

# How the TDK Group

TDK products play a vital role in many useful items of daily life.

## ICT (Information and Communication Technology)

In an increasingly networked world, the power of craftsmanship, which is a core strength of TDK, provides advantages when it comes to realizing the goals, such as making mobile devices more compact and versatile, or enabling data centers to store more data while consuming less energy.



### ■ Lithium ion batteries

These rechargeable batteries with high energy density are extensively used in various kinds of mobile devices. Advanced TDK technology for key components such as electrode materials and separator materials provides a decisive advantage.

[Main applications]

Smartphones, tablets and other mobile devices



### ■ Neodymium magnets for VCMs

Voice coil motors (VCMs) that drive magnetic heads in hard disk drives use neodymium magnets from TDK. A new material that does not require dysprosium, an extremely scarce rare earth material, has also been developed.

[Main applications]

VCMs in hard disk drives for notebooks, desktop computers, etc.



### ■ Thin film common mode filters

These products combine a common mode filter (highly effective in suppressing noise without affecting the signal) with a low-capacitance ESD suppressor that protects the circuitry from electrostatic discharge.

[Main applications]

High-speed differential signal interfaces in smartphones, tablets, notebooks, hard disk drives, solid state drives, etc.



### ■ SESUB

This proprietary substrate technology from TDK involves embedding lowered-profile IC chips directly in a multilayer substrate which allows highly reliable connections between chip terminals and board wiring. It is implemented in various types of modules that help to make mobile devices smaller and thinner.

[Main applications]

Power supply modules and wireless communication modules, etc. for smartphones, tablets, wearable devices and similar



## Cloud Computing (Data Centers)



### ■ HDD Heads

Hard disk drive (HDD) heads from TDK contribute to the realization of extremely high storage capacities required by data centers. TDK also has developed magnetic heads for thermal assisted recording to achieve super high recording density in the next generation of HDDs.

[Main applications]

Servers and storage solutions for data centers



### ■ Solid State Drives (SSD)

Data centers are implementing multi-tier storage systems where frequently accessed data are processed by means of SSDs which feature higher access speeds. SSD products from TDK designed for industrial use are playing a vital role here as well.

[Main applications]

Servers and storage solutions for data centers



# Makes Value Creation Happen

By pursuing a path of innovation for technologies and products geared to the needs of society, we consistently create new values.

## Automobiles

TDK is making significant contributions to improved performance and better fuel efficiency in environment-friendly cars such as hybrid electric vehicles (HEV) and electric vehicles (EV), as well as for self-driving vehicles currently under development.

### Film capacitors

A type of capacitor that uses plastic film as a dielectric. Characterized by high energy density, extended temperature range, high reliability and long life, they are therefore suitable especially for use in automotive electronics.

[Main applications]  
*Inverters for EV/HEV, etc.*



### Automotive-grade multilayer ceramic chip capacitors

The TDK capacitor lineup for automotive applications comprises high-temperature types that can withstand extreme temperatures up to 150°C such as exist in the engine room of a car, metal fitting type terminal (Mega Cap) and soft electrode types that are resistant to solder cracks caused by thermal shocks as well as mechanical stresses caused by board flexing, and mid level voltage types for hybrid and electric vehicles.

[Main applications]  
*HEV/PHEV/EVs (DC-DC converters, inverters, BMS), drive train ECUs (engine ECU, ABS, EPS, TCM), safety related ECUs (radar, camera), etc.*



### Current sensors

These sensors allow contact-free detection of battery charge and discharge currents in HEVs and EVs, inverter drive currents, etc. They are available in various product configurations such as Hall element types and GMR element types.

[Main applications]  
*Battery charge/discharge current management for HEV/EVs, inverter drive current management, etc.*



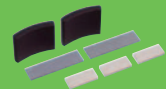
## Industrial Equipment & Energy

The use of renewable energy sources is expanding worldwide. The lineup of innovative TDK products in this area is instrumental in efforts at resolving serious issues such as global warming and the depletion of resources.

