

# Honing NGK's Distinctive Technologies As a Source of Competitive Strength

Research and development is the key to the medium and long-term growth of the NGK Group.

We have become the market leader thanks to our unshakable commitment to distinguishing ourselves from our competitors by setting unique development themes and delivering unprecedented products.

There are around 800 employees in the NGK Group who are involved in research and development in some capacity. We are engaged in ongoing research in the three sectors of energy, ecology, and electronics. In all of these sectors, our aim is to keep honing the distinctiveness of NGK technology. Our competitive strength in the marketplace is derived precisely from the fact that we offer features and affordability that other companies cannot match. By maintaining a commitment to distinguishing ourselves through our technology and improving the sophistication of the materials we develop, focusing chiefly on fine ceramics, we aim to bolster the competitive strength of our existing products as well as create new and competitive technologies and products.

NGK is strong in such techniques as extrusion, mold-casting, crystalline orientation, joining of differing materials, and hydrothermal synthesis. Thanks to these strengths we were able to put the EnerCera<sup>®</sup> chip-type ceramic secondary battery into mass production in April 2019.

In fiscal 2017, we achieved our "2017 Challenge 30" goal of ensuring that at least 30% of consolidated net sales comes from new products. We have set a company-wide "Keep up 30" goal to maintain this percentage for fiscal 2018 onward and are focused on creating new products and businesses.

### Concentrating resources into specific sectors

Research and development expenses in fiscal 2018 were 23.3 billion yen, which was equivalent to 5.0% of net sales. We anticipate a very similar result for fiscal 2019, with research and development expenses equivalent to 5.1% of a projected 25.0 billion yen in net sales. Our aim is to keep research and development expenses at a level equivalent to 4% to 6% of sales, regardless of business conditions and performance trends. In terms of monetary amount, this represents a level that is more than double what we were spending 10 years ago.

With regard to the creation of new business based on the new technologies and sectors cultivated primarily by Corporate R&D, we keep resource investment limited to

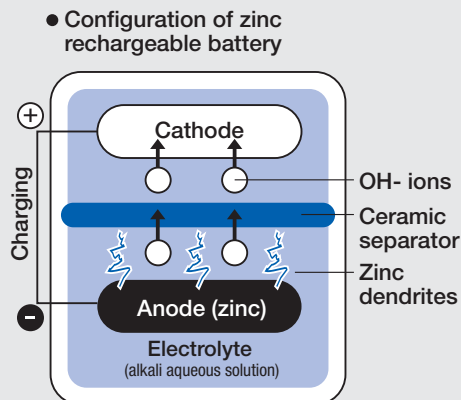
### Distinctive technologies:

#### OH<sup>-</sup> ion-conducting ceramic separator—a key part in the zinc rechargeable battery

The zinc rechargeable battery provides performance on a par with lithium-ion secondary batteries while being much less prone to catching fire due to the use of an alkali aqueous solution as the electrolyte. The basic principles of the zinc rechargeable battery with zinc anode have long been understood, but applying it to a commercial product has eluded researchers until now. Because of its inherent properties, zinc anodes develop dendrites during charging. These dendrites penetrate through conventional polymeric porous separators to reach the cathode and short the battery.

Now, the NGK Group has developed dense OH<sup>-</sup> ion-conducting ceramic separators, which allow the OH<sup>-</sup> ions necessary for cell reaction to pass through but which block dendrites, thereby successfully keeping the battery from shorting.

The zinc rechargeable battery is currently undergoing in-house and outside demonstration testing as a stationary storage battery, with the aim of bringing it to market.





specific sectors. In order to ensure we can generate new business, we concentrate our resources into those sectors where growth is expected, based on market trends, as well as those sectors where our distinctive technologies give us a competitive advantage over our competitors.

In addition, we do not rely solely on Corporate R&D for new product development. Rather, we treat it as a company-wide endeavor comprising the business divisions that will market the new product, Corporate Manufacturing Engineering that will determine how and where of mass production, the Intellectual Property Department that will handle patents, the Purchasing Department that will secure the necessary materials, and all the other departments that will have some connection to the new product. This approach has already produced some results. One advantage of this is that it allows us to consider mass production during development and facilitates the creation of a pilot line for test production during the latter half of new product development. Just prior to EnerCera entering mass production, Corporate

R&D took the lead in creating a pilot line, which could produce one million units a month, thereby facilitating trial and error improvement.

