Semiconductor Strategy

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Yoshifumi Kato
Senior Executive Officer, CTO
DENSO Corporation

DENSO supports the Sustainable Development Goals (SDGs).
Response to the Semiconductor Shortage

DENSO’s Response to the current and mid to long term semiconductor shortage
DENSO’s response to the semiconductor shortage (1)

Collaboration with suppliers, and Efforts to secure supplies by taking full advantage of the procurement volume of vehicle semiconductors, which is among the highest in the industry

STEP 0
Utilization of risk inventory
Keep the risk inventory in stock at both suppliers (trading companies) and DENSO

STEP 1
Optimization of allocation of parts
Allocate across the global DENSO Group and utilize the pipeline inventory

STEP 2
Switching to alternative parts
Study the possibility of using alternative parts for critical model numbers

STEP 3
Priority production and increase in production capacity
Mechanism to put priority on the process and increasing capacity (in-house/addition of foundries)

STEP 4
Optimization of production priority
Change the priority of production for DENSO at suppliers and optimize production

Promote activities to maintain the supply chain with suppliers to secure supplies.
DENSO’s response to the semiconductor shortage (2)

Prevent risks, and expedite initial action in an emergency by establishing a structure for cooperation with suppliers and by introducing DX.

**Sharing of Future Trends**

**Long term**
- Trends of technology and volume over the next ten years

**Short term**
- Fixed order placement

**Fire Prevention Measures and Strengthening Earthquake Resistance**

**Example**
- Increase inspection items for fire prevention measures based on experience
- On-site check of plants at suppliers

**Progress in on-site check**
- 37% completed
- Systematic promotion
- To be completed in FY2022

**Introducing DX to risk inventory management (will start in October 2022)**

**In normal times**
- Improvement of inventory management level
  - (real-time visualization of volume)

**In an emergency**
- Reduction in lead time to calculate the day on which parts will run out

**Centralized internal and external inventory information (visualization)**
- **Expediting initial action**

**Reinforcing Supply Chain and Preventive Management**

**Identify social changes and visualize issues**

**Changes in geopolitical risks, etc.**
- (collaboration with external specialized organizations*)

**Linkage**
- Issues in the supply chain
  - Such as oligopoly
  - (collaboration with suppliers)

**Greatly strengthen the capability to maintain the supply chain in close cooperation with suppliers.**

* Government-affiliated agencies, overseas diplomatic bodies, trading companies, financial institutions, etc.
DENSO classifies the automotive semiconductor into three areas and formulates strategies for each area, taking into account the technology used, the industries driving that technology, and the companies driving mass production, etc.
Vehicles and Semiconductors in the Era of CASE

1. Changes in the Electronics Platform

- Single ECU
- Integrate ECU

2. Expansion of Electrification

- Power Control Unit
- Battery Monitoring ECU

3. Evolution of Driver Assistance

- Vision Sensor
- Millimeter wave radar

Microcomputer & System on Chip (SoC)

Power & Analog

Sensor

Semiconductors are the key to achieving these solutions.
As the semiconductor market expands, automotive semiconductors will continue to increase. Strategy formation and collaboration between the automotive and semiconductor industries are essential for the advancement and stable procurement of in-vehicle semiconductors.

Source: Omdia & in-house survey
Basic strategy of DENSO’s semiconductor business

Develop novel and rugged in-vehicle semiconductors while taking full advantage of existing semiconductors, depending on fields.

**Microcomputer & SoC**
- Division of labor into Specifications, Design and Manufacture
- Require Upstream Strategic Collaboration

**Power & Analog**
- Require Performance which Fits in-vehicle Environment
- Automotive Industry Drives Technology

**Sensor**
- Utilize non-automotive technologies
- Collaborate with automotive sensor semiconductor vendor

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Develop and Present Specification with Strategy and Maintain Stable Procurement

In-House Manufacture Semiconductors that Differentiate from Competitors

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Specifications → Design → Manufacture

Microcomputer vendor
SoC vendor

TSMC
UMC

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In-House Manufacture

TSMC
UMC

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Collaborate with strategic partners

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autoemotive sensor semiconductor vendor

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DENSO Strategic partners

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CRAFTING THE CORE
Microcomputer & SoC
Performance improvement, function development and establishment of a stable procurement network
Changes in the electronics platform and impact on in-vehicle semiconductors

Evolution of each single domain

Past

Logic semiconductor: Microcomputer
Application: Actuator control

Future

Cross-domain evolution

Advanced actuator control ⇒ Microcomputer
AI, Image Processing, OTA, Cloud Cooperation, etc. ⇒ SoC

Microcontroller performance for control will be improved and SoC will be responsible for cross-domain function development.
DENSO’S VISION

Promote two activities to secure stable procurement of advanced logic semiconductors

