

# New Product Information Session for FY2018 (Ended March 2019)

April 26, 2019



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SINCE  
**1010**  
YEARS

# Today's presentation

Iwao Ohwada

General Manager,  
ADC (Advanced Device Components) Division

- Chip-type Ceramic Secondary Batteries “EnerCera®” Series
  - ✓ Outline, lineup, application development, expected sales
- Wafer-related Products — Outline and Future Prospects
  - ✓ Bonded wafer
  - ✓ Gallium Nitride (GaN) wafer “FGAN®”

- Ultra-small lithium ion secondary battery best suited for IoT devices etc.
- Realized [high capacity, small/thin design](#), low internal resistance and high heat resistance by [adopting NGK's original Crystal Oriented Ceramic Plate](#) as electrodes.
- [Can output large current](#) from several tens to several hundreds of mA required for operating ICs, sensors and wireless communication systems.
- [Mountable by high-temperature process](#) indispensable for mass-production of devices.



## EnerCera® Pouch

(Shown on the left side in photograph)

- Ultra-thin and bendable battery that can be embedded in IC cards etc. (Thickness: 0.4 mm)
- [Applicable to hot lamination process](#), which is the standard method of manufacturing cards.
- Also capable of fast charging corresponding to contactless card reader




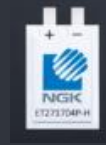


## EnerCera® Coin

(Shown on the right side in photograph)

- Coin-type battery that [can be mounted on circuit boards by reflow soldering](#) (Thickness: 1 mm or more)
- Constant-voltage-charging capability eliminates the need for a charger IC.

**Both “EnerCera Pouch” & “EnerCera Coin” win CES 2019 Innovation Awards as innovative secondary batteries that will expand the IoT device market.**

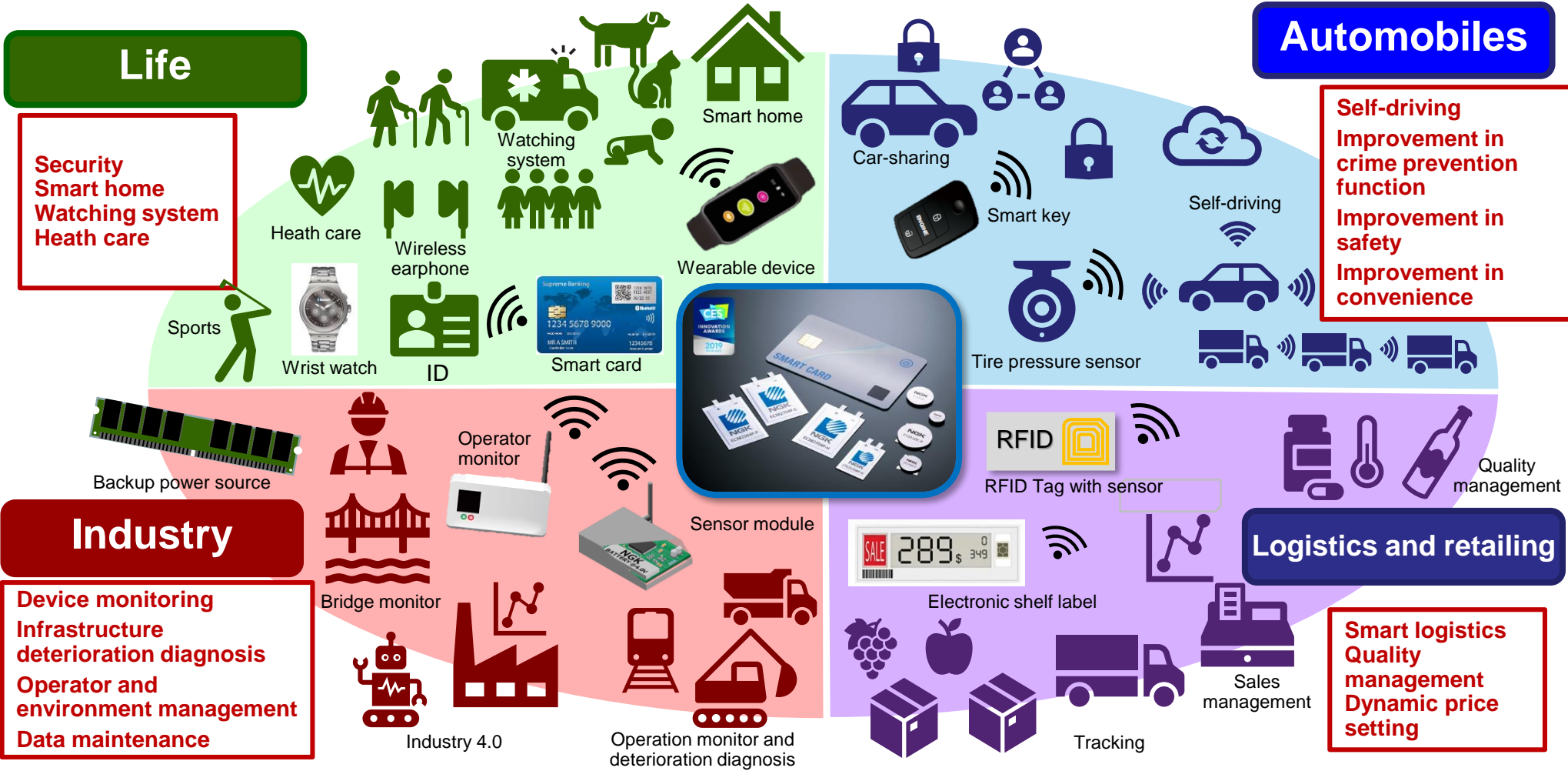
# Lineup of Chip-type Ceramic Secondary Batteries “EnerCera®” Series

