Contribute to the World through Technology

Important Themes
- Addressing social issues by developing new kinds of products the world has not yet seen
- Pursue zero-defect product quality

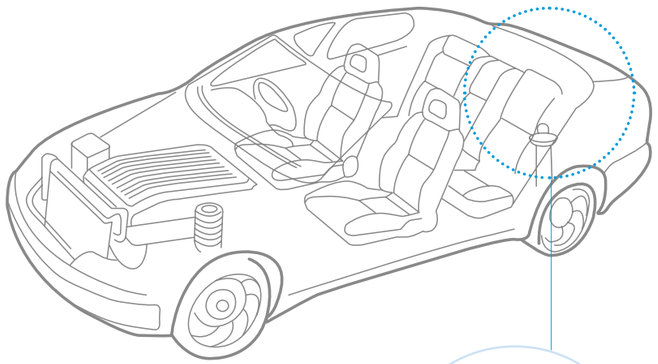
Addressing social issues by developing new kinds of products the world has not yet seen

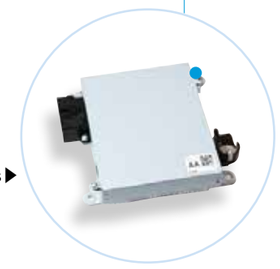
The high-level fusion of *Monozukuri* and *Kotozukuri*

TDK contributes to society by anticipating customer needs and developing creative responses to issues affecting customers and society as a whole. Breakthrough solutions are created by combining different technologies and products that arise from the manufacturing excellence or *Monozukuri* that TDK has cultivated for more than eight decades. TDK is now taking *Monozukuri* to the next level to create solutions with expanded value for customers, partners and society: (a concept we call) *Kotozukuri*.
The some products demonstrate the high-level fusion of *Kotozukuri* and *Monozukuri* to which TDK aspires. In this section, we take a closer look at how leaders from various divisions deploy these concepts in their work.

Automotive DC-DC converters

Automotive DC-DC Converters, Contributing to Reducing the Environmental Load of Cars





Automotive DC-DC converters ▶

Recent years have seen policies announced to promote a shift to EVs in Europe, China, and elsewhere, and the widespread use of EVs is expected to accelerate worldwide. Automotive DC-DC converters are responsible for charging auxiliary batteries in EVs, and for supplying the power needed in electrical systems, and high-efficiency DC-DC converters are also in demand for extending vehicle cruising range. Making full use of the power electronics technology accrued through its development of consumer and industrial switching power supplies, TDK is developing and offering automotive DC-DC converters that are smaller, lighter, highly efficient, and highly reliable.

1 Material

Atsushi Yakuwa
Manager
Prepreg Production Group
Production Division, EV Power BU
Energy Systems Business Group
TDK Corporation

Expanding the scope of vision beyond materials to anticipate solutions and contribute to the safety of environment-friendly vehicles

I am a leader in the Manufacturing Group. The high heat dissipation substrate prepreg*1 I was in charge of developing offers outstanding thermal conductivity, allowing it to be installed on the circuits of components that emit enormous heat. This innovation also contributed to the development of a new DC-DC converter, which while compact and lightweight still offers high output. Embedded within the product, the material does not call attention to itself or indicate the investment of time put into its development. With this project, I realized it is important that we look not only at the material, but refine our sensitivity so that we are constantly aware of our contribution to *Kotozukuri*, while also sharing our thinking with those involved in *Monozukuri*. Going forward, I hope to contribute to the development of even more compact, higher-performance DC-DC converters, taking on the challenge of new materials and processes so that we can aid in boosting the popularity and greater safety of environmentally friendly vehicles.

*1 Prepreg: A semi-hardened glass or carbon fiber cloth impregnated with a thermosetting resin.

2 Process

Kenji Kotegawa
Senior Manager
Monozukuri Element Development Department
Monozukuri Center
Production Engineering HQ
TDK Corporation

Introduction of robot cells*2 makes low-volume, high-mix *Monozukuri* possible stable, high-quality manufacturing contributes to automobile safety

I am in charge of deploying robot cells in the manufacture of the DC-DC converter. This production technique has allowed us to adjust the number of cells to respond flexibly to changes in volume, which in turn has enabled low-volume, high-mix production without picking, reducing costs and making traceability by individual product possible. Working with other departments, the ability to identify manufacturing problems and quickly provide feedback to the design team were particularly important factors. Variability or flaws in automotive components can have serious consequences for life and health. The introduction of robot cells to ensure a stable supply of high-quality products is thus directly connected to automotive safety. Accelerating the cycle by which improvements are reflected in design, as we did with this project, increases our First to Market advantage. This is why we hope to continue using *Monozukuri* technology to play a part in *Kotozukuri* that responds to market needs.

