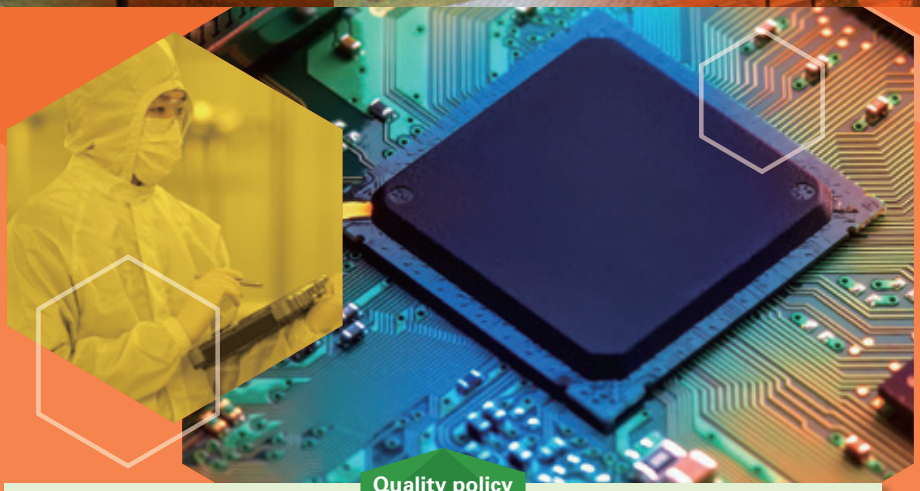
Material Business

Manufacturing and sales of electronic functional materials and high-purity chemicals

TOK TAIWAN CO., LTD.

TOK Advanced Materials Co., Ltd.

Keiichi Yamada
Director, Officer, Department Manager, Marketing Dept.



Quality policy

Aim to be a globally trusted corporate group by inspiring customers with high value-added products that have satisfying features, low cost and superior quality. Deepen and expand existing business domains and swiftly launch new business domains.
Each one of us clearly understand current situation and challenge ourselves with a sense of crisis.

1. Strengthen marketing ability, be motivated by a strong sense of crisis, prepare well, and take immediate action.
2. Promote human resource development for global operation.
3. System to capture customer's voice accurately and to respond them immediately.

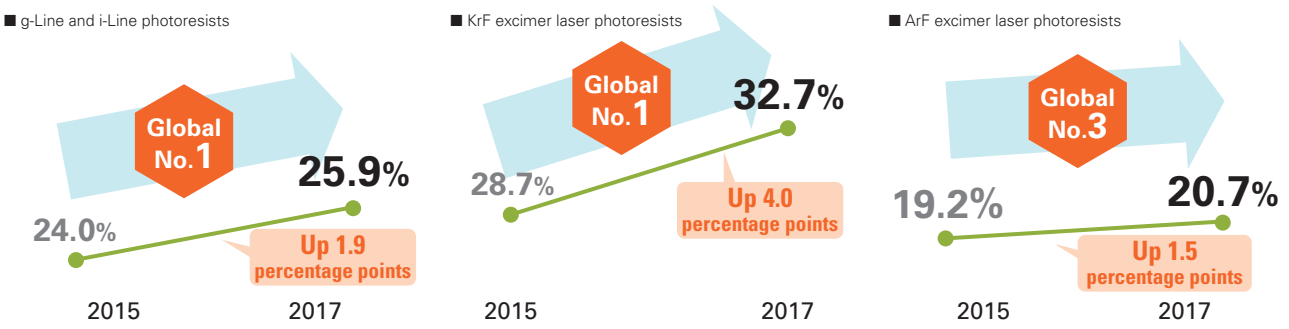
Material Business Performance

(Millions of yen)

	FY2017/3	YoY*	FY2017/12 Result*	FY2017/12 Calendar year adjustment*	FY2018/12 Result		
						Change	%
Net sales	86,558	78,842	90,532	98,250	102,626	+4,376	+4.5
Electronic functional materials	53,074	47,318	51,230	56,947	58,793	+1,845	+3.2
High-purity chemicals	33,475	31,026	38,676	41,165	43,733	+2,567	+6.2
Other	9	496	623	134	95	(39)	(29.3%)
Segment income	14,470	12,448	12,816	14,868	15,075	+207	+1.4
Segment income margin	16.7%	15.8%	14.2%	15.1%	14.7%	—	—
Segment assets	97,542	—	106,220	—	104,903	—	—
Depreciation	5,831	—	5,833	—	6,769	—	—
R&D costs	7,513	—	6,371	—	7,856	—	—

* Due to the change in fiscal year-end, adjusted results for the fiscal years ended December 2016 and December 2017 are presented as adjusted figures for nine months' (April–December 2016) earnings of companies that ended their fiscal years in March 2017 (the Company and its domestic consolidated subsidiaries). Revised results for the fiscal year ended December 2017 are presented as adjusted figures for 12 months' (January–December 2017) earnings of companies that end their fiscal years in March (the Company and its domestic consolidated subsidiaries).