	Pouch				Coin	
	High power	High capacity	High heat resistance	Fast charging	Reflowable	
Appearance						
Weight (g)	0.7g	0.8g	0.8g	0.3g	0.5g	2.0g
Model No.	EC382504P-P	EC382704P-C	EC382704P-H	ET271704P-H	ET1210C-R	ET2016C-R
Dimensions (mm)	38 x 25 x 0.45t	38 x 27 x 0.45t	38 x 27 x 0.45t	27 x 17 x 0.4t	Φ12 x 1.0t	Φ20 x 1.6t
Capacity (mAh)	20	27	20	5	5	25
Nominal Voltage (V)	3.8	3.8	3.8	2.3	2.3	2.3
Energy density (mWh/cc)	180	220	170	70	100	115
Constant voltage charging	-	-	-	OK (10 min/80%)	OK (25 min/80%)	
Peak discharge current (mA)	500	250	200	150	25	60
Operation temperature (recommended)	0°C-45°C			-20°C-60°C		
Heatproof temperature (in process)	80°C (Cold lamination is available)		135°C (Hot lamination is available)		260°C (Reflowable)	
Major applications	Long-distance wireless communication card	Biometric card with fingerprint authentication, using dedicated charger		Biometric card with fingerprint authentication, not using dedicated charger (Charged during settlement process)	IoT module (Smart key, RFID tag, electronic shelf label, wrist watch, backup power source, etc.)	

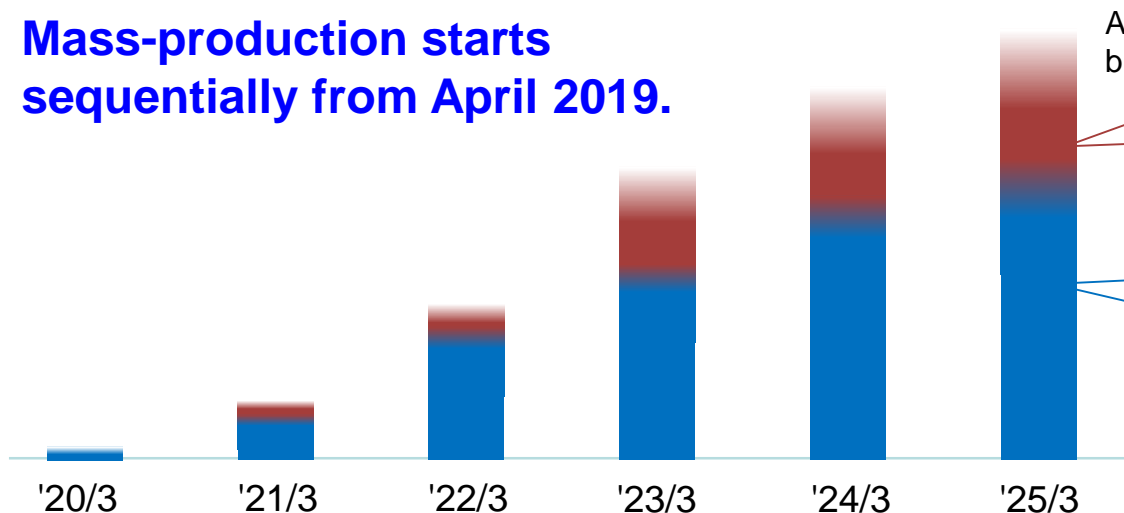
The IoT device market is expanding to realize an IoT society where all things are connected to the Internet. The market size is expected to reach 30 billion units by 2020.\*

