Feature

# Special Feature

# tok *in Society*

## —Creating Shared Value through Business—

## Megatrends

Megatrends have begun to emerge with new innovations in mobility, such as CASE (Connected, Autonomous, Shared and Electric) and MaaS (Mobility as a Service). In most of these fields, the scope of value provided by semiconductors and semiconductor materials has been growing. With Level 3 (Conditional Driving Automation) reaching a practical stage, major automobile manufacturers and IT platformers are competing more fiercely to develop Level 4 (High Driving Automation) and Level 5 (Full Driving Automation) systems. Recently, SoCs*, the "brains" of automobiles, and automotive storage solutions have become more important. In this context, 10–7nm level semiconductors at the cutting edge of miniaturization, and 3D-NAND with vertically stacked memory cells, have drawn attention as solutions.

* System on a Chip: A semiconductor device with multi-functional parts in a single IC chip

Outline of definitions for self-driving car levels, and progress towards each

| Level | Level 1 | Level 2 | Level 3 | Level 4 | Level 5 |
|---|---|---|---|---|---|
| Name | Driver Assistance | Partial Driving Automation | Conditional Driving Automation | High Automation | Full Automation |
| Outline of definition | The system executes either a longitudinal or lateral vehicle motion control subtask under limited domains. | The system executes both longitudinal and lateral vehicle motion control subtasks under limited domains. | The system executes all dynamic driving tasks under limited domains. The driver must respond appropriately to requests to intervene when the system encounters problems. | The system executes all dynamic driving tasks and responds when it encounters problems under limited domains. | The system executes all dynamic driving tasks and responds when it encounters problems under all conditions (namely, not in limited domains). |

* Source: Road Transport Bureau, Ministry of Land, Infrastructure, Transport and Tourism's "Guideline regarding Safety Technology for Automated Vehicles in Japan" (refers to U.S. SAE J3016 (2016), etc.) (September 2018)

## Risks and Opportunities

Level 4 and more advanced self-driving vehicles will require not only the world's highest-performing SoCs and automotive storage, in terms of high-speed, large-capacity, space-saving and low-power-consuming devices, as the human-replacing "brains" that will make instantaneous decisions about driving conditions, but also require strong functional safety features to minimize risks to human life and the risk of accidents. TOK's customers, semiconductor manufacturers, view self-driving vehicles as a new business opportunity and have been concentrating their resources on the development of semiconductor devices that offer both the highest performance in the world and functional safety. Keen to turn this into an opportunity for new value creation, TOK is developing and providing cutting-edge materials while fine-tuning them for the variances in each process at each customer through its customer-oriented sites in Japan, the U.S., South Korea, and Taiwan.


Autonomous

Connected

Autonomous

Electric

# Development of High Value-Added Products

EUV photoresists

ArF excimer laser photoresists

KrF excimer laser photoresists

High-purity chemicals

Achieving SDGs




ent and Safe Society

Value

## Providing Cutting-Edge Materials for the "Brains" of Next-Generation Mobility

More specifically, TOK develops and provides EUV photoresists and ArF excimer laser photoresists for 10–7nm level semiconductors, which include SoCs used in automated driving systems, as well as clean solutions materials*1. The Company also develops and supplies KrF excimer laser photoresists for 3D-NAND, including memory used in automotive storage solutions. Lately, in order to advance miniaturization and increase layers, TOK has been concentrating on the development of EUV photoresists and clean solutions materials for 5nm semiconductors, as well as KrF excimer laser photoresists for 3D-NAND with 100 or more layers. Once these are developed, TOK will be able to contribute even more to the realization of a convenient and safe mobility society.

Shared

EUV photoresists/ ArF excimer laser photoresists

High-purity chemicals (clean solutions materials)

EUV photoresists market forecast: CAGR 225.7%*2 (2018→2022)

ArF excimer laser photoresists market forecast: CAGR 5.8%*2 (2018→2022)

KrF excimer laser photoresists market forecast: CAGR 6.1%*2 (2018→2022)

Impurity contamination level for cutting-edge high-purity chemicals: ppq*3 level

*1 Clean solutions, thinner, developing solutions and other high-purity chemicals for semiconductor production processes
*2 Based on sales volume (Calculated by TOK based on Fuji Keizai's "Whole View of Photo-functional Material and Product Market 2018")
*3 1 ppq = 1 part per quadrillion

## Tireless Challenge to Become an Only One, Number One Company

At the Tongluo No. 2 Plant, which develops and produces clean solutions for 10–7nm level cutting-edge semiconductors, quality management is extremely strict because our products are used in cutting-edge processes at customers. Materials production methods have become more advanced alongside the miniaturization of circuit line widths. In addition to refining raw materials, we effectively utilize software and hardware to improve quality and manage EHS in order to provide the best value to our customers, while also taking the environment into consideration and ensuring occupational health and safety.

