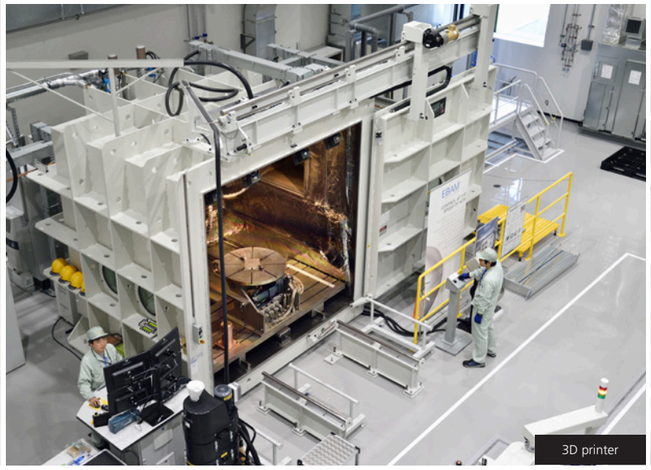
# GRIT
# research center creating disruptive and discontinuous innovation

Against the backdrop of current megatrends, the frameworks of industries themselves are changing in a variety of sectors. To address these rapid environmental changes, we believe that in addition to swifter decision-making, cross-sector initiatives that transcend internal company boundaries, and innovation that looks 20 years into the future, are important. With the aim of being a "genuinely development-driven company," we have established a corporate research lab to conduct research and development in advanced materials and processes that will lead to sustainable growth and contribute to society. We are embarking on a new stage of "change and challenges" in research and development.

# R&D

## R&D Innovation

3D printer


**Kenichi Inoue**
Head of Global Research & Innovative Technology center, Technology, Research & Development Division

**PROFILE**
Joined Hitachi Metals in 1993 and assigned to the Metallurgical Research Laboratory. Involved in the development of surface treatment (coating) technologies, which attracted attention of mold manufacturers and automakers. Launched the full-scale surface modification business in 2005 with the establishment of the Surface Modification Center (current name: Solution and Engineering Center in the Specialty Steel Company, Yasugi Works). Appointed General Manager of Technology at High-Grade Metals Company (current name: Specialty Steel Company) in 2016. Assigned to lead GRIT in 2017.

### Overview of GRIT and its direction

## Pursuing the challenge of impossible, discontinuous innovation through continuous research and development

The Global Research & Innovative Technology center (GRIT) was established as a corporate research lab, and with the construction of the new research wing complete, GRIT has begun full-scale operations. In English, GRIT has the connotation of "the strength to follow through with undaunted courage and mettle, even when something is difficult," which exemplifies our spirit of creating new technologies for 10 to 20 years into the future.

The new research wing represents an investment of roughly ¥10 billion, with a layout based on the concept of open space to facilitate active discussion. Even meeting rooms have glass walls, creating an image that contrasts sharply with that of a closed research facility. A major, unique feature of the facility is that in addition to research and development, GRIT can play a major role in marketing activities, with equipment in place for demonstrations of 3D printers and machine tools, as well as an exhibition space for presentations of Hitachi Metals' products and technologies.

Digitalization, as seen in the Internet of Things (IoT) and artificial intelligence (AI), has already brought about creative disruption in a number of industries. Well-known examples include major innovations in production systems and the shift from gasoline-powered to electric vehicles. It is easy to move forward with continuous innovation, but today, in the midst of a paradigm shift, it is necessary to take a different approach that will bring about discontinuous innovation and disruptive innovation. GRIT was born as a venue where this can take place.

In addition to consolidating Hitachi Metals' experience and expertise, GRIT is focusing on being a venue for open innovation and the creation of free and open-minded ideas. A research area named Open Lab, for example, functions as a space where staff can work together with outside research partners and customers in a free and open atmosphere to resolve issues and create innovations. GRIT has no special rooms for me. This is so that discussions can take place and work can be done anywhere. By working in GRIT's various spaces, I intend to break down existing organizational levels.

### Global Research & Innovative Technology center

**Founding principle**
To promote research, development, and innovation for the future, looking beyond the present, to become a genuinely development-driven company.

**Q Concept**
1. Lay the path for sustainable growth in the future through advanced materials and processes
2. Cultivate the growth of human resources
3. Act as Hitachi Metals' technology base

### GRIT's missions

## Use new strategic approaches to develop innovative materials

Materials have driven industrial technology innovation, and the development of innovative, advanced materials is the starting point for social transformation. Recognizing the importance of this development and innovation, GRIT looks beyond iron and metals and pursues development themes for research into

# R&D Innovation

advanced materials for the medium to long term.

Research and development at GRIT are actually carried out by the Advanced Materials Development Department and the Advanced Process Development Department. The Advanced Materials Development Department is currently pursuing research into advanced materials under 16 designated themes. In addition, the Advanced Process Development Department is using advanced digital technologies to collect data via the IoT and analyze it using AI, and by providing feedback to the development site, we are pursuing production technology innovation through engineering.

Another of GRIT's important missions is to commercialize its research and innovation. For this reason, a new Business Innovation Department has been established within GRIT to assume functions across internal companies. A Strategic Innovation Department has also been established to produce research and development. This is where highly experienced managers identify new research themes, and groundbreaking trials are carried out under the guidance of these managers, who provide researchers with a clear direction for their work from start to finish. Researchers tend to submerge themselves in their research without considering its commercial possibilities, but by taking a strategic approach led by the Business Innovation Department and the Strategic Innovation Department, we expect to accelerate innovation at the global level.

