

ADVANCED DEVICES

Creating and growing businesses that solve issues faced by society and customers beyond the mobility domain

As a company reorganized to go beyond technologies and focus more on helping society and our customers, we are collaborating on the sensing and actuation fronts, and enhancing the value of systems through semiconductors that leverage our strengths derived from vertical integration. While creating new devices and systems, we aim to win the trust of our customers with an all-points approach to quality, cost, and delivery (QCD) in the expanding electrification market.



Yoshifumi Kato
Head of Business Group

Business Strengths

Creation of New Value with Sensing and Actuation

Within the business group, our core technologies in actuation (i.e., hands and legs) are combined with semiconductors (i.e., brains) and sensing (i.e., eyes) to create new devices and systems based on nimble concepts, enabling the development of “great-if-possible” solutions for issues faced by our customers.

Leadership That Drives Collaboration with Partners and External Production Contractors, in Addition to Internal Production of Semiconductors

In preparation for expansion in the electrification market, DENSO will internally produce silicon (Si) and silicon carbide (SiC) power semiconductors, which are key devices that incorporate world-first technologies. Moreover, we will build the supply chain needed to increase cost competitiveness and supply capabilities.

On-site Capabilities That Support Production Technologies Highly Resilient to Changes in Specifications and Volumes in New Product Domains

DENSO is broadening the scope of applications for new product domains where it is competitive, thanks to human resource development and handpicked young employees. DENSO leverages digital-twin technology and collaborative robots to build a production system that can be optimally organized and configured by changing production line shapes and locations in accordance with fluctuations in volumes for new products.

Business Strategy

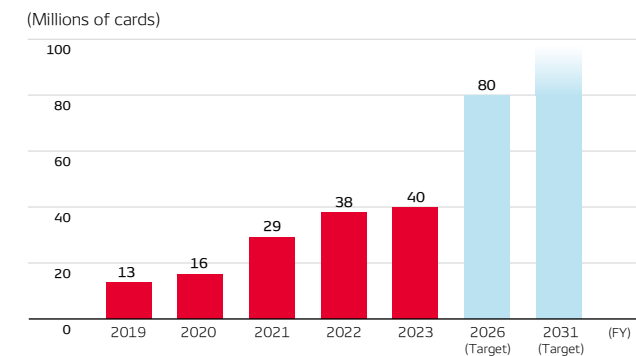
We will formulate winning scenarios and create new businesses through outstanding technological capabilities, speed, and alliances.

High Aspirations and Meticulous Work	To steadily transform our business portfolio from internal combustion engine products toward products for CASE vehicles, we will build variable-mix, variable-volume production lines that can adapt to product replacement and business environments with significant volume fluctuations. In addition, by digitalizing the expertise and knowledge of operators, we will take on ambitious production innovations that facilitate unmanned and nonstop production and compensate for a decline in the working age population.
Realization of Carbon Neutrality	As the presence of BEVs increases, we will capture demand in the vehicle electrification market through a two-pronged strategy of continuing our existing in-house production of inverter systems while establishing a business for the provision of modules catering to customers’ growing preference for producing inverters in-house. Also, we believe that the key to competitiveness will be the establishment of supply capabilities for the SiC used in BEVs. Going beyond conventional approaches, DENSO will efficiently and swiftly build a broad-based supply chain.
Creation of New Value	<p>The use of batteries is diversifying from primary to secondary usage as the introduction of BEVs gathers momentum. Given this trend, we believe that predicting battery life and reducing fire risk are important tasks. Through collaboration with other companies, DENSO will create and realize the widespread adoption of its differentiated products for sensing the health of batteries over their lifetimes, thereby providing additional safety and peace of mind when reusing and recycling batteries.</p> <p>We will identify the changes in electronic platform-related demand—which are accompanying the evolution from function-specific ECUs to the division of vehicles into multiple zones and the use of large-scale integrated ECUs controlled by central ECUs—and use semiconductor technologies to help enhance the value of systems. At the same time, DENSO will achieve business growth by increasing supply stability through alliances and outsourcing. In addition, we will support vehicle electrification by setting our sights on 2030 and accelerating the development of products for the next generation and beyond and by leveraging vertical integration to expand our lineup of control integrated circuits (ICs) for power semiconductors.</p> <p>We aim to establish multiple businesses in such areas as electric drives, human-machine interfaces, and thermal management as well as in non-mobility fields, including agriculture and plant logistics. In the CASE field, through the use of sensors and auxiliaries, DENSO will enable analysis of the energy management of individual vehicles and the optimization of system efficiency not only for such main components as batteries, motor generators, and inverters but also for other components. In these ways, we will benefit customers and society.</p>

