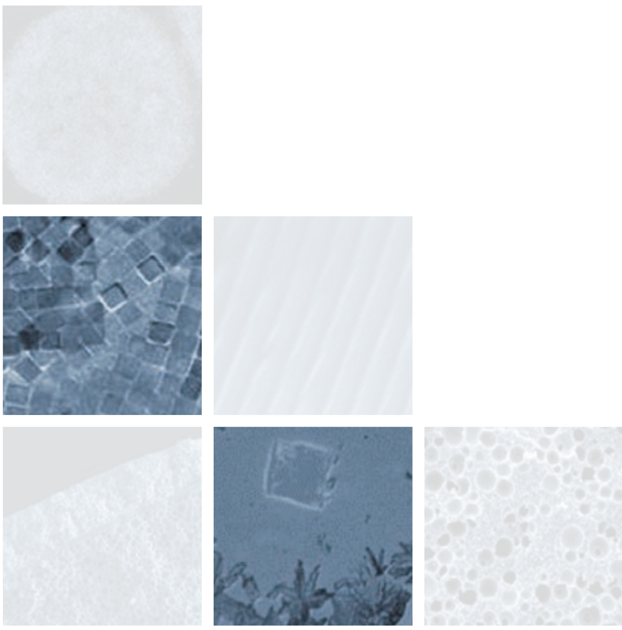
IFMRI

National Institute of Advanced Industrial Science and Technology

# Innovative Functional Materials Research Institute

国立研究開発法人 産業技術総合研究所

# 極限機能材料研究部門



AIST

Create the Future, Collaborate Together

## Greeting

Director

**Yoshinobu Fujishiro**

To strengthen the industrial base for Japan's manufacturing industries, it is essential to create new material technologies by AIST original research. Innovative Functional Materials Research Institute (IFM-RI) is engaged in the research aimed at enhancing the functionality of various new materials such as fine ceramics, magnetic materials, composite materials and innovative manufacturing processes that cannot be caught up by other countries. To improve functionality of new material, we promote the research with industry and utmost the material performance by joining dissimilar materials and controlling the microstructure and interface state of materials for next-generation mobility, energy and environment fields, safe society, and daily living.

Our research institute promotes the research based on the following four targets. The enhancement of optical switching materials and gas sensors, which play an important role as a technology that improves comfort in houses and vehicles. The electrode materials and electrolyte materials aimed at realizing the theoretical performance limits of storage batteries and fuel cells that support energy and material conversion, which are indispensable for a carbon neutral society. Furthermore, we challenge on the development of materials that next-generation magnetic materials and related process technologies for mobility and industrial equipment, convert environmental pollutants into safe substances and new coating materials that prevent their adhesion to liquid and solid by technologies of smart materials and active sites of nano-space materials, which are important for circular economy and resource recycling society.

In recent years, material development requires both improved functions and improved development speed. In our institute, we will promote Materials Process Innovation Platform (MPI-PF), which is established at AIST Chubu Center from April 2022, will actively develop data-driven materials.

## Organization

**Director**

Y. Fujishiro

**Deputy Director**

K. Takagi

**Prime Senior Researcher**

W. Shin

**3 Technical Senior Officers**

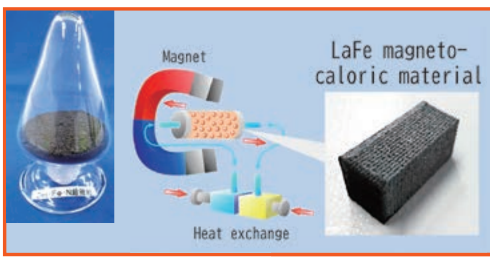
**7 Research Groups**
**48 Researchers**

- Electroceramics Group
- Light and Heat Control Materials Group
- Energy Storage Materials Group
- Solid State Ionics Materials Group
- Nanoporous Materials Group
- Next-generation Permanent Magnet Materials Group
- Functional Magnetic Materials Group

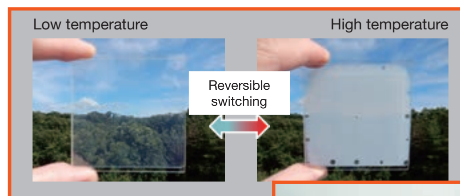
## Approach

# Developing innovative functional materials in order to realize energy saving and safe society

- Advanced stimulus response materials
- Highly efficient robust energy materials
- Advanced surface and nanoporous materials
- Development of innovative magnetic materials



