New Development Areas/ Summary

President and CEO
Takehiro Kamigama

Global R&D system

- Development functions of Head Office in Japan focus principally on material development and other medium- to long-term themes
- Overseas group companies strengthen their development functions beginning with research projects

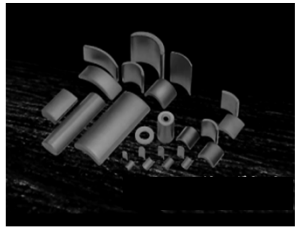
Energy device growth scenario / Automotive field

- Strengthen power unit components for next-generation vehicles(BEV/HEV/PHV/FCV)
- Promote the sales of power-related components drawing on magnetic technology, which is TDK's core competence

Automotive field

1 to 2 years

3 to 5 years



Ferrite magnets

HEV motor-generators

High-performance neodymium magnets

Rare-earth-free/strongest magnetic materials for drive motors

Lead-free piezoelectric materials (thin-film, bulk)

Secondary batteries for xEVs (high-safety technology)

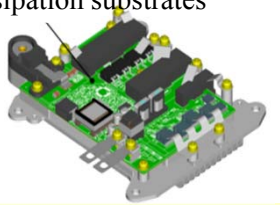
Dy-free magnets with Nd reduced by half for drive motors

- Performance improvements by grain-boundary composition control technology

Lead-free piezoelectric material (Ceralink)

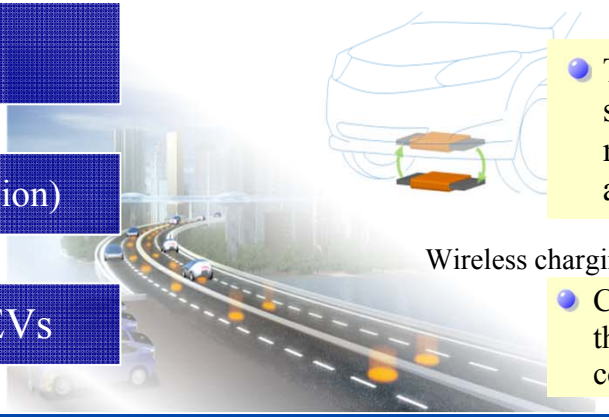
High-efficiency small DC-DC converters & chargers

High heat dissipation substrates



- TDK's proprietary high heat dissipation substrate and high-performance ferrite material used to achieve size reduction and efficiency improvements

Secondary batteries for xEVs (lithium ion)



Wireless charging during driving

Wireless charging systems for xEVs

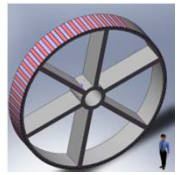
- Compliance with noise regulations set out in the Radio Law, using TDK's proprietary coil noise reduction technology

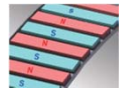
Energy device growth scenario / Industrial equipment & energy fields

- Strengthen energy devices for renewable energy-related systems
- Promote the sales of power components drawing on magnetic technology, which is TDK's core competence

Industrial equipment & energy fields

1 to 2 years	3 to 5 years





- Free from the impact of instability in the supply of rare-earth elements

Rare-earth-free/strongest magnetic materials for wind power generation

Lead-free piezoelectric materials (thin-film, bulk)

Secondary batteries (Stationary type, high-safety battery technology)

Dy-free magnets with Nd reduced by half for wind power generation

Lead-free piezoelectric material (Ceralink)

High-capacity high-efficiency power supplies

Secondary batteries (Storage battery systems)

Wireless charging systems (for industrial machinery)

- Ceramic capacitors that reach the maximum capacitance under a high DC bias voltage

- Battery material technology combined with processing technology to reduce electrode expansion

- Deployment of wireless charging technology for xEVs in the area of industrial equipment

Chip component mounter

Deployment of wireless charging technology in the automotive and industrial equipment fields

- Build wireless charging systems for use in the automotive and industrial equipment fields

Automotive and industrial equipment fields

Wireless charging systems for xEVs

Small power-receiving coil unit

- Downsized power-receiving coil with a built-in multilayer ceramic capacitor

High-efficiency 3.3 kW transmission

- High transmission efficiency achieved by using low core loss material PC95
- Vibration resistance rendered by TDK's proprietary ferrite material