Based on the Group slogan "Challenge for the Future," we aim to become an only one, number one company through the provision of value that exceeds customer expectations, by enhancing the functions of the customer-oriented site in Taiwan and flexibly responding to changes in the market.

**Chih-hung Peng** *Manufacturing Dept. 2, Manufacturing, Tongluo Plant, TOK TAIWAN CO., LTD.*

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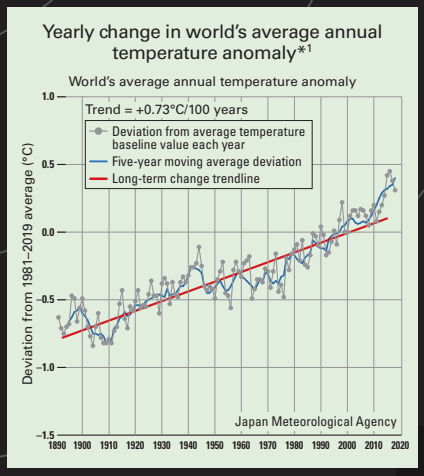
## —Creating Shared Value through Business—

### Megatrends

In 2018, the average world temperature (average of temperatures near the earth's land and ocean surfaces) was +0.31°C warmer than the baseline value (30-year average between 1981 and 2010), the fourth-highest temperature since statistics began to be compiled in 1891. While fluctuating up and down, the average annual world temperature has followed an uptrend, rising at a rate of +0.73°C every 100 years over the long term. Research papers indicate that there have been more years with high temperatures since the mid-1990s*1, and this global warming phenomenon has led to more frequent extreme weather events related to climate change, such as larger hurricanes and typhoons.




*1 Source: Japan Meteorological Agency

### Risks and Opportunities

Targets of SDGs for combating climate change include "take action to mitigate and adapt to climate change," "strengthen resilience and adaptive capacity," "integrate climate change measures into national policies, strategies and planning," and "improve education, awareness-raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning." On this basis, national governments, local governments, and corporations are taking steps to minimize climate change risks.

TOK believes addressing climate change risks is an important management issue, and its Environmental Policy calls for action to "promote activities to conserve energy and mitigate global warming." For the "environmental protection" material issue, TOK is working on "promotion of environmental management" and "addressing climate change issues." Specifically, the Company has a PDCA cycle in place to make iterative improvements in energy-related $CO_2$ emissions per base unit, energy consumption per base unit and energy consumption per base unit in distribution. Viewing its products as opportunities to create environmental value, TOK focuses its efforts on helping to reduce power consumption in semiconductors through the miniaturization of semiconductors, and the development and production of environmentally friendly products.

Address change

Shared

Renewable energy systems

### Constantly Creating New Value while Fulfilling Responsibilities as a Supplier

Until the late 1990s, g-Line and i-Line photoresists had propelled advances in the miniaturization of semiconductors. Today, these photoresists are essential materials in the production of power semiconductors, LEDs and sensors, and have become the most-used photoresists in the world*. In addition to reliably supplying i-Line photoresists, TOK has developed new photoresists based on i-Line photoresists for efficiently fabricating SiC (silicon carbide) power semiconductors, a type of next-generation power semiconductor (see page 47 "Creating New Environmental Value through Business"). In this way, the Company focuses on creating new value by applying its technologies in cutting-edge fields. We believe this ability to continuously find new value in legacy products is one factor driving TOK's sustainable growth potential.

**Takeshi Kurosawa** *Imaging Material Marketing Div., Marketing Dept.*

* 62.5% of the total the photoresist market on a sales volume (gallon) basis in 2017
(Calculated by TOK based on Fuji Keizai's "Whole View of Photo-functional Material and Product Market 2018")

# Stable Supply of Environmentally Friendly Products

g-Line photoresists | i-Line photoresists

Achieving SDGs


climate issues

Value

## World's Top Share in Materials for Key Energy Conservation Components

Power semiconductors are key energy conservation components in renewable energy systems, including wind and solar power generation that help reduce the risk of climate change, as well as electric vehicles, hybrid cars, and energy-saving home appliances.

