

One material, boundless potential: green and digital ceramics solutions



One material, boundless potential

Even after nearly four decades working for and recently becoming president of NGK Insulators (NGK), the world's leading industrial ceramics manufacturer, ceramics can still be full of surprises for Shigeru Kobayashi.

"What's amazing about the material is how it has continued to provide unexpected functions to match society's changing needs over time," says Kobayashi.

Using unique moulding, firing, processing and evaluation technologies, NGK has continued to bring out ceramic products with new properties and industrial applications. The company's century of evolution reflects this versatility.

Since being founded in 1919 to produce Japan's first insulators for transmission lines, NGK's numerous products across various sectors have become indispensable globally. Power grids in more than 100 countries rely on its ceramic insulators to safely deliver electricity. Half of all internal combustion engine cars produced today contain NGK's substrates and its automotive-related ceramic products. In the last decade, the company has become the top supplier of critical ceramic components necessary for equipment used to manufacture semiconductors.

As know-how accumulates, NGK's laboratories continue to innovate, from next-generation batteries to molecular sieves. Driving all this is a patience to keep at a project for years, sometimes decades, before successful commercialisation.

These assets will play a crucial role in NGK's mid- to long-term vision announced earlier this year. Having identified carbon neutrality and digital transformation as the world's most urgent priorities and where growth lies, NGK pledged to become: "A company to contribute to carbon neutrality and digital society with our unique ceramic technologies". In a drastic self-transformation, NGK aims to generate half of its total sales from products related to carbon neutrality and digital areas by 2030 from its current 30 per cent. This proportion will rise to 80 per cent by 2050.

Harnessing renewables through ceramics

Heading the list of technologies NGK hopes will help realise its new group vision are its unique batteries.

"Now that the whole world is racing towards carbon neutrality, batteries which can store more energy for longer durations are increasingly in demand," says Kobayashi.

Indeed, global renewable energy capacity in solar and wind power increased at record rates last year. But as these renewables are intermittent sources of energy—affected by weather and time of day—there is a growing need to store and shift this energy for when power is needed or can be transmitted through the grid. Without such storage, renewable energies are wasted.

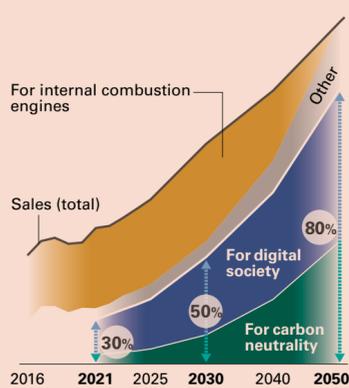
The NAS[®] battery ideally matches such requirements of long-duration energy storage systems for renewables, explains Kobayashi.

The NAS battery is made of sodium (Na) and sulphur (S) electrodes separated by a fine ceramic electrolyte. Development of the technology started in 1984 to provide more flexible energy storage than pumped



Shigeru Kobayashi
President, NGK Insulators, Ltd.

Projections for carbon neutral and digital society-related businesses by 2050



hydro for a Japanese utility company. The first NAS system was deployed in 1995, making it the world's first commercialised large-scale energy storage battery system. It is now in use in about 200 locations worldwide with a total output of more than 695MW and a storage capacity of 4.9GWh.

The NAS battery has multiple advantages over its rivals: scalability, constancy of up to six hours or more of high electric power output, and durability. In addition, they are compact, allowing for rapid and cost-effective deployment, and boast safety features proven through extensive field experience.

"Although lithium-ion batteries for large-scale storage have been in the limelight recently, there are risks such as resource constraints," says Kobayashi.

Over the past year, lithium prices have surged along with demand for electric vehicle batteries, raising concerns about future shortages. The NAS battery, on the other hand, only requires comparatively common materials, so its production costs will not be affected even if output is ramped up. Once economies of scale kick in, NGK argues that NAS batteries can be offered at a price far lower than its already competitive level. And unlike lithium-ion

batteries, the NAS battery is resilient to harsher weather conditions and able to handle full discharge cycles frequently, making it an attractive long-term option.