#### **Collaborating with outside research organizations**

In order to help NGK cultivate new and distinctive technologies, we seek out collaboration with universities and other outside research organizations. In 2011, we established the NGK Material Innovation Laboratory (NIL) together with Nagoya Institute of Technology (NITech) as a result of a comprehensive collaboration agreement. NIL is a virtual research institution without its own research facilities and equipment. It comprises six to seven professors, associate professors, etc., from NITech and 20 to 30 employees from the NGK Group. NIL members come and go between the university's laboratories and NGK Corporate R&D as they undertake the challenges of developing next-generation battery materials, transparent semiconductor materials, and various other materials with revolutionary properties.



NGK Material Innovation Laboratory  
 (From left) Naomi Teratani Corporate R&D member, Professor Masaki Tanemura (NITech), Naomi Fukui Corporate R&D member, Associate Professor Kalita Golap (NITech), Associate Professor Noriyuki Sonoyama (NITech)





## Capitalizing on distinctive technology to drive the development of innovative and competitive products

**Emiko Hamada** Outside Director 

Program Officer at the Japan Science and Technology Agency. Spearheaded the invention and commercialization of the CD-R (Compact Disc-Recordable) at Taiyo Yuden. Later, joined the faculty of the Nagoya Institute of Technology and Nagoya University, where she is engaged in mainly industry-academia-government collaborative research.

### How important would you say research and development are for the NGK Group?

**Nanataki:** No company can continue selling the same exact thing forever. For a company to endure, it has to keep coming up with something newer, which it can then commercialize. The NGK Group has the “Keep up 30” target, which aims to ensure that new products always make up 30% of the Group’s total product offerings.

**Hamada:** Companies need to always have something new. And companies expect research and development to play a major role in providing that ‘something new’. I too have high expectations for what R&D can produce.

### What are the NGK Group’s R&D policies and strategies?

**Nanataki:** We are focused on advancing our material technologies, centered on fine ceramics, for the sake of improving the competitive strength of our existing products and developing new products. The important thing is for us to narrow down to some degree our development efforts into areas where our distinctive technologies can make us competitive against other companies, all while meeting the needs of the times. We look for niches in a number of different areas, such as wafers, batteries, and separation membranes, and then quickly identify workable research themes to which we allocate resources.

Also, a major key to success is working in concert with the Business Groups from the early stages of development. Getting the Business Groups, Corporate Manufacturing Engineering, and others involved in product development and then having customers evaluate the trial products facilitates a smooth transition from product development into mass production-focused commercialization.

**Hamada:** I think this is a good approach to have, as successful development requires that everyone connected with a new product have a sense of personal investment in its success. Often times, R&D ends up just coming up with a product and not thinking about launching it into the market. But the success rate is immensely higher when all departments have a sense of mutual responsibility for a new product’s success.

### What are your major focuses in research and development?

**Nanataki:** Compared with other companies NGK is strong in terms of elemental technologies like ceramic crystalline orientation technology, hydrothermal synthesis technology, techniques for combining differing materials, and co-firing technologies. We capitalize on these distinctive technologies to drive the development of innovative and competitive products. All of our new products, including our bonded wafers for SAW filters, gallium nitride (GaN) wafers, and EnerCera® chip-type ceramic secondary batteries, were developed using this approach.

However, creating an innovative and competitive product takes time, sometimes requiring two to three years to commercialize, and even 10 or more in some cases.

**Hamada:** It certainly took more than 10 years for NGK’s GaN wafers. Research into solid oxide fuel cells (SOFC) has been ongoing for the past 30 years.

**Nanataki:** Nevertheless, it is important that we are committed to using those technologies where NGK stands apart from its competitors to create innovative and competitive products.

At the same time, it is also important to pursue an open innovation approach to our work, such as by collaborating with universities, in order to help us develop more new and distinctive technologies. At present, we have over 40 collaborative development projects underway.

**Hamada:** University researchers and companies have different focuses. That means when they work together, it can often produce results that neither side was expecting.