Forklift/AGV※

- Application of wireless charging technology to forklifts

Outdoor cart

- Application of wireless charging technology to outdoor carts

※Automatic Guided Vehicle

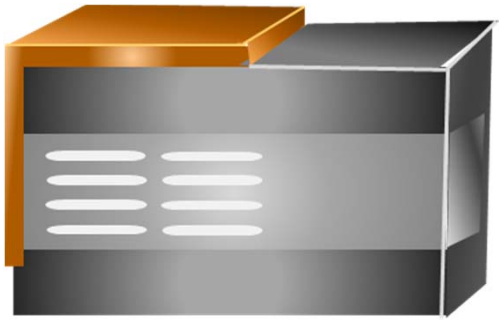
Goals for the thin-film device business

TDK has developed thin-film technologies through its head business and materials technologies through its passive component business. By merging these technologies, we will provide high value-added products that positively respond to the needs of the information and communications fields that are expected diversify in the future.

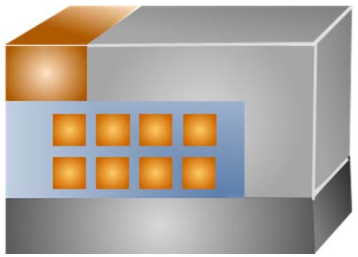
Advantages of thin-film technology
Reduced conductor shape variability
Reduced variability in film thickness for dielectric materials and piezoelectric layers
High aspect ratio (conductor)

Differences from semiconductor technology
Three-dimensional fine structure
Features of thin-film materials (magnetic/dielectric/piezoelectric) used at the core of TDK's high-performance products

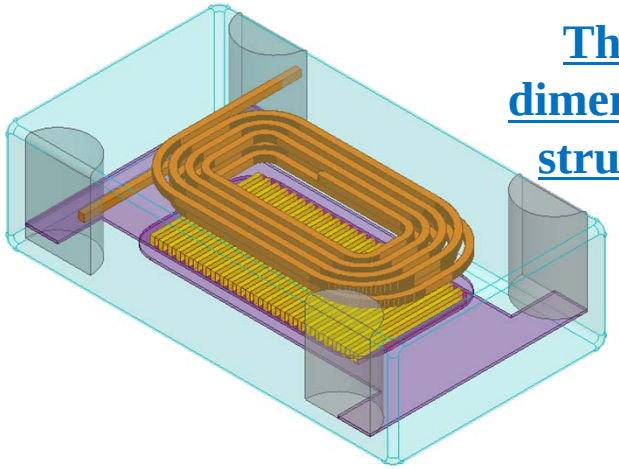
Multilayer type



Thin Film type



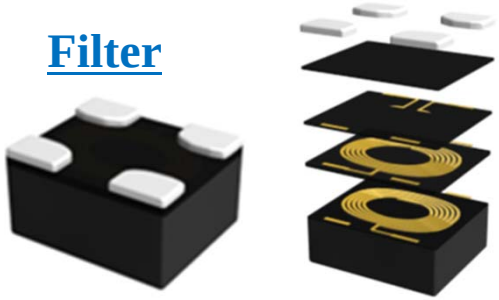
Three-dimensional structure



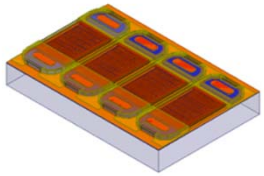
Product families in the thin-film device business and their features

Product family	Feature
Common-mode filters	Size reduction and performance improvements
High-frequency filters	Reduced footprint enabled by size reduction and use of arrayed configuration Performance improvements in high-frequency
Inductors	Low-profile power devices (low-profile modules) and embedded high Q-factor types (low profile)
Composite components (capacitors and inductors)	Reduced footprint and low profile achieved by composite design.
MEMS	Three-dimensional structure and material characteristics used at the core to achieve performance improvements.