Promoting Development and Standardization and Deepening the Cooperation with Specialized Manufacturers

- Present Strategic Specifications and Promote Standardization
- Have Several Sites to Produce with Standard Manufacturing Process and Strengthen BCP

More in-depth response, including development and manufacturing

Activities to Maintain the Supply Chain

Short to Medium Term
- Take Advantage of the Procurement Volume (Transport, alternative parts, and change)

Long Term
- Optimize the Gap Between Automotive and the Semiconductor Industry
- Promote optimization of semiconductor procurement structure
Efforts (1)
Promote development and standardization and deepen the cooperation with specialized manufacturers

**DENSO’s strength**

Present Strategic Specification for Automotive

Development to improve the recognition performance at night

Before application

![Before application image]

After application

![After application image]

Artificial intelligence IP of SoC for image recognition systems

Jointly develop driver assistance SoC with semiconductor vendors

Prepare for Production of 28nm Microcomputers in Japan

**jasm**

*JASM: Japan Advanced Semiconductor Manufacturing

Taking a minority stake in JASM (announced in February 2022)
Efforts (2)
Reform the semiconductor procurement structure

DENSO’s strength
Make proposals by Taking Advantage of Experience and Volume of Semiconductor Procurement

Key points in reforming the procurement structure

1. Share the medium- to long-term trends across the supply chain
2. Mechanism for industry standardization by taking advantage of the total volume
3. Switch earlier based on market trends

Gaps between industries (examples)

Semiconductor industry

- Foundry
- Semiconductor manufacturer
- Trading company

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OEM

Auto industry

- Quantity guarantee
- Fixed for a long term
- Early switching
- The Gaps: Absorption in the supply chain is limited
- Short-term order
- Long-term use

Example: Product life cycle

- Small volume and long-term supply
  - Cost increase to maintain production lines
  - Response to discontinuation of old models

Leveraging DENSO’s strengths to reform the procurement structure
Power & Analog

The differentiation area driven by automobiles, materials, design, and manufacturing processes are insourced, semiconductors are also manufactured in-house.
History of in-House Manufacture of Semiconductors at DENSO

Expansion of wafer production facilities

1949 DENSO established
1967 IC Research Center established

1975 Head office wafer plant
1991 Kota wafer plant
2012 Iwate wafer plant
(transferred from Fujitsu Semiconductor)

2020 Hirose wafer plant
(transfered from Toyota Motor Corporation)

2023 collaboration with USJC

Global History of Semiconductor Development

1967 An electronic calculator (TI) developed
1968 Intel Corporation established
World’s first CMOS IC (RCA)

The development of ICs accelerated
globally in the 1960s.

Ranking by in-Vehicle Semiconductor Revenues in 2021

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Country</th>
<th>Revenue</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Infineon</td>
<td>🇩🇪</td>
<td>695.9</td>
</tr>
<tr>
<td>2 NXP</td>
<td>🇳🇱</td>
<td>608.5</td>
</tr>
<tr>
<td>3 Renesas</td>
<td>🇪🇸</td>
<td>508.5</td>
</tr>
<tr>
<td>4 ST Micro</td>
<td>🇨🇭</td>
<td>477.2</td>
</tr>
<tr>
<td>5 DENSO</td>
<td>🇯🇵</td>
<td>420.0*</td>
</tr>
</tbody>
</table>

*Equivalent to sales

Source: Gartner & in-house survey

*DENSO’s CAPEX in semiconductors: 160 billion yen
(total for past three years)

DENSO has produced in-vehicle semiconductors for nearly 50 years

Increase Production Capacity through M&A and Collaboration
DENSO’s vision

Develop and Manufacture in-House “Devices & Wafers” and “Manufacturing Processes” to Maximize System Competitiveness

**Power: Devices & Wafers**

- Production of Large-Diameter Silicon Wafers with Strategic Partners
- Full-Scale Launch of Silicon Carbide, which is Advantageous for BEVs

**Analog: Manufacturing Processes**

- SOI-BCD Process Attains the Performance Required for the in-Vehicle Environment
- Design Capabilities to Anticipate and Meet System Needs

**Strengthen competitiveness of high voltage power semiconductors**

**Strategic ASIC development**

- ASIC: Application Specific IC

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Denso's vision:

- **Battery Control**
  - Improved by up to 10%

**DENSO SEMICONDUCTOR STRATEGY DAY 2022 / Jun 1st, 2022**

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Efforts (1)
Improve Cost Competitiveness of Silicon Power Semiconductors

DENSO’s strength

Reduce the Loss by Integration

IGBT and diode ▶ 30% smaller

RC-IGBT

IGBT: Insulated Gate Bipolar Transistor

Compact and low-loss device structure

Large-Diameter Wafers (300 mm)

USJC: United Semiconductor Japan Co., Ltd.