### Neodymium magnets

Large, high-performance neodymium magnets from TDK are used for example in gearless type wind power generators (multi-pole, permanent magnet synchronous generators) and in the rotor structure of industrial motors.

[Main applications]  
*Rotors of multi-pole, permanent magnet synchronous generators, etc.*



### Bidirectional DC-DC converters

These power conversion devices can turn the DC current of the source into a suitable voltage, and also perform conversion in the opposite direction, sending current to the source. They also enable energy regeneration in industrial equipment powered by electric motors.

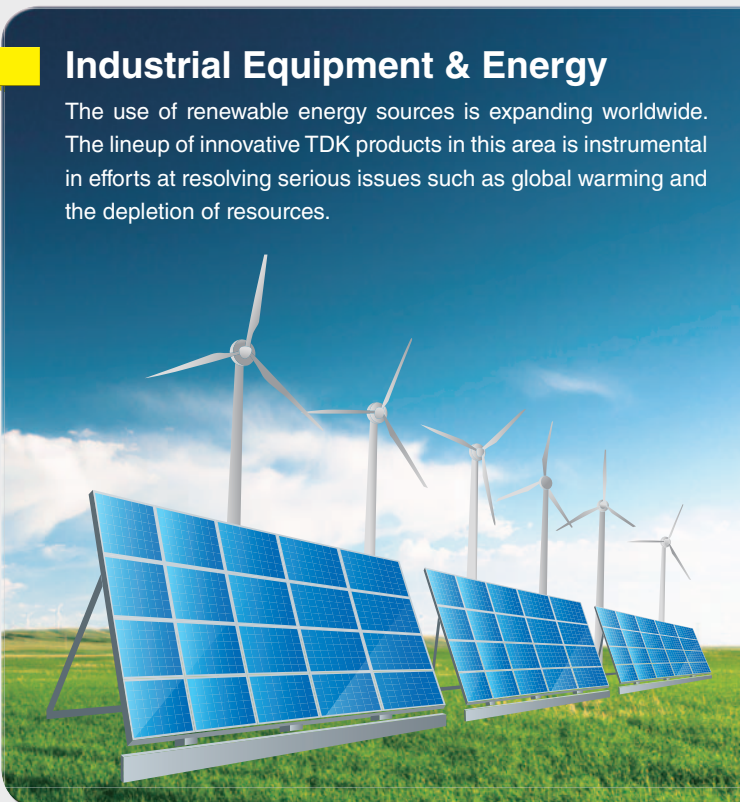
[Main applications]  
*Smart grid, DC power supply systems, and energy regeneration in industrial equipment*



### Aluminum electrolytic capacitors

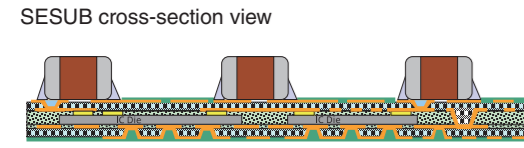
A type of capacitor using oxide coated aluminum foils as a dielectric, enabling high capacitance ratings. They are used in various kinds of power supplies for industrial applications, as well as in inverters and converters for solar and wind power installations.

[Main applications]  
*Various types of power supplies, solar and wind power generation systems, etc.*



### TDK's SESUB technology makes ultra-compact power management units (PMUs) and Bluetooth® modules a reality!

By embedding lowered-profile IC chips into the substrate, the SESUB (Semiconductor Embedded in SUBstrate) technique allows the realization of smaller, high-performance PMUs for smartphones, as well as Bluetooth® modules with world-leading compact dimensions.