**Nanataki:** That’s why our expectations for open innovation are high. We are pursuing joint research not only with universities but also with public institutions, and we seek a broad range of partners with whom to undertake research and development.

**Hamada:** By interacting with a variety of different researchers, it opens up all sorts of new perspectives in terms of materials and processes. One approach is to collaborate with user companies while having a university in the middle.

The NGK Group draws its strength from research and development. We interviewed Emiko Hamada, outside director who has a wealth of experience in R&D at a company and universities, and Tsutomu Nanataki, Senior Vice President and Group Vice Executive of Corporate R&D on future goals and what makes the NGK Group's R&D so unique.

## Tsutomu Nanataki Senior Vice President

(Group Vice Executive, Corporate R&D)

Group Vice Executive of Corporate R&D and Project Leader of the Functional Materials Development Project. Studied industrial chemistry at Shizuoka University Graduate School before setting out on a career at NGK in the R&D sector.



I think that the truly core aspects of ceramics technology should be pursued in the way that they currently are, with research being carried out in conjunction with the country's top specialists. In the area of ceramics, Japanese universities are quite strong.

### Tell us about any memorable experiences you have had while doing research and development.

**Nanataki:** One time I got anomalous data when doing measurements of a prototype. I usually ignore that kind of data, but on this particular occasion, that abnormal data caught my attention. I kept analyzing it to find its cause, only to realize that the data pointed to an essential phenomenon, which ended up significantly advancing the creation of marketable product. It is times like these when I feel my persistence as a developer has paid off. I always tell those under me not to ignore that sort of anomalous data.

**Hamada:** It really is thrilling for a researcher to discover something. Even if it is something that only occurs only one out of 100 times, that excitement when it does turn into something is tremendous.

**Nanataki:** The skill of a researcher lies in not letting that sort of data go unnoticed. You could describe it as the ability to listen to what the material is telling you. It is crucial to pay close attention to all data in order to recognize even the smallest clues that will lead you to the underlying mechanism explaining the phenomenon.

### What are some things that leaders in your position need to be aware of?

**Nanataki:** You need to be able to recognize when it is time to stop and when it is time to put more effort into it. Stopping is particularly hard. No matter how much you may want to keep going, resources are limited. If you do not stop when you should, you will hinder your ability to concentrate resources on promising research. It is a hard thing to recognize and will likely remain a perpetual challenge for those in charge.

**Hamada:** There comes a time when you have to stop. And when that time comes, the person in charge has to be the one to take full responsibility for the decision.

### As an outside director, what sort of advice do you have for the NGK Group's research and development?

**Hamada:** NGK is still not very good at explaining things from the customers' perspective. For example, when NGK increases battery capacity, instead of explaining this in terms of what advantages this larger capacity has for the customer, they tend to focus on how much the battery capacity numbers have been improved. It is not enough to only talk about how fantastic a product's features are; researchers need to also be able to talk about what real value the product can provide.

Take EnerCera, for example. The fact that its capacity has been doubled is fantastic. But doubled capacity is not enough to make customers ignore a high price tag. You need to first determine the price you want to sell them at and, based on that, determine what the necessary production costs would be. And then you carry out development towards that goal. It is important to think about what the customer will value, and this includes not just performance but price as well.

**Nanataki:** That is definitely an area where we are lacking. We will need to work harder.

**Hamada:** Also, I would like to see NGK researchers not be so overly focused on their own areas of specialization but, rather, pay more attention to the technological trends happening in various other fields so that they are more sensitive to how the world is changing.

### Where is NGK research headed to in the future?

**Nanataki:** I would like for NGK to focus more on coming up with proposals for customers that explain how they can utilize the products we develop. For those of us in R&D, product integration, utilization ideas, improvements, and other marketing-esque jobs are likely to take precedence in the future. This is already what is happening with EnerCera. We are focused on identifying customer needs and then working with them to develop products with diverse applications to meet those needs.

**Hamada:** I would add that there are quite a few ceramic materials and technologies that are essential to the production processes of a variety of industries. HPC (ceramics for semiconductor manufacturing equipment) is a truly amazing product. The possibilities for expansion are limitless, and it is important that NGK continue to explore them.