Filter



Array Type

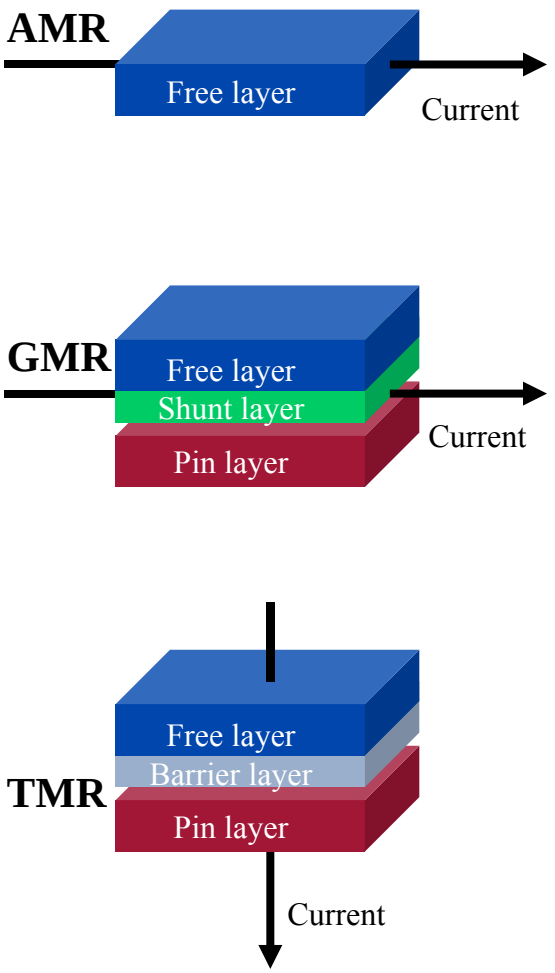


Future angle sensor accuracy requirements (for automobile applications)

Application	Accuracy of predecessor	Future accuracy requirement
Throttle valves	±2° to ±3°	±1°
Wipers	±1.2° (20 to 130 mT)	±0.6° (20 to 130 mT)
Steering (EPS motor)	±0.6° (20 to 80 mT)	±0.3° (20 to 80 mT) Redundancy ISO 26262

At least a two-fold angle sensing accuracy will be realized with this technology

Development of magnetic sensor technology



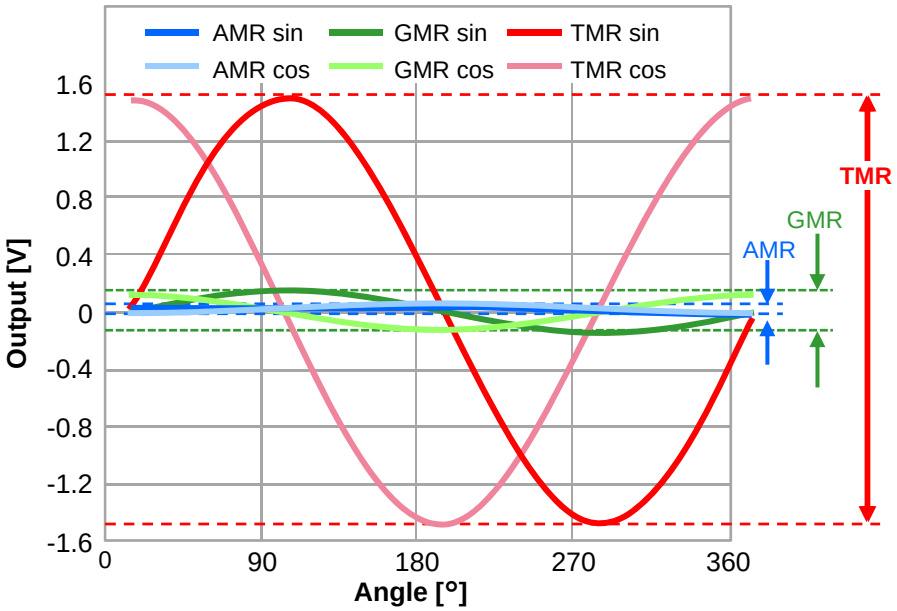
	MR Ratio [%]	Output [mV]	SNR @ 10 kHz [dB]	Temperature dependence 25 °C to 125 °C [%]
AMR	3	90	72	-29
GMR	12	360	77	-23
TMR	**100**	**3000**	**96**	**-13**