*2 Robot cell: A method in manufacturing where one or more robots are employed in the assembly of products.

3 Component

TDK's *Monozukuri* conceives new components from materials and realizes solutions for customers

Masahiro Gamou
Manager
Development Division
EV Power BU
Energy Systems Business Group
TDK Corporation

I am responsible for the optimization and miniaturization of magnetic components. All car makers have a common need of requiring the DC-DC converter to be smaller, capable of handling very high current and also be highly efficient. But each customer has different specifications, which presents a challenge for us.
In order to realize *Kotozukuri* for each customer, we can draw upon our original innovation: ferrite. This essential material, our core resource, allows us to create new products and solutions that competitors cannot.
Ferrite, uniquely among the various magnetic materials, has the advantages of being low in cost, able to operate in high frequency, and capable of taking myriad shapes. Working with other TDK divisions, we can create high value-added products from ferrite. In other words, by approaching and advancing our *Monozukuri* with new ideas, we can bring about true fusion. I look forward to working closely with other departments and divisions with different experiences and knowledge in order to shape the next generation of *Monozukuri*.

4 Solution

Advancing *Kotozukuri* and *Monozukuri* that aligns with customer needs

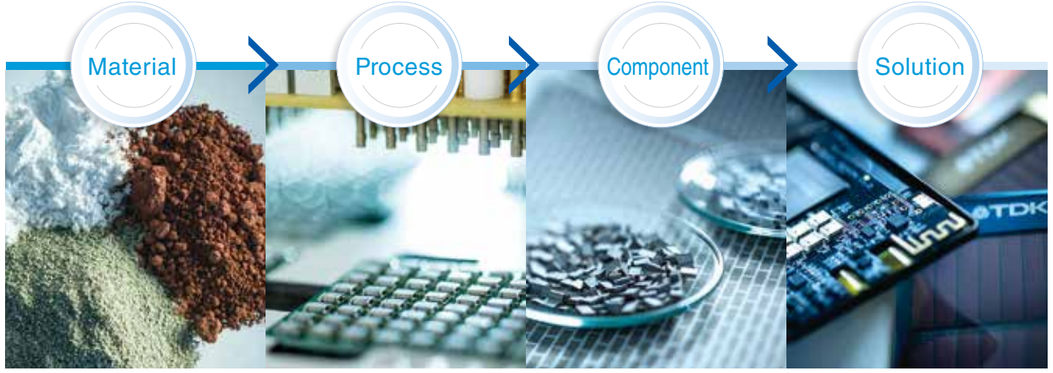
Yoshiaki Ishikawa
Development Division
EV Power BU
Energy Systems Business Group
TDK Corporation

My job is designing the substrate for the DC-DC converter. Since this product serves as the vehicle's power supply source, any failure could risk an accident.
We need to consider every factor, including the extent to which we can predict dangerous situations, overall safety, and reducing the vehicle's environmental load.
At times, customer needs range well beyond anything we might imagine, making it essential that we build close relationships with their suppliers and ensure we are all headed in the same direction. In that sense, you could say my role is that of a liaison with the *Monozukuri* worksites, helping customers achieve their own *Kotozukuri*.
Working with everyone involved in manufacturing at TDK, I hope to be more in tune with our customers, ensuring I approach my design work from their point of view, and continuing to take on the challenge of resolving social issues such as safety and the environment.

Solid-state rechargeable batteries

Safe battery technology for IoT: CeraCharge™ the world's first solid-state rechargeable battery in SMD technology

CeraCharge™ is a unique battery based on solid ceramic-based electrodes and electrolyte produced with multilayer technology. This enables a relatively high energy density based on Li-ion battery technologies and smallest volume to be combined with the high volume manufacturing benefits of multilayer components. As a key safety feature, CeraCharge™ eliminates the risk of fire, explosion, or leakage.
CeraCharge™ will open up a wide range of possible applications – particularly in devices intended for the Internet of Things, such as energy storage devices for Bluetooth Beacon, wearables, energy harvesting, or backup battery for real-time clocks.



New kinds of solid lithium-oxide powders enable safe energy storage.

An extremely precise manufacturing process combined material know-how with multilayer and thermal process control.

The CeraCharge™ design was validated and aligned to the real needs of both our customers and their customers.