Agreed to cooperate in production with USJC
(Announced in April 2022)
Efforts (2)
Improvement of performance of SiC power semiconductors

Achieving Both High-Voltage Resistance and Low On-Resistance

Using electric-field-limiting trench MOS

Patented technology

Electric-Field-Limiting Structure
* Patented technology
High Reliability in Large Currents

Device structure with high-voltage resistance and low on-Resistance

Forecast for Global car sales
Unit: million cars

Source: BCG analysis (April 2021)

Widespread use of silicon carbide due to rapid expansion of BEVs
**Efforts (3)**

**Improvement of Cost Competitiveness of Silicon Carbide Power Semiconductors**

"Manufacturing capabilities” to Fabricate Equipment in-House

- **RAF Method**
  - c-plane
  - a-plane
  - Screw dislocation
  - RAF: Repeated A-Face

- **Sublimation Method**
  - SiC single crystal
  - Growth Speed: 0.2 mm/h

- **Gas Method**
  - Raw Material Gas
  - Growth Speed: 3 mm/h (15 times)

**Achieving of high-quality and inexpensive SiC wafers**

**Increasing the Wafer Growth Speed 15 Times**

- **Sublimation Method**
  - CO₂ emissions during manufacture reduced by 90%

- **Gas Method**

**Target Cost: ▲30% from current level**
Efforts (4) Strategic ASIC development

DENSO’s strength

150V High-Voltage Resistant Process

World’s first

Achieving Both High-Accuracy Detection and Monitoring of Many Cells

Lithium-ion battery monitoring IC

- Battery voltage detection accuracy: ±3 mV or less
- Number of battery cells that can be monitored is 25 cells/IC

Anticipate and meet the need for battery control

Competitor’s product

Monitoring of 12 cells

DENSO’s product

Monitoring of 25 cells

The number of battery cells monitored is double that of a competitor’s product.
Sensor

ADAS and AD etc. sensors work with strategic partners who are willing to work with in-vehicle
Sensor Semiconductors for Safety System Products

Expand safety system products through competitive strategic partnerships.

AD & ADAS Business

Various Semiconductors for AD & ADAS Products

Revenue (billion yen)

- 2016
- 2020
- 2025
- 2035

320
500

1.5 times

Vision Sensor
Millimeter-Wave Radar Sensor
LiDAR

Semiconductor Vendors

Imager
MMIC
Laser diode

DENSO
Crafting the Core
DENSO’s vision

Strengthen the “judgment capabilities” for current situation and “realization capabilities” for the future to achieve competitive strategic partnerships.

Judgment capabilities
- Anticipate rapidly changing technology trends
- Disseminate in-vehicle trend to strategic partners

Realization capabilities
- Plan novel semiconductors in the era of CASE
- Develop structure to achieve the vision

Competitive strategic partnerships

Development of sensors for autonomous driving
Efforts (1)
Development of SPAD LiDAR for Autonomous Driving

Another Supplier

DENSO
### DENSO’s goals

**Semiconductors**

Maximize system competitiveness using rugged in-vehicle semiconductors through collaboration with strategic partners.

<table>
<thead>
<tr>
<th>Goal</th>
<th>Basic Strategy (Business Policy)</th>
<th>Attainment Level at Present</th>
<th>Target for 2025</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Microcomputer &amp; SoC</td>
<td>Promoting development and standardization, deepening the cooperation with specialized manufacturers and working on maintain the supply chain to secure stable procurement</td>
<td>Establishment of a stable procurement network (1) Utilize standard products and manufacturing processes (2) Reform the semiconductor procurement structure</td>
<td>Equity participation in partners of design and manufacture has been completed.</td>
</tr>
<tr>
<td>2. Power &amp; Analog</td>
<td>Develop and Manufacture in-House &quot;Devices &amp; Wafers&quot; and &quot;Manufacturing Processes&quot; to Maximize System Competitiveness</td>
<td>In-House Manufacture Semiconductors that Differentiate from Competitors (1) Strengthen competitiveness of high voltage power semiconductors (2) Strategic ASIC development</td>
<td>Revenues of 420 billion yen for in-house manufacturing semiconductor*</td>
</tr>
<tr>
<td>3. Sensor</td>
<td>Strengthen the judgment capabilities for current situation and realization capabilities for the future to achieve competitive strategic partnerships</td>
<td>Collaboration with strategic partners (1) Collaborate with competitive partners (2) Develop sensors for automated driving</td>
<td>Mass production of Global Safety Package 3</td>
</tr>
</tbody>
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*Part of in-house manufacturing power semiconductor, ASIC and sensor

Resolve social issues in “green” and “peace of mind” by offering rugged in-vehicle semiconductors.