\* FY2018 white paper on telecommunications by the Ministry of Public Management, Home Affairs, Posts and Telecommunications

**Aim to expand the business with EnerCera® series as the compact/thin power source for IoT devices.**



**Mass-production lines for monthly production of 2 million units have been introduced.**  
**Mass-production starts sequentially from April 2019.**



Approx. 20 billion yen



RFID tag  
Smart key  
Electronic shelf label  
Wrist watch  
Tire pressure sensor  
Wireless earphone  
Backup power source  
etc.



Smart card  
(Payment, ID, etc.)  
RFID tag  
Wearable device, etc.

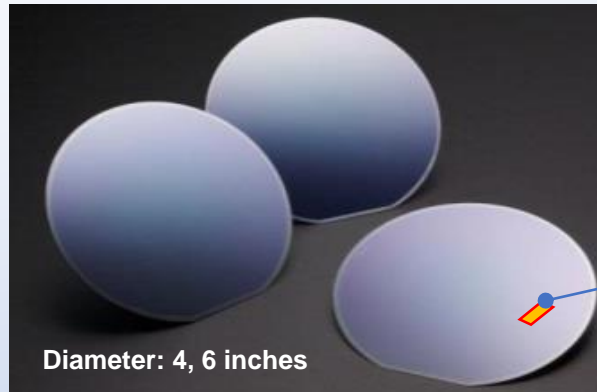
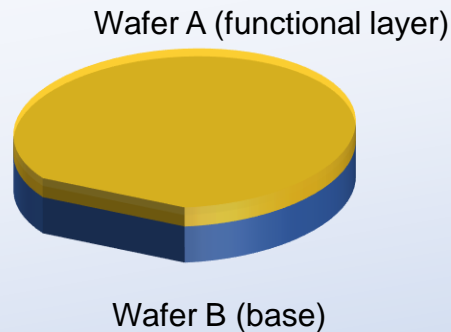
## Reference: Smart card market trends

- The world total amount of damage caused by fraud use of credit cards and debit cards is about 2.3 billion dollars (2016)\*<sup>1</sup>.  
The economic loss in the U.S. due to leakage of IDs is about 1.7 billion dollars (2017)\*<sup>2</sup>.
- In this situation, a new smart card with a thin secondary battery embedded has appeared.
  - High-security credit card with fingerprint authentication function
  - High-security and convenient multi-functional payment card with wireless communication function, display, etc.
  - ID card with fingerprint authentication for foreign worker management and workers of high-security institutions such as government agencies.
- It is estimated that the market size will expand from about 10 million cards in 2019 to 270 million cards by 2025.\*<sup>3</sup>

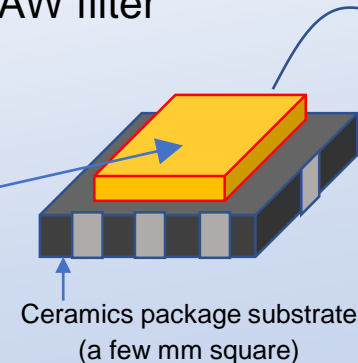
Bonded wafer manufactured by bonding single crystal, ceramics, etc. with characteristics different from each other using NGK's original technology.  
By combining different features of each material, the bonded wafer helps to improve the performance of a high-frequency filter (SAW filter) for smartphones etc.