#### Features

**Smaller parts and lower profile enable smaller dimensions of the end product while contributing to longer battery life and providing a higher degree of freedom for design. Further advantages are improved thermal dissipation and lower noise emission levels.**

### Always thinking about how to contribute to society

My work involves the realization of characteristics and specifications as envisioned by the customer together with us. I am involved in the process ranging from deciding on product specifications, through basic design and prototype manufacture, to finalizing product characteristics and ensuring quality. With mass production in mind, creating a product that is easy to manufacture has an important influence on product quality. Product design always needs to keep

the big picture in mind, from the manufacturing process to the final usage pattern by the customer. Even when there is a difficult demand from a customer, I aim to explore various possibilities and try to think of ways for meeting the requirement that we can propose to the customer. Unless we take this approach, we cannot create something that did not exist before. Through the use of SESUB technology, we not only offer products that are convenient

for the customer, but also contribute to the conservation of resources and reduction of environmental impact. For the future, integration with other technologies should enable solutions that can further enhance the benefits to society. In one's everyday work, it is easy to get caught up in the immediate task at hand, but I believe that it is equally important to always evaluate whether what we do also contributes to society at large.

### The "Improve quality" approach is a core strength of TDK

How can we package integrated circuits (ICs) in thinner and smaller form factors? How can we machine them without impairing yield? These are some of the questions that we ponder when trying to come up with structural solutions and methods that realize the concepts worked out by our design and development people in response to customer requests. TDK employees share an awareness of the importance of raising quality. They

know that this must start from the design stage and be implemented at every step in the process, rather than only through final inspection. I believe that this is a strong point of TDK. I am keenly aware that we must prevent problems from occurring after the product has left our factory and has become part of the customer's end product. This is even more true for SESUB modules which are often key components for the performance and characteristics of the end product.

In the past, the development of electric appliances for use in the home freed humans from various chores, and later the advent of mobile phones changed the way people communicate with each other. In this way, an invention may end up causing a change in lifestyles or sense of values. I believe that we should continue to aim for the development of innovative electronic components that help to bring people closer together.

### Reducing waste and helping to conserve resources

Within the SESUB manufacturing process, my work involves embedding IC chips in the substrate. Because there are several hundred to several thousand chips embedded on a single panel, the status of each chip has to be monitored in order to precisely position it at the designated location. I operate the IC bonder that bonds the chips to the substrate. I always strive to avoid operator errors

and increase yield in the IC chip embedding process. Increasing yield also means that there is less wasted material, which helps to conserve resources. Incidentally, the machinery equipment used in the IC bonding process is proprietary to TDK. I joined TDK less than a year ago, and am still relying on the kind assistance of people around me who teach and guide

me every day. My goal is to quickly become as proficient as they are. I want to do my best, because I strongly feel that the products we make are innovative and are the focus of high expectations by customers.

## SESUB Bluetooth® module

—Bluetooth Low Energy—

[Main applications]

- Smartphones, mobile phones, tablet devices
- Digital still cameras, mobile devices
- Health care products, wearable devices, etc.

### Design and Development



**Sayuri Terazaki**  
Supervisor,  
Design Section,  
SESUB Business Unit,  
Manufacturing Strategy Division,  
Thin Film Device Center

### Development



**Reo Hanada**  
Supervisor,  
SESUB Development Section,  
SESUB Business Unit,  
Manufacturing Strategy Division,  
Thin Film Device Center

### Manufacturing



**Daiki Takaishi**  
Manufacturing Section,  
SESUB Business Unit,  
Manufacturing Strategy Division,  
Thin Film Device Center

# How the Value Chain Works

—Creation process of a SESUB module—

Creating products that match the needs of customers and offer new value to the world-TDK's Monozukuri (manufacturing) consists of a number of and a variety of processes. How do people working in the lab, on the shop floor, or in the field see their mission? By way of an example to illustrate this topic, we introduce the

Monozukuri stance of personnel working in various areas of the new Semiconductor Embedded SUBstrate (SESUB) technology. SESUB is a solution that meets the market's demands for smaller dimensions, lower profile, and higher frequency operation in sectors such as ICT and health care.

