Competitive Strength

Making ceramics is like putting together a complex jigsaw puzzle

From its very beginning, the NGK Group has sought to reexamine conventional ceramic manufacturing practices in light of the latest science and technology in order to help it identify the optimal combination of process conditions for each of its products. And after nearly 100 years, this pursuit of optimization has accrued a wealth of technology and expertise from which the NGK Group draws its competitive strength.

Ceramic manufacturing is patient, methodical work, which requires you to blow life into inanimate material that is hard and brittle.

There are three stages by which raw materials become products, and each requires advanced technologies.

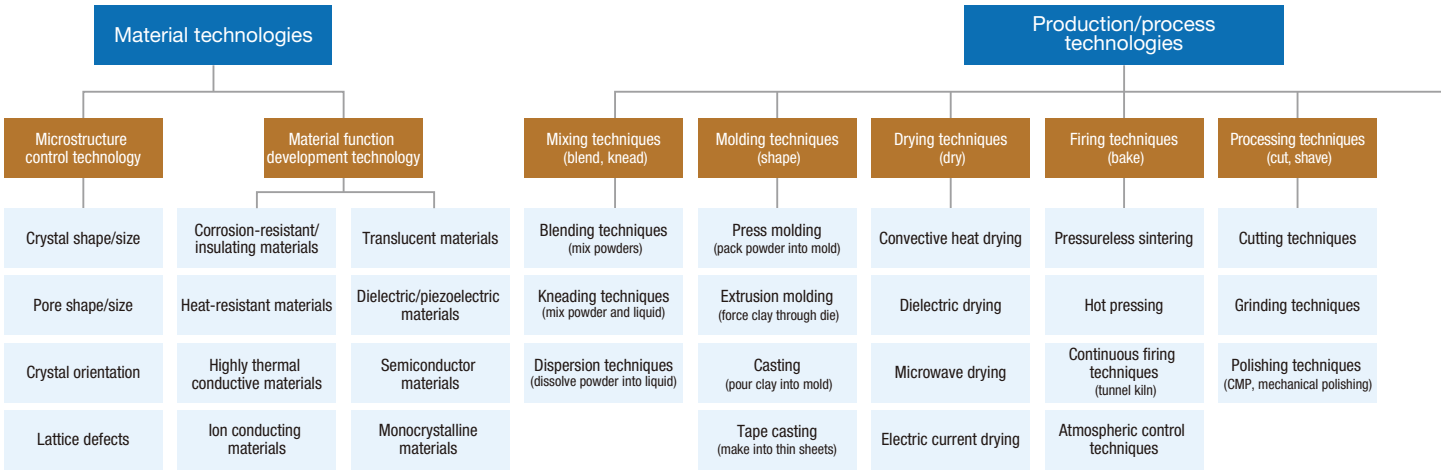
1. **Selecting and blending the raw materials on which the product is based: Mixing and kneading**
2. **Molding the product: Shaping**
3. **Firing the product so as to realize the optimal crystalline structure: Baking**

Particles of the powdered raw materials that form ceramics have a diameter of just 1/1,000 of a millimeter. If the particles are too large, it will take too long to fire them, and if they are too small, they will exhibit cracking and variability. If particles of different sizes are mixed together, distortion may result. The optimal raw materials must be chosen from tens of thousands of possibilities and blended together.

The blended raw materials are molded using a method that suits the shape of the product and fired in a kiln. Upon firing, the particles of raw materials fuse together and contract, causing finished products to shrink by about 25% for insulators and about 10% for HONEYCERAM®. The key priority is to create uniform, appropriate gaps between powder particles during the molding stage. Failure to do so will result in variability in how the product shrinks when fired, causing its shape to change. Temperature distribution in the kiln is also important. The powdered raw materials harden to create minuscule crystals, and the structure of these crystals determines a ceramic product's characteristics. That crystallization process is influenced by the temperature and duration of the firing process. If temperature variations inside the kiln create differences in how firing proceeds, the finished product will not be uniform.

In this way, high-performance ceramic products can only be produced if a variety of conditions are satisfied at every stage of manufacture. It is like a complex jigsaw puzzle. The breadth of accumulated technologies and expertise is the source of the NGK Group's competitive strength.

Core Technologies of the NGK Group



Embracing the challenge of developing new products by inheriting and improving distinctive technologies

I have been involved with developing the ceramic electrode plates that lie at the heart of the EnerCera® lithium-ion rechargeable battery. Currently, I am working to develop mass-production processes and more advanced material technologies. My goal is to create materials with even higher capacity and greater durability and thermal resistance.

The NGK Group's distinctive technologies—crystalline orientation control technology and multi-ceramics lamination technology—made it possible to develop the EnerCera battery. These technologies emerged during the study of piezoelectric materials that could control the flow of ink when the NGK Group was developing piezoelectric micro-actuators for use in inkjet printers more than 20 years ago. We accumulated expertise as we were applying the technologies to various products, and they were incorporated into the development of the EnerCera battery, which I was a part of.

NGK's organizational culture, one that encourages to never to give up, underpinned this long-term development program. Every day I see how this environment helps us consider how a technology can be taken advantage of in other ways, even if it does not yield results immediately in the form of a product. For example, the extrusion molding technology and thin-film technology used in HONEYCERAM originated decades ago, but even today engineers continue to refine associated knowledge. The process of inheriting and improving technologies in an unbroken chain from those who came before us leads directly to the development of leading-edge products.

I believe that not only tenacious effort, but also connections to a variety of people are important. If we were to list them all, the technologies we handle comprise more than 100 fields, and no single person can grasp them all. However, the NGK Group has not only a base of accumulated technologies, but also many talented engineers. I often gain hints from people with specialized knowledge in different fields, and I am fast to seek advice since it helps me refine ideas in my development work. This approach proved useful in the development of the EnerCera battery, too.

After studying the basics of metals, ceramics, and other materials during my student days, I joined NGK in 2008 because I wanted to be involved with developing new materials from the beginning. Since that time, I had been eager to show my family and friends a product that I helped develop, and that dream finally came true with the EnerCera battery.

Going forward, I hope to be involved in developing a completely new technology. I want to come up with a technology that will become a major source of revenue for NGK, for example by combining ceramic technology with recycling and effective resource use.

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