## Bonded wafer

### Structure



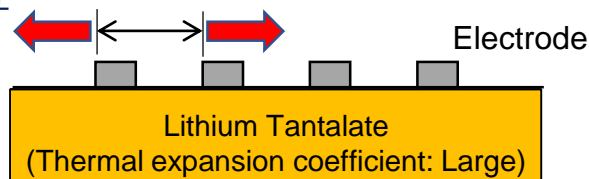
### SAW filter



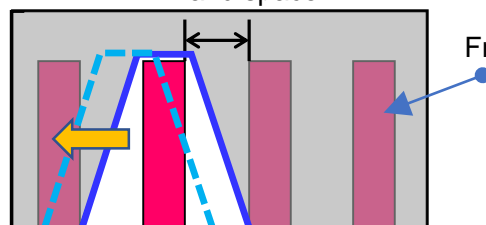
Smartphone

## Effects of bonded wafer

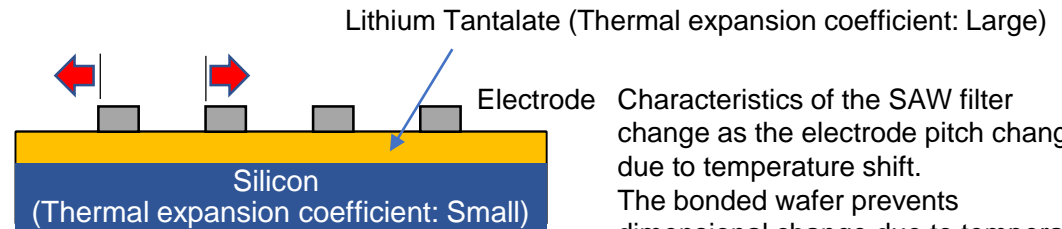
### No bonding



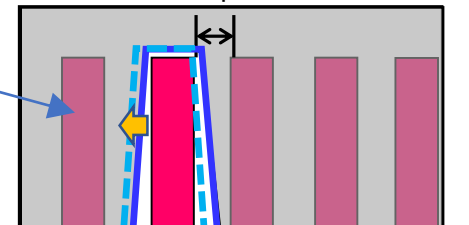
### Band space



### Bonded wafer



### Band space



Characteristics of the SAW filter change as the electrode pitch changes due to temperature shift. The bonded wafer prevents dimensional change due to temperature and stabilizes the characteristics of the SAW filter.

Because the band space of the filter with bonded wafer is narrow, frequency bands can be laid out closely to each other and frequencies can be used efficiently.

Conceptual diagram of SAW filter

SAW filter performance



As services of the 5th-generation communication system (5G) start, demand for the bonded wafer will increase because higher frequencies are to be used and higher performance is required for the filter.

## Spread of 5G

		4G		5G
Features of 5G	Large capacity	1 Gbps		<b>10 Gbps</b>
	Multi-connection	100,000 devices/km <sup>2</sup>		<b>1 million devices/km<sup>2</sup></b>
	Low delay	10 msec		<b>1 msec</b>
Required performance of filter	Higher frequency	~3 GHz		<b>~6 GHz</b>
	Band space *1	20 MHz~		<b>10 MHz</b>

(\*1: In the case of middle band)