### Sales

**Klaus Ruffing**  
Executive Vice President,  
IT/PMU, Embedded Solutions  
Systems, Acoustics, Waves  
Business Group



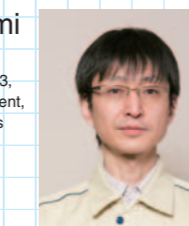
### Marketing

**Ichiro Yaginuma**  
Supervisor,  
Marketing Section,  
SESUB Business Unit,  
Manufacturing Strategy Division,  
Thin Film Device Center



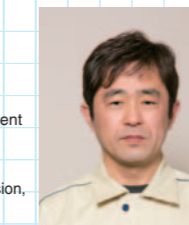
### Quality Assurance

**Kenichi Iwanami**  
Supervisor,  
Quality Assurance Section 3,  
Quality Assurance Department,  
Systems, Acoustics, Waves  
Business Group



### Production Technology

**Tomohide Yokozawa**  
Chief Inspector,  
SESUB Process Development  
Team,  
SESUB Business Unit,  
Manufacturing Strategy Division,  
Thin Film Device Center



### Bringing competitive products to the world

A SESUB module features lowered-profile chips embedded in the substrate. The appeal of such a product is not only that it realizes the smallest dimensions and lowest profile ever, it also offers excellent thermal dissipation and extremely low power consumption. Furthermore, thanks to their excellent shielding, SESUB modules emit very low levels of electromagnetic interference.

The successful technological development is a result of cooperation between the Japanese SESUB team and our Embedded Solutions team in Munich. The former's wide-ranging technology expertise and production know-how, paired with our extensive experience with high-frequency applications in the area of smartphones and other mobile devices, produced a synergy that best leverages the strengths of both sides.

This product will prove indispensable for the design of smartphones with further enhanced capabilities. It is our mission to bring SESUB products to worldwide markets, establish the technology as the market-leading standard for embedding, and thereby realize a major business opportunity. In close collaboration with the R&D department, we aim to create products with an even stronger competitive edge.

### Serving as a bridge between the development team and customer

Rather than simply trying to expand sales, I feel that my mission is to act as a kind of antenna, taking both TDK's course and the customer's requirements into consideration and facilitating the development of actual products. Since SESUB is still a new technology, customers sometimes come up with unexpected ideas for applications. Because we are the point of contact for the customers of TDK, we continue to communicate with them also after

product development has begun, and we convey their opinions to the development team. What's important here are responsiveness, speed, and the readiness to tackle tasks that others would rather avoid. Many employees working in marketing at TDK have technical job experience. Having the skills needed to actually design products is bound to enhance their trustworthiness in the eyes of the customer.

My aim is to be involved in creating a system which produces the sense of security that comes from connectedness. In our current age of longer life expectancy and falling birth rates, the number of people living alone is on the rise. The power of electronic devices can create a framework that provides support without being intrusive, and I would be happy if I can help in creating such a framework.

### Improving quality management through all stages from design to manufacture

The most important aspect of ensuring product quality is proper management of an approach that always asks how we can prevent the emergence of defective products. Various types of data are constantly being monitored to verify that there are no problems in the respective production processes. If a problem is detected, we provide guidance for identifying the cause and implementing suitable countermeasures. In the case of SESUB, if a chip does not function

properly, the entire product will be useless. Chip damage and connectivity therefore are two of the aspects that we pay special attention to. Customers increasingly demand a thinner substrate profile, but we have to evaluate how this may affect quality. We analyze possible risks and make sure that the results are reflected in the development process. Many aspects of the quality of a product are already determined at the design stage. When TDK designs new products

and manufacturing processes, data are shared extensively among many departments including the design, development, technology, and quality assurance sections. The design review stage provides a forum for deliberation about how to create a system that results in stable quality. In my opinion, this system plays an important role in maintaining our high quality standards.