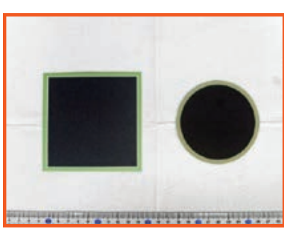

Next-generation magnet & New Magnetic Functional Materials




Chromogenic materials & Coatings
(Thermochromic, Water and oil repellency)

Gas sensors

Nitrogen recycling & Catalytic conversion device
(NO emission)



Fuel cells / Electrochemical Reactor
(High efficiency)

All-solid-state battery
(High capacity, Fast charge / Discharge)

**Innovative functional materials for mobility**

**Fuel cells, Li-ion batteries, Gas sensors, Magnetic materials, Chromogenic films, Nanoporous materials, Water and oil repelling coatings**

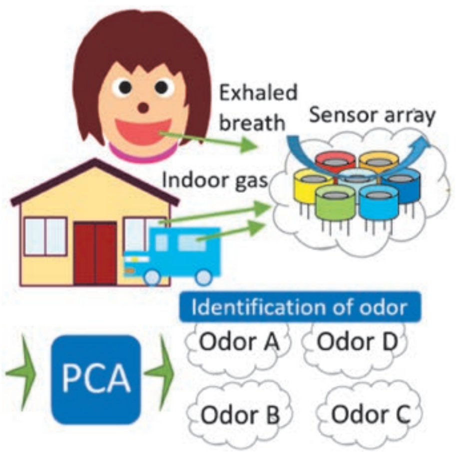
**Energy saving and Safe society = Innovative materials**

# Advanced stimulus response materials

## Electroceramics Group

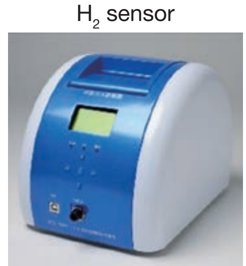
Group Leader: Yoshitake MASUDA
masuda-y@aist.go.jp

Electroceramics Group develops ceramic nanomaterials and electronic ceramic devices.
Our research includes:
Development of ceramic nanomaterials with aqueous solution processes.
Development of platinum-substituting high-temperature conductive oxides.
Development of “bulk-response type” gas sensor materials.
Development of gas sensors for VOCs, exhaled breath, skin gas, indoor gas, etc.
Development of odor identification technology using sensor array and machine learning.
Development and commercialization of thermoelectric power generation modules.

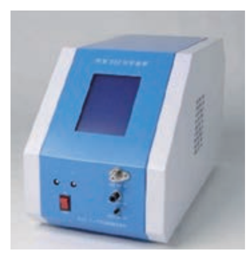



**Odor identification technology using sensor array and machine learning**

$H_2$ sensor

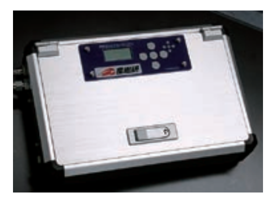


VOC sensor



Halitosis sensor

Multi sensor



**Development of gas sensors**

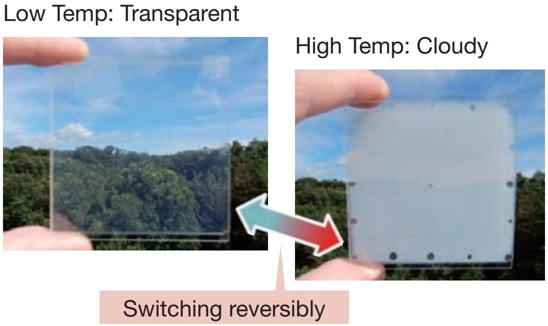
## Light and Heat Control Materials Group

Group Leader: Chihiro URATA
chihiro-urata@aist.go.jp

We are developing environmentally responsive materials that change their transmittance and maintain their anti-adhesion function over the long term. For example, we are working on the development of optical switching materials that control the amount of sunlight that flows into rooms and vehicles to realize energy-saving and comfortable spaces, and surface materials that support safe and secure living and energy creation by controlling snow and ice adhesion on road signs, solar panels, and other surfaces.

