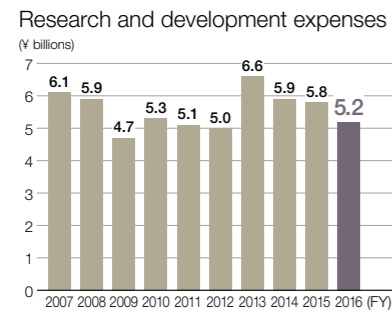


# Research & Development

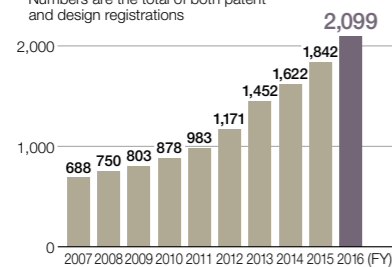
We are concentrating research and development resources on themes that can further contribute to business operations, such as increasing sales and cutting costs, as well as applying open innovation to create new products and businesses for the future. In addition to our four research and development sites, in December 2016 we established the ICT Promotion Office and started working on innovating production facilities using technologies such as IoT.



Recent years have seen a trend of around ¥5-6 billion per year. About 10-20% of the total comprises mineral resource and smelting and refining-related research and development expenses, while the rest comprises materials-related research and development expenses and basic research costs.

## Number of patents\* registered by the SMM Group

\* Numbers are the total of both patent and design registrations



We are actively promoting the construction of a patent network, as well as patent applications that contribute to stable business operation and development, and research and development.

## Research and development strategy and structure

SMM advances research and development company-wide, with the Technology Division at the core. Within the selection and concentration that we perform in our core businesses of mineral resources, smelting and refining, and materials, we prioritize allocation of research and development costs, and position smelting and refining process technology, powder synthesis and surface treatment technology, crystal growth and processing technology, and exploration, mining, and mineral processing technology as core technologies. We also consider analysis technology, computer aided engineering and analysis technology (ICT) as fundamental technologies, and are carrying out focused development on clearly defined technology domains.

The core of our research and development is carried out at four research and development sites: Niihama Research Laboratories, the Battery Research Laboratories, the Materials Laboratories, and the Ichikawa Research Center. These sites collaborate with business divisions over the development of products and production technology, and carry out basic research focused on acquiring new technologies for the future. For example, the Ichikawa Research Center is advancing basic research in the area of powder materials. Furthermore, the ICT Promotion Office was established in December 2016 and has started work on using IoT to increase facility operation rates and product recovery rates.