Most recent orders for NAS batteries include those for a solar power plant in Mongolia and a wind farm in South Korea. NGK will supply NAS batteries for the Mongolian plant so that renewable electricity can be used day or night, reducing the country's dependence on coal. In South Korea, NGK will supply, through its partnership with BASF New Business GmbH, a subsidiary of the German chemicals giant BASF, NAS batteries for a 21MW wind farm. NAS batteries there will ensure the stable supply of electricity for a power-to-gas plant which will produce green hydrogen from wind power. BASF is also planning to set up NAS batteries in its plants globally to store renewables which increasingly power its sites. In September, NAS batteries were connected to BASF's Verbund site in Antwerp, Belgium, making it the first installation of the technology in a BASF facility.

Along with expanding such orders, Kobayashi wishes to develop a business model of providing "energy as a service, in a kind of banking service of storing energy" using NAS batteries. He is also hoping to partner with renewable energy producers to use NAS batteries to supply green energy directly to NGK's production plants. Such measures will help the company reach its goal of halving its own carbon emissions by 2030 compared with 2013 and reach carbon neutrality by 2050. In addition, the company has announced that all electricity used at overseas bases—approximately 60 per cent of all electricity used by the NGK Group—will switch to renewables by fiscal 2025, helping to cut about 330,000 tonnes of CO₂ per year. Along with NAS batteries, NGK is also developing the world's first zinc rechargeable battery using a proprietary ceramic separator and aqueous solutions as the electrolyte. These features make the zinc rechargeable battery system safe and suitable for large energy storage indoors to provide emergency power supply and renewable energy use.

"Since zinc rechargeable batteries are lighter and smaller than lead batteries, they can be stored in about half the space required for lead batteries and are ideal for putting in all kinds of places indoors," explains Kobayashi. The company expects potential use cases in schools, stores, base stations, and communication buildings where maintaining power during black-outs is vital.

Capturing, storing and utilising carbon with ceramics

Of course, batteries for renewables are only one step towards achieving a carbon neutral society.

“Whichever system—hydrogen, methane, methanol, or e-fuel—becomes the standard for a carbon neutral society, our strategy is to be ready.”

Across the carbon capture, utilisation, and storage (CCUS) cycle, NGK technologies promise to play a significant role. For example, NGK has developed the world's largest ceramic membranes capable of separating out carbon dioxide using proprietary sub-nanometre-sized pore control technology. In the near future, there are hopes that these subnano-ceramic membranes could be used to directly capture carbon dioxide from the ambient air. The captured carbon dioxide may then be combined with water through another emerging NGK application—a solid-oxide electrolysis cell—to produce fuels and raw materials efficiently. Another stage in the CCUS cycle will be the production of synthetic fuels such as methane, methanol, and e-fuels. Here too, NGK's honeycomb structural reactors utilising large-scale ceramics extrusion and separation membrane technology may help efficient production.

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Funding this strategy, the company plans to pour some JPY 300bn over the next ten years into R&D, allocating 80 per cent of this for carbon neutral and digital society applications.

Diversifying with strength

One reason why the company can, in a sense, back so many horses and envision a long-term conversion of its business structure is that it does so from a position of strength. Two of its current main earners in the automotive and semiconductor ceramics business are in rude health.

Kobayashi explains that although the company is planning on a scenario that the global market for the internal combustion engine will hit zero by 2050, the process is not going to happen overnight. Besides, the company's revenues for semiconductor manufacturing equipment have risen steadily, driven by insatiable chip demand.

Both domains should generate steady revenues to fund NGK's transformation and keep shareholders happy. In the meantime, the company hopes to increase overall sales from JPY 452bn in the year ended March 2021 (with operating income of JPY 50.8bn) to some JPY 600bn (with operating income of JPY 90bn) by 2025.

Other products are also lined up to boost digital-related revenues. These include the prize-winning and recently commercialised EnerCera[®]—a high capacity, ultra-small, ultra-thin and long-living rechargeable lithium-ion battery—which promises maintenance-free energy for IoT. Another is the high-quality Gallium Nitride (GaN) wafer, which will be indispensable as the wafers used in the production of semiconductors for next-generation power devices. The new material is drawing close interest for its potential to contribute to carbon neutrality and enable IoT.

"Long before this global pivot to carbon neutrality and digitalisation, we have been steadfastly nurturing many ceramic-based seeds," says Kobayashi. "Now we come to find that many of them have applications for today's needs."

NGK's evolution reminds us that nothing is more powerful than an idea whose time has come. With many ideas up its sleeve, and patience to wait for the right time to come, the Japanese manufacturer will be indispensable as we shift to a greener and more digital world.



NAS systems, pictured here, are deployed at various wind and solar power stabilisation sites globally.