TMR Output

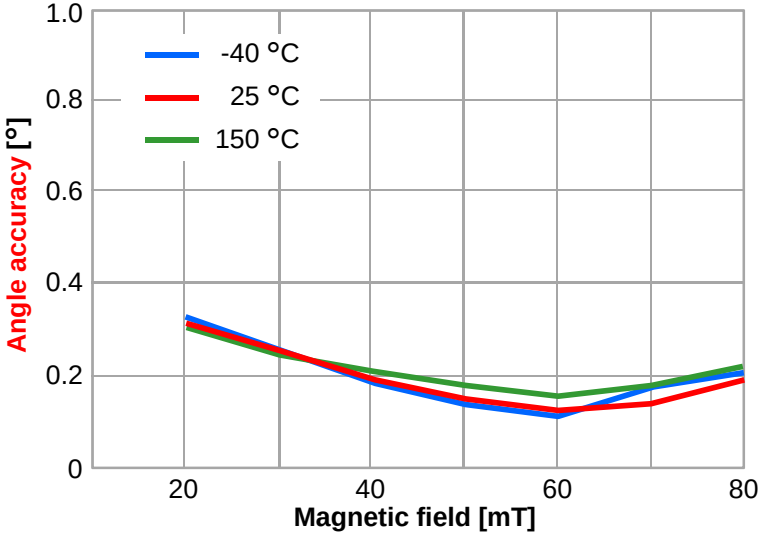
- **30 times better than AMR**
- **8 times better than GMR**
- **Stable angle sensing accuracy across a broad range of temperature variations**