CeraCharge™ was developed to provide a reliable and safe energy source, especially for compact mobile applications.

1 Material & Process

Combining our material and multilayer technology know-how with our thermal process expertise

Dr. Yongli Wang
Co-project leader CeraCharge™, Piezo & Protection Devices Business Group, Corporate R&D Materials, Deutschlandsberg, Austria

Material and process go hand in hand with CeraCharge™. It was first necessary to create new kinds of solid ceramic materials that could store sufficient energy safely and be able to perform up to 1,000 charge/discharge cycles.
The solution was innovative lithium-based oxide powders for both electrodes and electrolyte that are perfectly matched to each other and are capable of being co-fired in a special multilayer process.

In addition to the materials themselves, an extremely precise manufacturing process had to be implemented for the high-volume production of the multilayer components. Our challenge was to transfer the breakthrough technology to the Piezo & Protection Devices Business Group (PPD) and integrate it into an industrial-scale process.
To do so, we faced the key challenge of combining our knowledge about all-ceramic-battery material systems and multilayer technology with our expertise in precise thermal process control for the copper inner electrodes.

We succeeded in setting up sample production on a pilot line thanks to the extensive material know-how at the TDK Technology HQ in Chiba, Japan, and the industry-leading competence of PPD for multilayer processing, thermal process control and back-end processes acquired through years of experience with a broad range of ceramic and piezo products at the PPD in Deutschlandsberg, Austria.
The introduction of such novel components into the existing PPD ecosystem required a totally new mindset and multicultural communication to enable an efficient cooperative development process between the BG, Technology and IP HQ.

The challenge will be to tap into the technological competence from the entire TDK organization and our lead customers in order to provide solutions that fulfill dynamically changing requirements with more flexible designs, shorter lead times, better performance, higher quality and more reliability.

2 Component

More than 30 key customers were visited to gather valuable feedback about applications and markets

Masahiro Oishi
Co-project leader CeraCharge™, Piezo & Protection Devices Business Group, Corporate R&D Materials, Deutschlandsberg, Austria

My focus during the transfer of the CeraCharge™ technology from TDK's Technology and Intellectual Property HQ in Japan to the PPD BG in Deutschlandsberg, Austria, was on the development of the actual component. The first stage involved material screening and development and process screening.
For these purposes we developed first prototypes and established valid characterization procedures. The definition and implementation of a supply chain for the material demand throughout the R&D process was a special challenge in order to be able to produce CeraCharge™ prototypes. All along, our objective was to develop a marketable component, and in order to promote the new product to the customers, actual demonstrators were built.
Already in the early stages of development, more than 30 key customers were visited and shown the product's features and specification range. We used these meetings to gather valuable feedback about the potential applications and markets as well as validate and align our design to the real needs of our customers and their customers, and this information was fed back into the development process.
At the same time, we intensified cooperative development activities with IC companies on a system level. To create even more value for customers and users, we focused not only on the development of the CeraCharge™ component alone, but also considered how CeraCharge™ can be used and how we can create new markets.

3 Solution

The development focus is always on the solution and how customers integrate CeraCharge™ into their systems

Markus Puff
Head of Corporate R&D, Piezo & Protection Devices Business Group, Deutschlandsberg, Austria

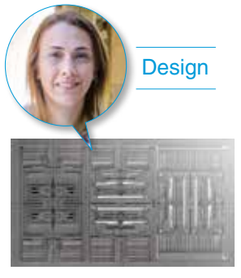
In the context of the "*Kotozukuri*" philosophy for creating solutions with expanded value for customers, partners and society, we sought to create a CeraCharge™ solution that meets all market requirements.
To accomplish this goal, it is necessary for all aspects of material and process design and component development to be optimally coordinated and interconnected. For this we defined USPs and benefits, analyzed the advantages and disadvantages of the technology on system level, performed benchmarking and feasibility studies, and explored cooperation with IC companies and other market leaders. Our development focus is always on the solution and the target applications with a strong emphasis on the benefits for our customers and how they integrate CeraCharge™ into their systems.
Over the entire development process, open and direct fact-based communication among the global, multicultural team proved to be the key to solving any challenges that arose. In order to realize our objectives and make a substantial contribution to the next generation of energy storage devices, we must further broaden and deepen our application know-how.
At the same time, we must also intensify the cooperation between Technology HQ, PPD BG, Sales, customers and other partners in order to enhance the benefits and user experience of the new CeraCharge™ technology.