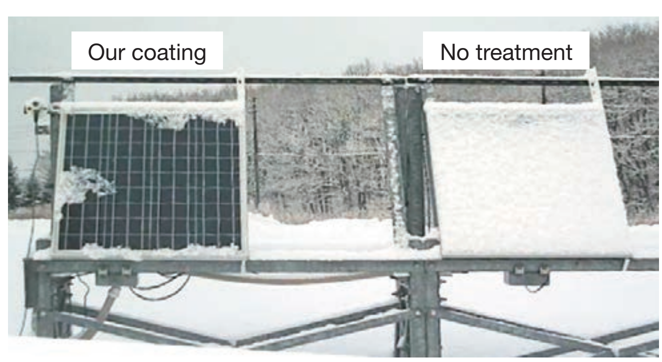
Low Temp: Transparent

High Temp: Cloudy




### Solar transmission control device with temperature response using polymer networked liquid crystal

The device can control reversibly solar transmittance by thermoresponsively switching optical clarity between cloudy and transparent states.




### Development of thermo-responsive coatings allowing to protect adhesion of ice and snow

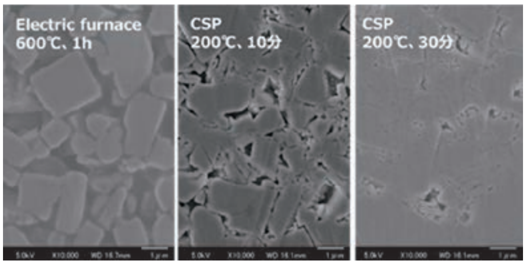
Novel organogel coatings showing thermo-responsive anti-icing/snow properties are developing.

# Highly efficient robust energy materials

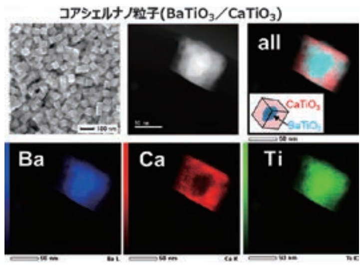
## Energy Storage Materials Group

Group Leader: Koichi HAMAMOTO
k-hamamoto@aist.go.jp

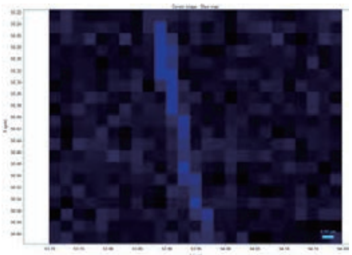
Energy Storage Materials Group promotes research and development on novel ceramic materials, process technologies, characterization technologies, and numerical simulation to realize next-generation energy storage devices such as all-solid-state batteries and ceramic capacitors, which are expected to be applied to mobility systems and IoT devices. We are focusing on the development of synthesis technology for advanced nanoparticles and cold sintering process (CSP), which can densify ceramics under 400°C, and improvements in analytical techniques such as environment-controlled high-resolution STEM and AFM-Raman (TERS).




**Densification of Solid Electrolytes by Cold Sintering Process**




**Dielectric core-shell nanoparticle**

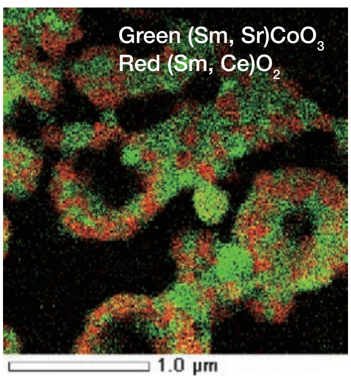


**Nanoscale Raman image of single CNT**

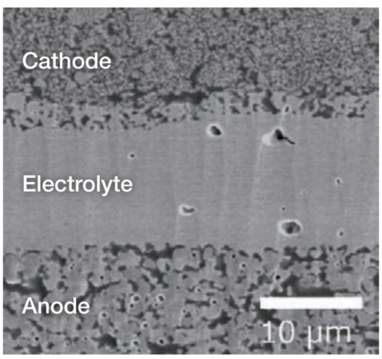
## Solid State Ionics Materials Group

Group Leader: Hirofumi SUMI
h-sumi@aist.go.jp

In order to realize solid oxide fuel cells (SOFC), electrolysis cells (SOEC) and protonic ceramic fuel cells (PCFC), which are energy and chemical conversion systems with high efficiency, we are developing new solid state ionics materials such as nanocomposite electrodes, and innovative fabrication processes such as low-temperature sintering for electrolytes. And, we are demonstrating fuel cells using multi-fuels (e.g. liquefied petroleum gas (LPG) and ethanol) for power sources of small mobile applications such as robots and drones.