### Thorough stabilization of quality

Working in production technology means being involved in the task of designing production lines. For me, the most satisfying aspect of this work is being able to produce results such as increasing yield by coming up with new ideas related, for example, to the development of new manufacturing methods or selection of materials, and having the customer appreciate the results. Because SESUB is still a new product

category, quality stabilization is the foremost goal. When a problem occurs in a production line, we of course have to look for the cause and eliminate it, but we also need to take measures to prevent a recurrence, and we must constantly verify whether such measures are working effectively. The fact that the entire SESUB production line from design to final shipping is contained within a single factory site is a

great advantage in this respect. It makes it easy to ensure good communication between processes and establish a speedy manufacturing setup. My area of responsibility is the substrate wiring formation stage. Trying to realize finer wiring patterns with a view towards cost reduction is the guiding concept of my work.

# Realizing the Spirit of Monozukuri Around the World

Craftsmanship in the Monozukuri tradition of TDK is spreading on a global scale. Harnessing a wealth of proprietary technologies, TDK continues to offer products that fit the diverse needs of regions around the world.



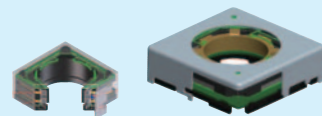
Taiwan

## Products Developed in Taiwan Tailor-made for the Increasingly Sophisticated ICT Market

### Realizing the dream of having an independent development base in Taiwan

TDK Taiwan has successfully developed actuators for camera modules, designed for realizing autofocus and optical image stabilizer functions in smartphone cameras. The development and design process of any new product usually has its problems and setbacks, and this project in a field where we initially had no experience was no exception. At the outset, our level of knowledge and our technical expertise were still inadequate, and we sometimes found ourselves unable to answer specific questions from customers. But in consultation with customers and aiming for a product with features not available from the competition, we were able to overcome the initial difficulties, and our persistent marketing efforts resulted in a gradual rise in orders. Our products now enjoy a large share of the Taiwanese and Chinese markets. More recently, new products developed by us have been selected also by customers in Europe and the U.S., and we are happy that technology from TDK Taiwan has been recognized by the world.

### Actuators for camera modules



Support autofocus and optical image stabilization functions on smartphone cameras

### Monozukuri craftsmanship with a TDK Taiwan advantage

Creating products in the spirit of Monozukuri for us involves two fundamental aspects. One is communication with the customer. To avoid embarking on vanity projects, one must build a close relationship with the customer and communicate effectively, to verify that their needs are really being met. Furthermore, the concept of "Time to Market" plays an important role in the business world of Taiwan, meaning that products must be made available at suitable speed. In order to achieve this, we have consultations with the customer before the product specifications are put together, and we make suggestions towards their content. This is the secret weapon that allows us deliver the required product within a short timeframe. TDK Taiwan is able to build upon the high-quality Monozukuri culture fostered in Japan, adding to it design speed as a particular strength.

The other major aspect is checking the manufacturing processes with one's own eyes. To design a top-notch product, engineers must get out from behind their desks and spend time on the production floor. With overall optimization in mind, they should inspect every production step from design to the end products themselves, and always look for possible improvements.

### Sharing Monozukuri power across the entire TDK Group

Social issues such as global warming and depletion of resources cannot be pushed aside as "someone else's problem." We believe that we must utilize our technological expertise and look for ways in which we can do our part in solving them, through our day-to-day development efforts. For example, by reducing unnecessary current consumption through higher efficiency of electromagnetic processes, or by increasing the recycling ratio of parts used in our products, we are trying to reduce dependency on petroleum products. We will continue our efforts at improving the environment and fulfilling our obligation to society, in order to be recognized by the public as a company that combines value creation with social contributions. All members of our staff share the group's policy, and we endeavor to implement an environment-friendly, sustainable management style.

As the actuators mentioned previously have shown, the Taiwan base is able to take the initiative in creating new products and successfully supplying them to customers. We hope that this example may inspire other bases of the TDK Group in their own efforts to pursue similar goals.



Yi-Liang Chan  
Manager,  
Product Development Department,  
TDK Taiwan Corporation



U.S.A.