Motion sensors

ICM-42600 6-axis motion sensor with 2 auxiliary interfaces to support dual-OIS camera modules for Smartphones

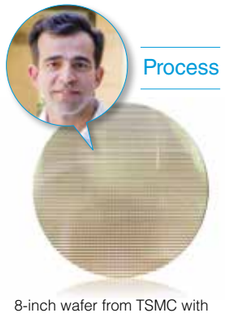
MEMS Motion Sensors are Semiconductors that include microscopic structures whose exact movement is measured through capacitance changes in surrounding electrodes. Acceleration and rotation are measured along 3 axis, allowing the sensor to accurately track the changes in position and orientation of a device. Motion Sensors provide critical inputs to control and navigation systems. One key application is the use of motion sensors to control Optical Image Stabilization (OIS) in camera modules for Smartphone and Digital Cameras. TDK-InvenSense new motion sensor can support 2 independent OIS systems, a key enabler of dual-camera OIS solutions in Smartphones, and a World first.

▲ICM-42600: World's first 6-axis MEMS Motion Sensor supporting dual-camera with dual-OIS image stabilization



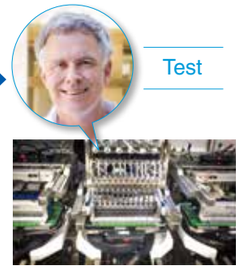
Design

Layout of a single-die 6-axis MEMS Gyroscope and Accelerometer Motion Sensor



Process

8-inch wafer from TSMC with TDK-InvenSense 6-axis MEMS Motion Sensors



Test

TDK-InvenSense proprietary "high-speed tester" for functional compliance verification of 6-axis MEMS Motion Sensors

Solution

World's first dual-OIS 6-axis MEMS Gyroscope and Accelerometer, ICM-42600

▶The full article of Motion sensors can be found on our website.
http://www.global.tdk.com/corp/en/csr/important/technology/csr30000.htm

Pursue "Zero-defect Product Quality"

With its proprietary technology, TDK has emphasized the pursuit of zero-defect product quality, based on *Monozukuri* that contributes to culture and industry through creativity. This is because we believe the key to successful *Kotozukuri*, or providing integrated solutions, lies in the pursuit of zero-defect product quality.

The Pursuit of Zero-defect Product Quality Starts from the Breaking Point

●Protecting customer safety is our lifeline

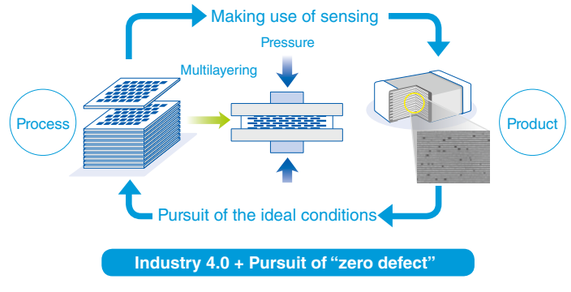
Why pursue zero-defect product quality? First and foremost, the objective is to protect customer safety, which is the lifeline of TDK's business. Only by building product quality into every level, from development and production processes onward, can we respond to the needs of our customers. For example, conducting pre-risk assessments during design screening and prior to mass production allows us evaluate latent risks, with the goal of achieving zero product defects when we do move to mass production. After taking those efforts to the breaking point, we work even harder. That is the true pursuit of zero-defect product quality.

Satoru Sueki
General Manager of Quality Assurance HQ
Corporate Officer
TDK Corporation

●Everyone participates in working toward a larger goal

In pursuing zero-defect product quality, it is crucial that each of us thinks and acts in terms of what each of us can do from the standpoint of our respective positions. This leads to the creation of value, and to the development of a global workforce comprised of employees who draw on their individual capabilities and bring ever greater motivation to enhancing their value of their work. The pursuit of zero-defect product quality involves more than simply reaching a numerical goal. As social changes progress, the quality expected of us will also grow. Today, we face issues such as an aging society and widening inequality, and going forward, we will be expected to generate value from a humanitarian and social welfare perspective. We will continue our pursuit of zero-defect product quality, responding to the evolving need for greater quality as we work toward this larger goal.

TOPIC: Introduction of a Model Line



At the Honjo Factory East Site completed in 2016, TDK is moving forward to deploy a model line for the pursuit of zero-defect product quality in the production of multilayer ceramic chip capacitors. In the multilayering process, which can have a significant impact on the quality of these capacitors, we compare a vast amount of sensor data regarding equipment operational status and product workmanship against data on product quality in pursuit of the ideal conditions for a non-defective product. Results obtained with this model line will be rolled out across other processes going forward.