**Nanocomposite electrode with 10 nm in diameter**



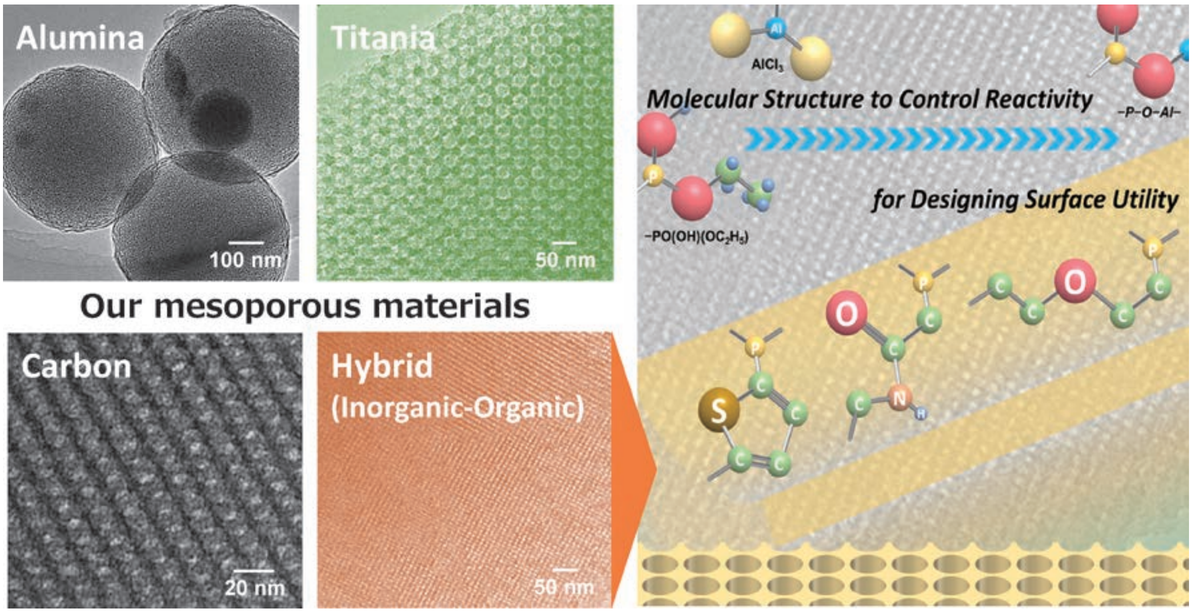

**PCFC electrolyte thin-film sintered at lower temperatures**

# Advanced surface and nanoporous materials

## Nanoporous Materials Group

Group Leader: Tatsuo KIMURA
t-kimura@aist.go.jp

Towards the proposal of a new industrial structure including the realization of a circular economy through the design of function, the renewal of property, the exploring of novel applications, etc., that cannot be completed by using conventional technologies only, we are aiming to develop inorganic based materials for chemical transformation and then enhance their utilization technologies by making a full use of various nanostructural controls based on our original approach for the porous materials design as the core technology.




## Topics

**Developed Process Technology for Alternating Layering of Barium Titanate Nanocube Monolayers and Graphene**

— Paving the way for dramatically thinner multilayer ceramic capacitors —

**A Facile Method for Preparing Transparent Anti-Fogging Films with Quick Self-Healing Abilities**

— Development of transparent films that self-heal physical damages in a short period and prevent fogging for a long period —

**Developed Sensing Technology to Determine Freshness of Fish Meats from Their Odors**

— Easy, non-destructive determination of freshness —

**Development of High-performance Electrode for Nanostructure-controlled Solid Oxide Fuel Cell (SOFC)**

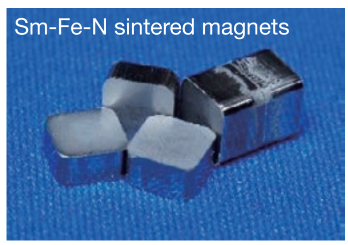
— Achievement of world top-level power generation performance —