TDK's TMR angle sensors with excellent characteristics

Output waveforms

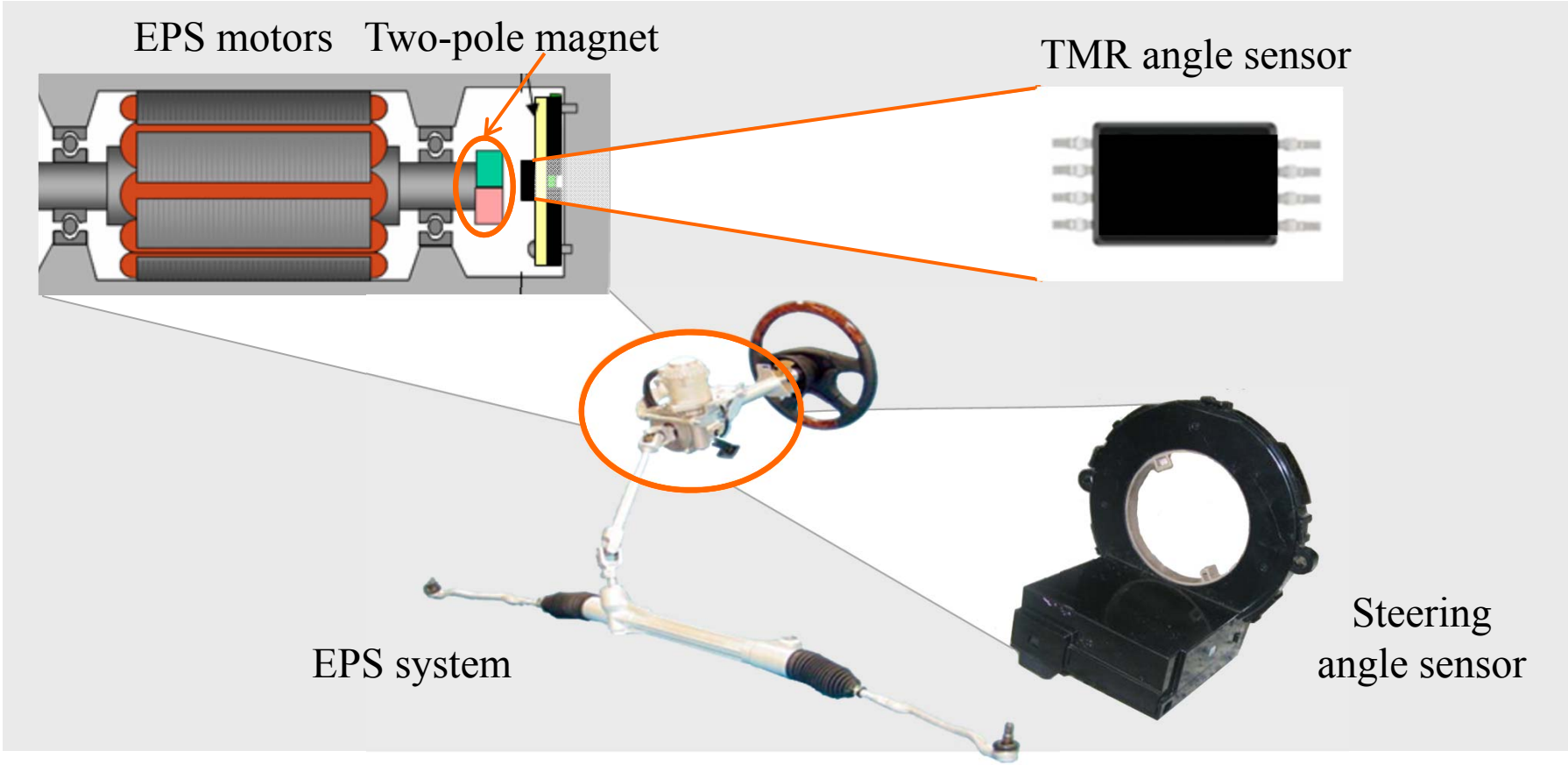


Angle sensing accuracy vs. magnetic field in a broad temperature range



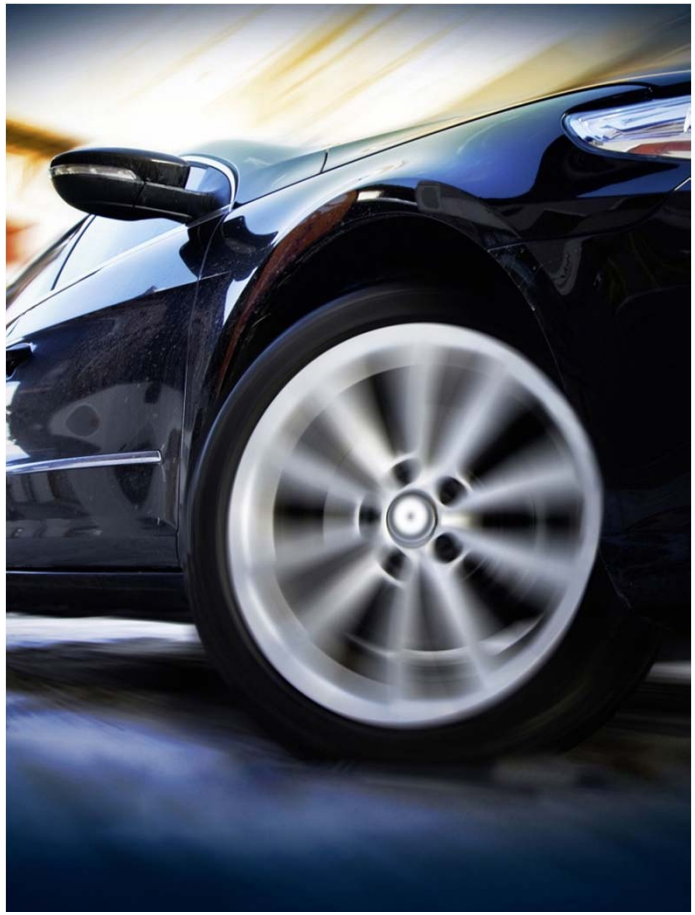
- **High power**
  3.0V_{pp} @ 5 V (30x AMR, 8x GMR)
- **Excellent angle sensing accuracy**
  Angle sensing error: within ±0.6°
  Conditions : Magnetic field range: 20 to 80 mT / Temperature range: −40ºC to 150ºC
- **Low power consumption**
  5 mW (under recommended conditions)

Steering systems: Largest angle sensor market



TMR sensor opposed to two-pole magnet

TDK TMR sensors : Enhanced product families for our customers



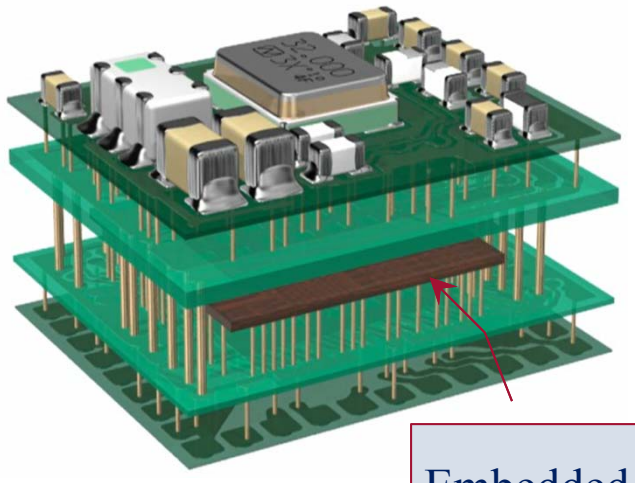
- High-accuracy angle sensors
- Rotation sensors
- Linear encoders
- Rotary encoders
- Current sensors

Angle sensors and other sensor products are geared to meet diverse application needs