Video transmission

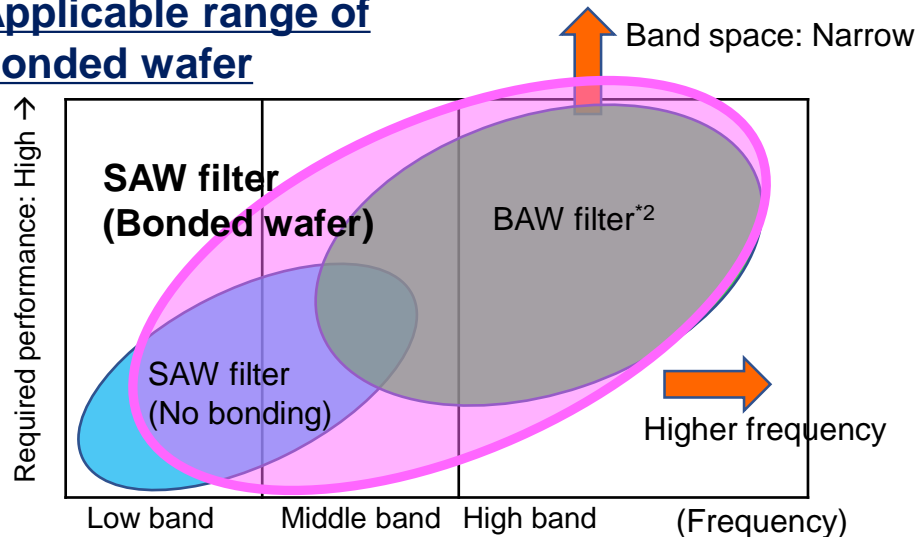
Self-driving



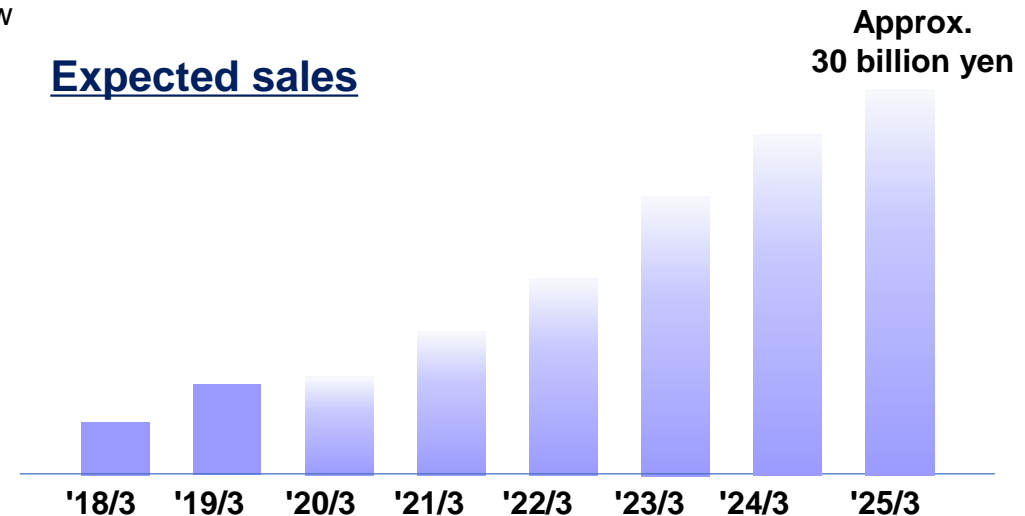
VR goggles



## Applicable range of bonded wafer



## Expected sales



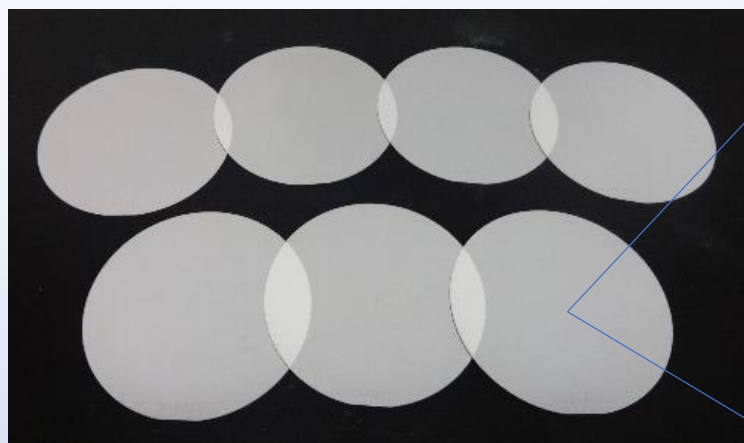
Approx.  
30 billion yen

(\*2: BAW filter: Filter with a complicated structure manufactured in the thin-film process)

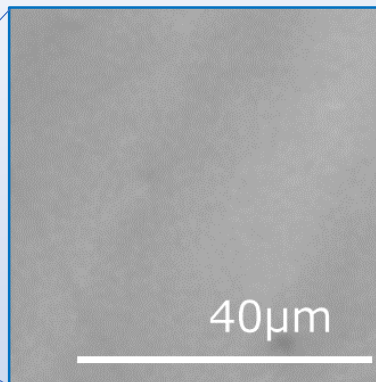


We provide high-quality and low-defect GaN wafers realized with our original crystal growth technologies (liquid phase crystal growth method). They are used in semiconductor lasers that are in greater demand as a substitute light source for mercury lamps because of regulations on the use of mercury required by the Minamata Convention on Mercury.