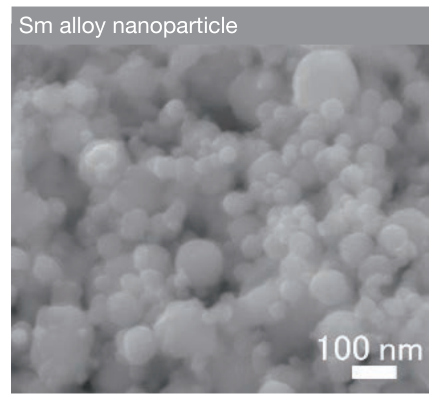
# Development of innovative magnetic materials

## Next-generation Permanent Magnet Materials Group

Group Leader: Yusuke Hirayama
hirayama.yusuke@aist.go.jp

We are developing post-neodymium magnets such as samarium alloy and metastable alloy in order to overcome the resource problem and low heat resistance of neodymium magnets, which are the key to EV motors. In particular, because the performance of magnets is significantly affected by microstructures, we focus on the creation of new powder metallurgy processes.




### Low oxygen powder metallurgy process

Rare earth magnets that are sensitive to oxidation can be prepared by powder metallurgy process under extremely low oxygen conditions without exposure to the atmosphere.

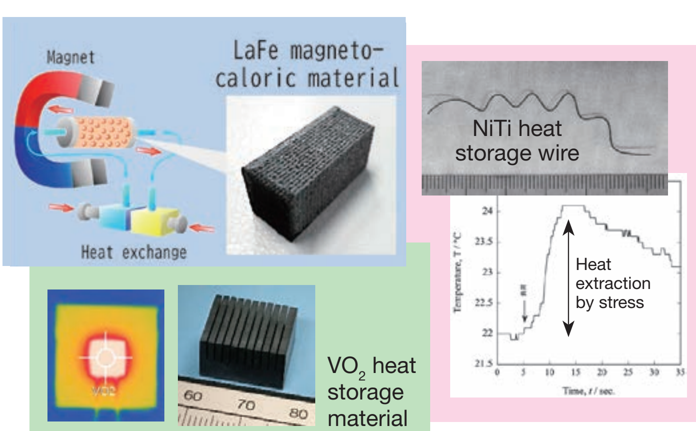
### Rare earth magnet nanoparticles

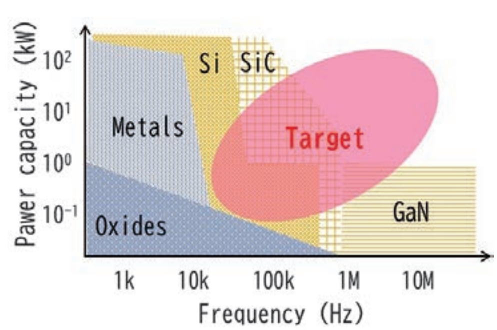
Our developed thermal plasma technology is able to synthesize rare earth alloy nanoparticles, which has been difficult in the past. A sintered magnet with a coercive force of over 5T was realized from these nanoparticles.

## Functional Magnetic Materials Group

Group Leader: Shusuke Okada
shusuke-okada@aist.go.jp

To realize a sustainable carbon-free society, we are developing soft magnetic materials that improve the energy efficiency of power electronics and mobility, together with solid-state caloric materials characterized by the magnetic entropy. Especially, the Fe-based magnetic refrigerants and the $VO_2$ / NiTi-based heat storage materials are aimed at social implementation by realizing new applications such as magnetic heat pump and active heat storage.



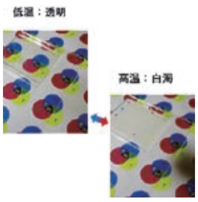




### Solid-state caloric materials

By realizing a caloric effects that utilizes various form of heat with metals (LaFe, NiTi) and oxides ($VO_2$), we are working to realize magnetic refrigeration and an active (external field-driven) heat storage.

### Process for developing soft magnets

To improve soft magnetic materials related to the output of EV motors and power semiconductors, we are taking on the challenge of building metallurgy/chemical processes.





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