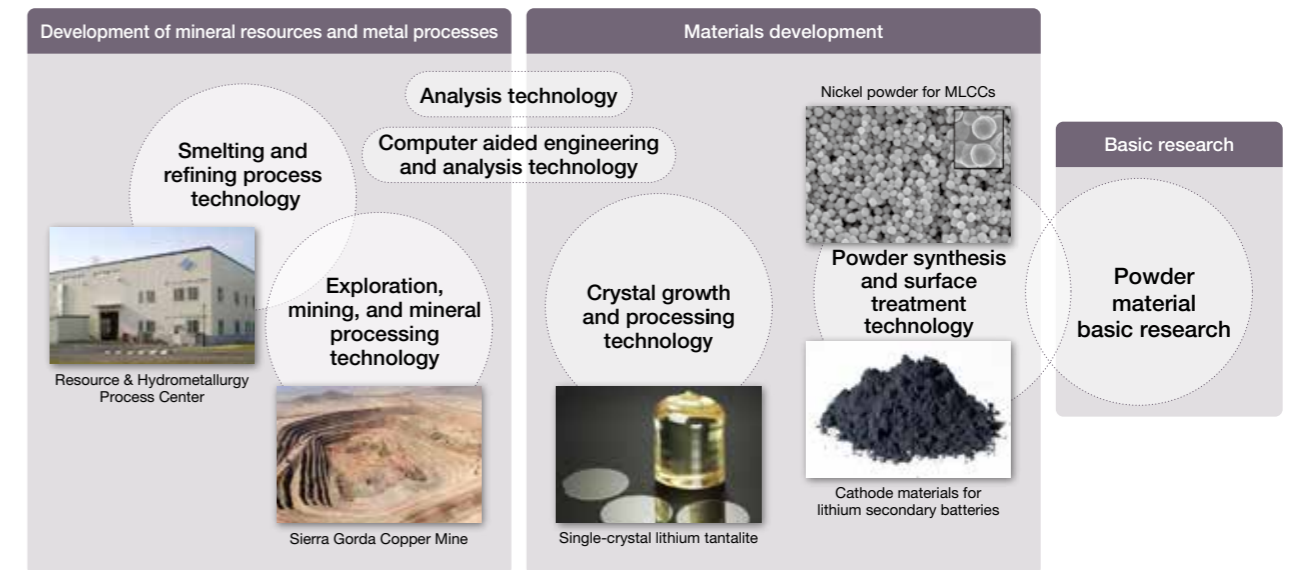
## Key research themes

Current main themes being advanced are mineral resource development and process/technology development in the field of non-ferrous metals smelting and refining, and in the materials field, we are focusing on materials and new technology development in the environment/energy fields and the information and communications fields, where great societal need exists. We perform research and development after clearly defining the scale of our sales targets for new products, an approach that is generating results.

As for battery materials, we are focused on development such as increasing capacity of cathode materials for high capacity/high output lithium ion batteries used in hybrid and electric vehicles. And for crystal materials, we are developing crystal growth and wafer processing technologies in response to increased production of lithium tantalite and lithium niobate substrates for SAW filters contained in communication devices such as smartphones.

The key theme for smelting and refining process development is the recycling of discarded lithium ion batteries. This is technology for separating and refining useful metals, such as nickel and cobalt, from used batteries. Furthermore, although SMM uses world-class technology called HPAL for extracting nickel, we aim to further strengthen our resource handling capabilities and have started developing pyrometallurgical smelting and refining processes that differ from HPAL.

## Research and development by the SMM Group



### Fundamental technology

#### Analysis technology

Technology to elucidate the mechanisms behind the manifestation of performance, occurrence of faults, etc.

### Fundamental technology

#### Computer aided engineering and analysis technology

Facility design based on fluid analysis, thermodynamic analysis, and other simulations, and material design technology based on first-principles calculations

### Fundamental technology

#### Information and communications technology (ICT)

Technologies such as IoT and big data analysis to increase facility operation rates and product recovery rates, transfer knowledge, and standardize operations

### Core technology

#### Smelting and refining process technology

Technology to separate and refine copper, precious metals, nickel and other valuable metals from ore and recycled raw materials

### Core technology

#### Exploration, mining, and mineral processing technology

Exploration technology and mineral processing technology for separating and concentrating valuable metals in ores at mine sites

### Core technology

#### Crystal growth and processing technology

Crystal growth technology that contributes to larger-diameter, longer, higher-yield lithium tantalate, lithium niobate, and other single-crystals used in the communications field, and technology for processing grown crystals into wafers

### Core technology

#### Powder synthesis and surface treatment technology

Technology to synthesize powder materials yielding required functions, with control over composition, particle size, surface condition, internal structure, etc.

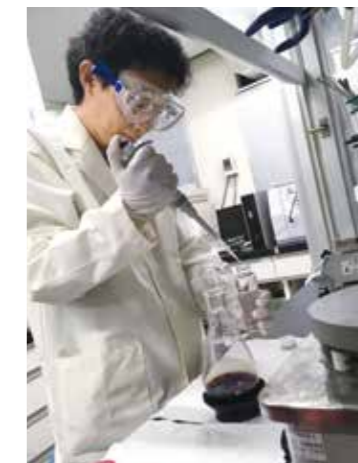
### Basic research

#### Powder material basic research

Basic research into powder materials manifesting new functions and innovative powder synthesis technology

## Reforming the research and development structure and cultivating personnel

We are working with each business division to actively engage in development aimed at creating products and businesses that will support the next generation. We have established working groups, composed primarily of young engineers, that transcend divisional boundaries, and built a system in which the findings of these groups are considered company-wide. Furthermore, the Ichikawa Research Center collaborates with external institutions, such as university research departments, to advance basic research based on open innovation. We are also putting energy into personnel development focused on the future, such as dispatching SMM personnel to university research laboratories and supporting the acquisition of doctoral degrees and the like.



An SMM dispatched employee conducting research at the Kyoto University Institute for Chemical Research

## Masaki Imamura

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General Manager of  
Technology Div.