Target applications of thin-film devices/SESUB

Target Applications		SESUB	Thin Film Devices
Smartphones • Tablet Devices	Power line use	Power Module	Low-profile inductors
	RF use	PA/RF Module	High Frequency Filters Capacitors downsized, arrayed and with narrow tolerance Hign Q inductors MEMS
	Sensor	Asic Package	
	Other		Common mode filters Composite components
Wearable devices (health care)	Power line use	Charger Module	Low-profile inductors
	RF use	PAN Module	
	Sensor	Asic Package	
Data Centers (servers)	CPU		Embedded capacitors

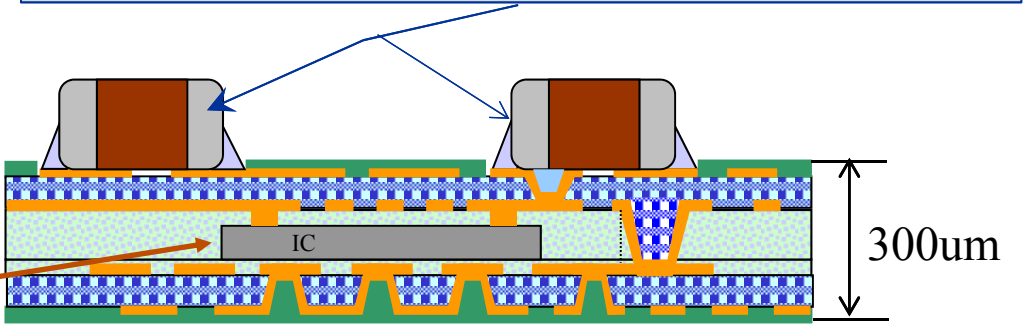
SESUB product features



Embedded IC

SESUB cross-sectional view

Components can be mounted on SESUB as on plastic substrates

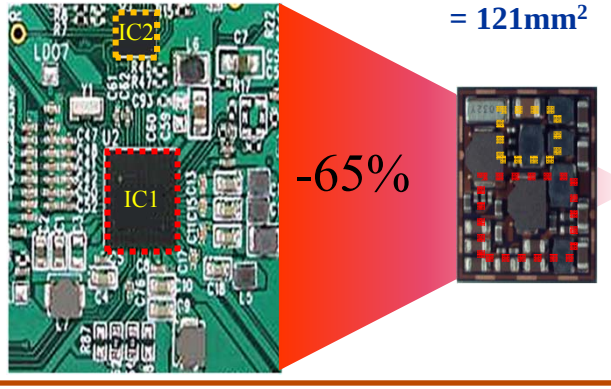


Size reduction

A high percentage of embedded components enables downsizing

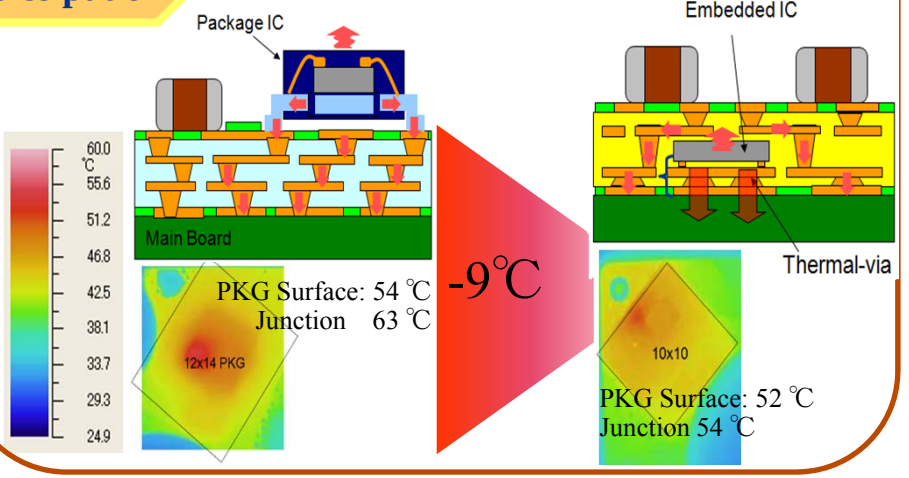
Discrete Solution = 350mm²

SESUB Module = 121mm²



Excellent heat dissipation

Excellent heat dissipation capability
To raise the degree of deign freedom



Business model for SESUB products

Market change

Industry led by IC manufacturers rather than by telephone manufacturers

- Uniformized specifications
- Standardized OS (e.g., Android and iOS)
- Shortened development period