Examples of research and development

## Turnaround concepts transforming threats into business opportunities

GRIT is engaged in medium- to long-term research with a view toward threats and opportunities. One example of this is the development of metal powders for metal 3D printers.

Today's specialty steels are manufactured using complicated processes like melting, forging, and scraping, but we believe a switch to the use of metal 3D printers has significant potential for future cost benefits with ultra-small-lot components like aircraft parts. We also believe there may be similar benefits with metal 3D printers in the automotive sector for parts where strength is not a particular requirement. These predictions would have been conventionally seen as a threat to Hitachi Metals, but if we can achieve technological innovation, these could become major opportunities.

In this way, we will approach the field of metal 3D printers, a technology that is changing *monozukuri* in significant ways, by looking beyond existing products including stainless steel, nickel-based alloys, and aluminum alloys, and developing various new materials using the special features of additive manufacturing. GRIT does not simply make materials; it uses CAE* analysis technology, which we have accumulated, to simulate the properties and deformations of metals in advance, and conduct repeated verification to develop recipes for each material. One of these successes has been the joint development with Hitachi, Ltd.'s R&D group of metal powder for metal additive manufacturing. This has made it possible to manufacture with high-entropy alloys.

We are accelerating our research and development using CAE analysis technology to optimize materials, and we plan to make major advances in developing light, strong, new materials for the automotive, aircraft, and energy-related segments. In addition to new materials, we also intend to apply this to product development for special, single-batch production. Going forward, although iron will remain our main material, we will look to develop compound metals using combinations of a wide range of materials with various functions, including superalloys, aluminum, carbon nanotubes, and ceramics.

Another of GRIT's R&D themes is to develop products together with customers. In the development of magnets for EV motors, for example, the amount of valuable heavy rare earth metals used has a major impact on productivity and costs. We are therefore working with customers to make heavy rare-earth-free and less-rare-earth magnets higher performance.

Medium- to long-term R&D themes taking into account threats and opportunities (examples)

| Company | Current products | Development theme based on perceived threats |
|---|---|---|
| Specialty Steel | Mold materials | Additive manufacturing |
| | Aircraft- and energy-related materials (ultra heat-resistant steel) | Composite materials |
| Magnetic Materials | Neodymium magnets | New magnets |
| Functional Components | Cast iron (NM) | Composite materials and multiple materials |
| Cable Materials | Copper wire | Aluminum conductors and compound conductors |

Open innovation and future outlook

## Resolving social issues through open innovation and human resource development

The pursuit of open innovation is one of GRIT's important missions. We are already engaged in open innovation, working closely with Hitachi, Ltd., as well as with universities, companies, and other third-party institutions.

In July 2016, we opened the NIMS-Hitachi Metals Next-Generation Materials Development Center jointly with the National Institute for Materials Science (NIMS) and began researching practical uses for next-generation ultra heat-resistant alloys. The use of this research in metal materials for aircraft engines and gas turbines is contributing to reductions in $CO_2$ emissions and resource conservation.

GRIT is also playing an important role as a center for human resource development. Previously, most researchers hired as new university graduates were assigned to the research lab of one of the internal companies, but we are increasing the portion assigned to GRIT to give them more opportunities to understand the businesses of the entire Hitachi Metals Group immediately after joining the company. GRIT is also teaching technological skills needed by technical service staff, and dispatching them to customers' locations around the world to understand their various needs firsthand. When they return to GRIT, they are able to use that expertise in their research and development. In addition, we are considering using GRIT for the training of coaching staff for local sales staff in places like China, which is expected to be the main battleground for EVs going forward, and holding training programs at GRIT for local sales staff.

GRIT's mission is to conduct research and development that creates discontinuous innovation and to take the lead in bringing that innovation to commercialization. We are also planning to open an overseas center in roughly five years, to be able to identify global trends as quickly as possible. As a venue for finding research partners and business proposals, and for deepening interaction and cooperation with overseas researchers and outside institutions, GRIT is proactively making use of and training regional human resources. Looking ahead, GRIT's research and development contributing to the resolution of social issues as well as the Hitachi Metals Group's sustainable growth can be expected.

* CAE: Computer Aided Engineering. The use of computer simulations to determine whether designed items can perform the functions required prior to actually producing the item.

## Success in manufacturing with high-entropy alloys using a metal 3D printer

Together with Hitachi, Ltd.'s R&D group, GRIT has developed metal powder for metal additive manufacturing (metal 3D printers), and by identifying process requirements that use this development, successfully developed manufacturing technology with the high-entropy alloy "HiPEACE®*."

High-entropy alloys are defined as alloys that include at least five chemical elements in roughly equal amounts and feature no main element. These alloys are superior in terms of strength and corrosion resistance, but are also difficult to cast and process. GRIT verified properties and deformations in high-entropy alloy by using its CAE analysis technology, which we have accumulated, and has succeeded in optimizing high-entropy alloys for additive manufacturing.

We have confirmed that these high-entropy alloys are strong, malleable, and corrosion-resistant, and can be used in harsher environments than nickel-based alloys. We will pursue further verification testing going forward, with the aim of practical applications.

"HiPEACE®" high-entropy alloy

* HiPEACE® (Hitachi Printable Extreme Alloy for Corrosive Environment) is a registered trademark of Hitachi, Ltd.