## Versatile Functionalities and Environmental Friendliness that TDK Supports in the Evolving U.S. Automotive Market

### Ever growing U.S. automotive market

The U.S. light-vehicle sales have now advanced for the fourth straight year, and all major automobile makers are launching electric vehicles one after the other. In addition, wireless power transfer, Wi-Fi and other consumer product applications are now being integrated into vehicles, allowing consumers to quickly charge their phones as they move in and out of their vehicles, bringing even further mobility and connectivity to them.

### Value that TDK provides

TDK is providing electronic components that are indispensable for wireless power transfer and Wi-Fi devices. TDK's innovative design and fully automated production processes are helping to manufacture parts with both superb performance and smaller size cost effectively, and thereby supporting the comfortable lives of consumers.

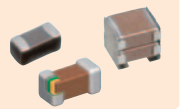
We consider maximizing the "One TDK" product portfolio and establishing excellent communication with customers extremely important in order to provide optimum solutions. We communicate with everyone in the customer's organization; i.e., engineering, purchasing and production. Each area provides valuable information on what is needed by the customer. We also work closely and repeatedly with our internal divisions to provide the best solution as quickly as possible.

### Manufacturing that responds to social changes

As a mother of two young kids, I am always concerned about the importance of leaving a beautiful environment to them. In that respect, I am proud to work for a company that takes so much care to develop business processes and products that are environmentally friendly.

### Multilayer ceramic chip capacitors for automobiles

Compact high-capacity capacitors for storing electric charge



The U.S. automotive market will continue to require new technologies to meet the needs driven by consumer demand and government regulations in the time ahead. In order to realize ever evolving functionalities such as Self Driving Cars and Vehicle to Vehicle Communication and achieve increased fuel efficiency in vehicles through the use of smaller devices, TDK, as a leader of the electronic components manufacturer, will be at the forefront of developing products for these applications to respond to changing market needs.



Lori Sieczkowski  
Global Account Manager,  
TDK Corporation of America



Hungary

## Tech Power of ONE TDK Sustains Growth of Renewable Energy

### Rise of the renewable energy market

In the industrial equipment sector in Europe, the market of products for wind power systems and other renewable energy sources is growing, propelled by developments such as rising energy costs and the enactment of laws prescribing the conservation of energy. In particular, offshore wind farm installations are advancing rapidly, in Europe as well as globally. Compared to land-based installations, facility maintenance for offshore sites is more difficult and costly, making not only efficiency, but also rugged construction and reliability important requirements.

### Advantages of EPCOS aluminum electrolytic capacitors

EPCOS aluminum electrolytic capacitors for use in wind power equipment offer a number of advantages, such as high capacitance, high reliability, and robust construction. They are optimized to deliver high energy density, making it possible to obtain stable DC voltage with power losses low while keeping heat generation.

A wide range of products are used in systems for the generation, conversion, and transmission of electric power, and stringent quality requirements have to be met. Product lineups in this area therefore must be constantly improved and augmented. Our design team consists of professionals who have extensive knowledge in the physics and electrical engineering aspects of power electronics as well as advanced practical experience. We are therefore in an ideal position to meet the diversified demands of customers in this field.

### Synergy of ONE TDK creates true value

In the future, the demand for power generation equipment incorporating leading-edge technology for use in offshore wind farms is bound to keep rising. Power converters for such equipment must provide even higher performance to clear the more

### Aluminum electrolytic capacitors

Suitable for high power applications thanks to high capacity ratings and stable quality



rigorous specifications of power grids. We are therefore engaged in ongoing development efforts aimed at new capacitors with even higher power handling capability and enhanced thermal dissipation efficiency.

As an organization that combines a wide range of product portfolios under a single umbrella, ONE TDK can bring a unique synergy into play, offering optimal solution packages that exactly meet customer requirements, while also creating added value for society at large.



Gábor Székely  
Product Development Engineer,  
Aluminum and Film Capacitors B.Grp,  
EPCOS Elektronikai Alkatrész Kft.

Realizing the Spirit of Monozukuri Around the World

Highlight 1