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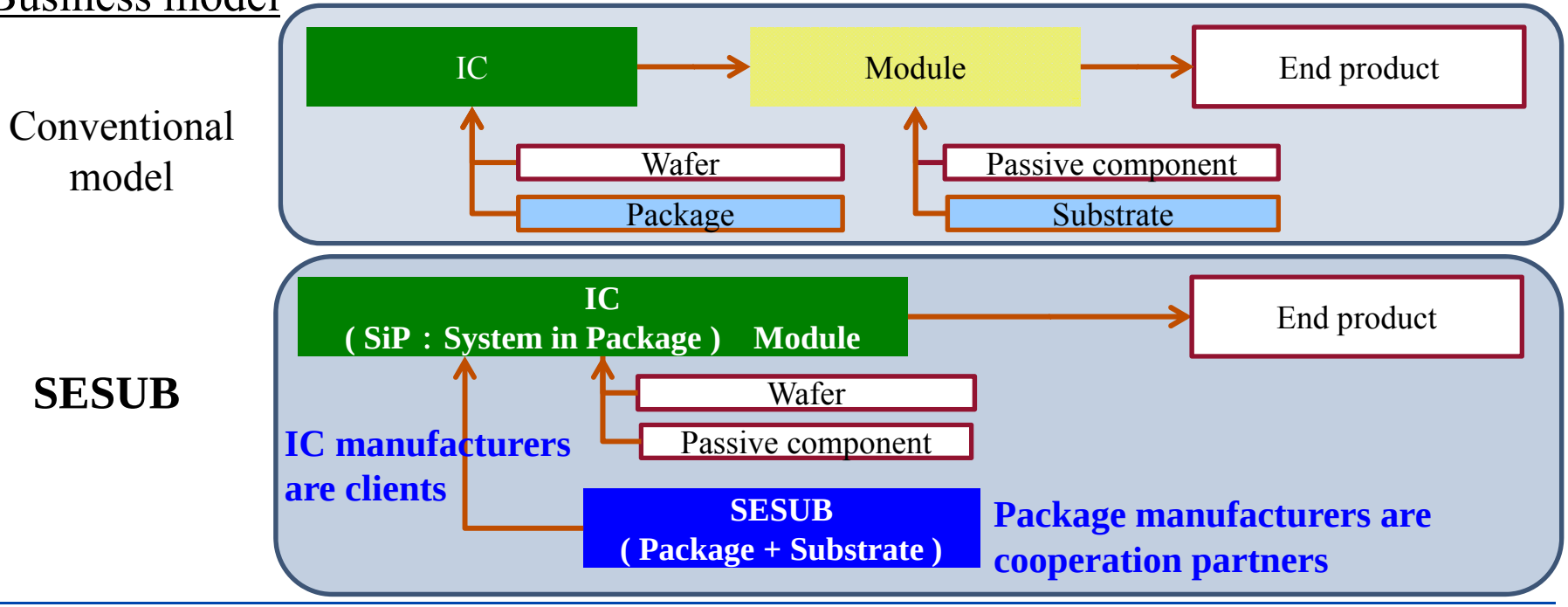
Smartphone manufacturers use IC manufacturers' references

SESUB business: IC manufacturers are our clients, while IC package manufacturers are our cooperation partners

Business model



Corporate goals in mid-term

① **Launch new businesses following the three key segments to hit ¥100 billion sales**

② **Pursue zero-defect quality drawing on the Company's high level of technical expertise**

③ **Conduct speedy business operations to promote true globalization**

Cautionary Statements with Respect to Forward-Looking Statements

This material contains forward-looking statements, including projections, plans, policies, management strategies, targets, schedules, understandings, and evaluations about TDK, or its group companies (TDK Group). These forward-looking statements are based on the current forecasts, estimates, assumptions, plans, beliefs, and evaluations of the TDK Group in light of the information currently available to it, and contain known and unknown risks, uncertainties, and other factors. The TDK Group therefore wishes to caution readers that, being subject to risks, uncertainties, and other factors, the TDK Group's actual results, performance, achievements, or financial position could be materially different from any future results, performance, achievements, or financial position expressed or implied by these forward-looking statements, and the TDK Group undertakes no obligation to publicly update or revise any forward-looking statements after the issue of this material except as provided for in laws and ordinances.
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