Outcome of Strategies for “Green” and “Peace of Mind”

Objective: Begin collaboration with a chip foundry to meet growing demand for automotive semiconductors
Results: In April 2022, concluded an agreement to collaborate on the production of insulated gate bipolar transistors (IGBTs) at a 300-mm wafer plant operated by United Semiconductor Japan (USJC), the Japanese subsidiary of United Microelectronics Corporation; in May 2023, began IGBT shipments; and combined USJC’s wafer production technologies with DENSO’s system-targeted IGBT device and process technologies

Number of Power Semiconductors Produced (Power Cards)



SiC power semiconductors: Power losses approximately 70% lower than conventional Si devices

Inverters drive and control the motors that power BEVs. Compared with inverters that use conventional Si power semiconductors, our inverters that use SiC power semiconductors in their drive devices reduce power loss by approximately 70% under certain driving conditions. Consequently, our SiC power semiconductors help extend the driving distance of BEVs by increasing their electric mileage.

Specific Initiatives to Achieve Strategic Aims Beginning to Equip Vehicles with Inverters That Use SiC Power Semiconductors

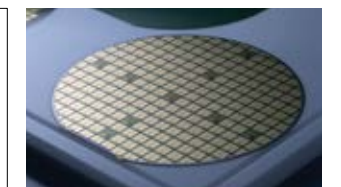
Our first inverter to use a SiC power semiconductor has been incorporated into the eAxle electric driving module. This module has been installed in the new-model RZ, unveiled as the first dedicated BEV LEXUS in March 2023. In the manufacture of power semiconductors, we have halved the number of crystal defects that cause disruption in the atomic arrangement of crystals, which prevents devices from operating properly. This improvement has been achieved based on the application of quality enhancement technology jointly developed by DENSO and TOYOTA CENTRAL R&D LABS., INC., and through the utilization of SiC epitaxial wafers,* which incorporate the results of work commissioned by the New Energy and Industrial

Technology Development Organization (NEDO). The aforementioned reduction of defects ensures in-vehicle quality and contributes to stable production of SiC devices.

* These are wafers formed by growing a thin film of crystals on a substrate of SiC crystals so that the upper layer of crystals aligns with the crystal plane of the substrate.



SiC power card



SiC power semiconductor wafer

Resolving Social Issues through Our Businesses



Helping to Address Global Water Shortages by Automating Agricultural Irrigation Systems

We are creating new solutions by connecting core sensing and actuation technologies developed in the mobility field. In the field of agriculture, for example, the shortage of water for global grain production has motivated us to launch an initiative tasked with applying variable flow technology used for engine coolant control valves to agricultural irrigation systems. In a demonstration test that used this technology on a farm, water savings of more than 30% were achieved compared with irrigating at a constant discharge rate. Moreover, we are

combining the technology with soil sensors that measure the appropriate moisture content and pressure sensors that detect water leakage and blockages, thereby demonstrating the value of the system as an automatic irrigation system. We are already in discussions with a global manufacturer of agricultural systems with a view to commercialization of the system, and we aim to start up mass production in 2025. In non-mobility fields, we will utilize and develop our core technologies to benefit initiatives that address such issues as labor shortages, population aging, and the realization of carbon neutrality.