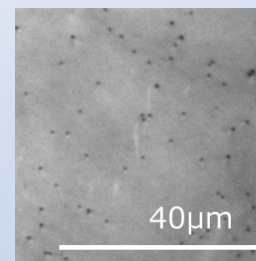
## Appearance of FGAN®



Cathodoluminescence image\*



Dislocation density:  $10^5/\text{cm}^2$



Conventional product  
(GaN crystal grown by  
HVPE method)  
Dislocation density:  
 $10^7/\text{cm}^2$

\* Method to detect defects  
in crystal as dark dots

## Application examples



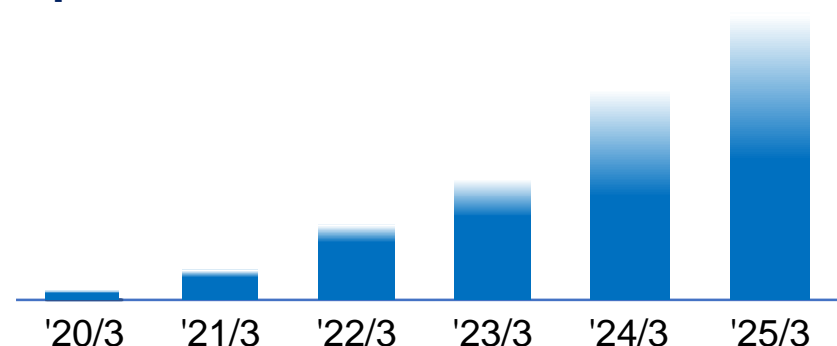
Business projector



Headlamp with light  
distribution control

## Expected sales

Approx. 10  
billion yen



The GaN wafer will improve the performance of the semiconductor elements for power conversion equipment (power devices), which will be key devices for realizing a low-carbon society, and also enhance the performance of wireless communication signal amplifiers (high-frequency devices), which support the coming 5G communication age.

## Application examples of power devices



Inverter for HEV/EV  
motor drive



Power conditioner for  
photovoltaic power generation

## Application examples of high-frequency devices

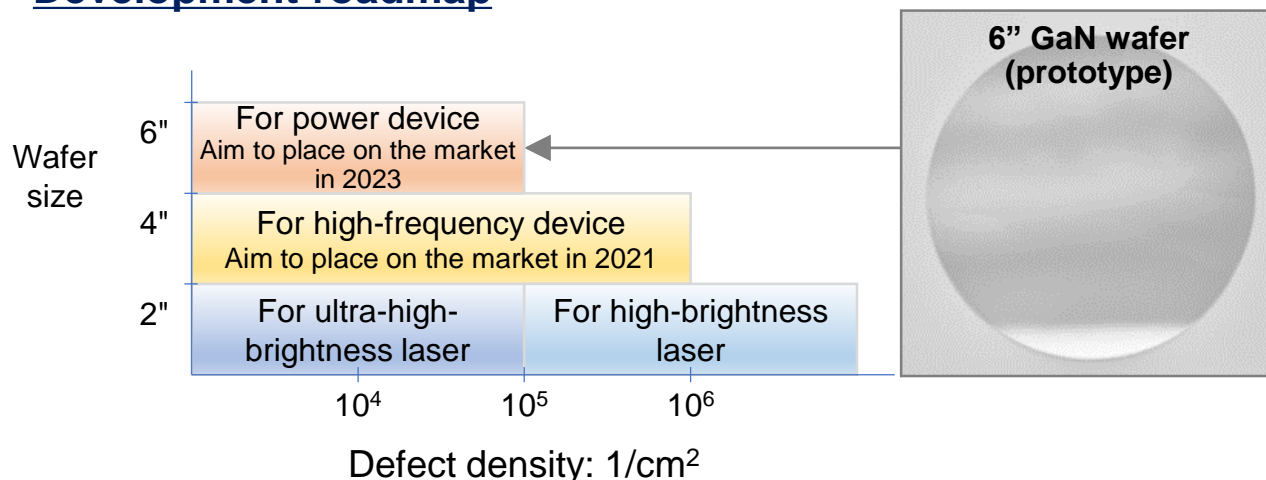


Amplifier for  
cellular base station



Amplifier for satellite  
communications

## Development roadmap



NGK is making efforts to realize next-generation power devices through joint research with Professor Hiroshi Amano, Nagoya University.