TOK has the largest market share*2 in the world for g-Line and i-Line photoresists, which are essential in the manufacture of power semiconductors, and these photoresists have reliably accounted for almost 7 to10% of consolidated net sales. The volume of g-Line and i-Line photoresists used differs greatly at each semiconductor manufacturer, because they use different volumes and thicknesses in coatings of photoresists. TOK will continue to fulfill its responsibilities as a supplier with top market share by carefully addressing customer needs and stringently managing quality, with the ultimate aim of helping to reduce climate change risks.

TOK's share of g-Line and i-Line photoresist market (2017):
**25.9%*2**
Global No.1*2

g-Line/i-Line photoresists market forecast:
**CAGR 4.9%*2**
(2018→2022)

Overall power semiconductor market forecast:
**CAGR 6.7%*3**
(2017→2025)

*2 Based on sales volume (Calculated by TOK based on Fuji Keizai's "Whole View of Photo-functional Material and Product Market 2018")
*3 Manufacturer shipment value basis (Source: Yano Research Institute "A Survey on the Global Power Semiconductors Market (2018)", released on January 15, 2019)


Electric vehicles


Energy-saving home appliances


Smart houses


i-Line photoresists

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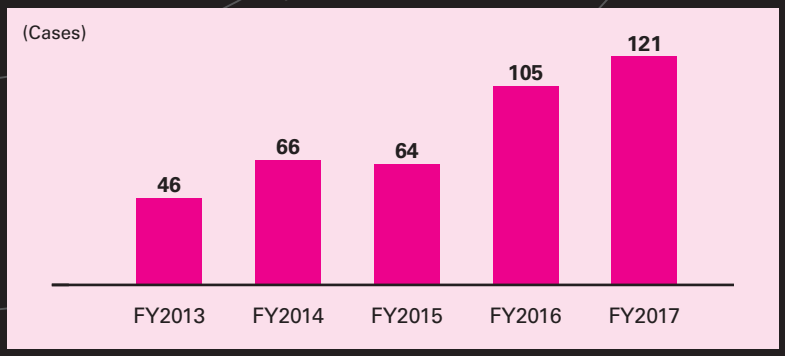
## —Creating Shared Value through Business—

### Social Issues

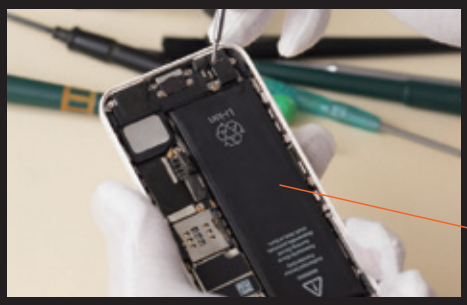
Lithium-ion batteries used in smartphones and other mobile devices are also used in electric vehicles, hybrid cars, rolling stock, and industrial machinery. Lithium-ion batteries are essential for our convenient and comfortable life and social infrastructure.

However, the risk of a fire increases when lithium-ion batteries are subject to mechanical shock. Around 2007, there were a few incidents where smartphones and other devices burst into flames because their structures were susceptible to shock. Over the four years since fiscal 2013, the number of such fire incidents has more than doubled, an issue in society in search of a solution.

Number of fire incidents in products with lithium-ion batteries



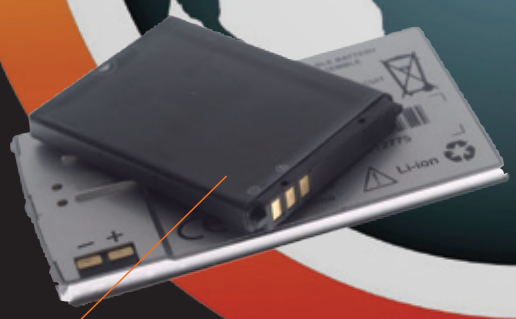

Source: National Institute of Technology and Evaluation's news release on January 24, 2019



Lower-risk parts and materials need to be developed for lithium-ion batteries, an essential part of our lives

## Safety and with Heat

## Shared



Lithium-ion battery for special B-to-B applications

### Risks and Opportunities

Separators inside lithium-ion batteries can be damaged by external shock, which may cause an internal short between the cathodes and anodes inside the battery, and spark a fire. For this reason, companies in the industry are researching and developing ways to make separators and other battery materials more heat resistant and durable, and companies are also developing next-generation batteries such as solid-state batteries that are safer and more efficient. TOK views this as an important business opportunity to develop new businesses. As a result of efforts to develop materials able to lower the risk of fire in lithium-ion batteries, TOK brought high-functional films to market in 2017.

* Photos of batteries and smartphones on this page are sample images.