Global market share for semiconductor photoresists (sales volume basis in 2015 and 2017)



Source: Fuji Keizai's "Overview of Photo-Functional Material and Product Market 2016" and "Whole View of Photo-Functional Material and Product Market 2018"

Review of the "TOK Medium-Term Plan 2018"

Short of targets for ArF excimer laser photoresists despite advantages in cutting-edge fields

During the "TOK Medium-Term Plan 2018" (fiscal year ended March 31, 2017 to fiscal year ended December 31, 2018), as the global semiconductor industry expanded strongly, TOK further deepened its strategy of building close relationships with customers that began in earnest under the "TOK Medium-Term Plan 2015," and moved on reforms to its business portfolio with a focus on creating high added value as an R&D-driven company.

More specifically, in ArF excimer laser photoresists, TOK tapped into demand for 10nm-level semiconductors and acquired its adoption on processes less than 10nm. In KrF excimer laser photoresists, the Company focused efforts on expanding adoption of thick-film photoresists for 3D-NAND. In high-density integration materials, the Company worked on the development of materials for cutting-edge package processes and MEMS, such as for fan-out wafer level packages. In high-purity chemicals, TOK endeavored to introduce new clean solutions. Furthermore, TOK concentrated on the development of applications for its products in IoT sensors, electronic components, and power devices.

As a result, sales of KrF excimer laser photoresists expanded for 3D-NAND, implants and IoT sensor applications. In high-density integration materials, thick-film photoresists also expanded strongly for fan-out wafer-level packages in high value-added smartphones. In high-purity chemicals, the Company won large contracts for supplying high value-added thinner and clean solutions for 10nm-level processes. Moreover, a major customer decided to use the EUV photoresists the Company has been developing as a new application for 7nm semiconductors. TOK scored major successes in the cutting-edge fields of miniaturization.

In ArF excimer laser photoresists, TOK concentrated on strengthening development and investing in facilities to regain market share, but fell short of targets due to insufficient customer adoption in Asia and delayed production plans at customers in North America and Asia.

Key Measures of the First Year of the "TOK Medium-Term Plan 2021"

Opportunities to work on new development themes in a retreating market

The semiconductor market grew to $468.7 billion in 2018, the largest it has ever been, but signs of a slowdown have strengthened in 2019 due in part to weakness in memory. According to World Semiconductor Trade Statistics (WSTS) announced in June 2019, the semiconductor market is projected to shrink by 12.1% in 2019, compared with the previous year.

The "TOK Medium-Term Plan 2021" was started in a retreating market, but the semiconductor industry is forecast to continue growing over the medium to long term on demand related to 5G and IoT. When market growth slows, our customers tend to pivot toward the development of the next generation of devices. It is therefore an opportune time for TOK to strengthen marketing based on "the trinity" of sales, development, and manufacturing, and focus all its energies on new development themes with an eye on the medium to long term.

TOK's Human Resource

Hee-sung, Lim

Manufacturing Team,
TOK Advanced Materials Co., Ltd.

Creating Advantages by Combining the Two Cultures of South Korea and Japan

At TOK Advanced Materials, our customer-oriented site in South Korea, we have worked hard to earn the trust of our customers and provide them with high levels of satisfaction through high-quality TOK products. Robust communication among the Korean and Japanese employees is vital to achieve this. In South Korea, we have a culture based on speed and willingness to take on challenges, and our customers prefer quick feedback and proactive responsiveness to their needs. The semiconductor market is expected to continue growing on heavy investments as advances are made in 5G and IoT. By blending the artisan spirit of Japanese employees and willingness to take on challenges of South Korean employees, we will further refine our photoresists and build advantages by creating a solid production system for EUV photoresists used in cutting-edge semiconductors.

SWOT Analysis — Material Business —

Strengths (S)
- Global structure of close relationships with customers (Japan, the U.S., South Korea, Taiwan)
- Earnings drivers in both the pre-process and post-process of semiconductor manufacturing
- Development capability in cutting-edge materials (miniaturization, high-density integration, 3D packaging)
- Proposal ability for semiconductor manufacturing processes (synergies with Equipment Business)

Weaknesses (W)
- Fewer customers, with the same number of photoresist manufacturers
- Over-concentration of business domains in the electronics industry (delay in new business development)
- Resistance to price hikes based on industry business practices

Opportunities (O)
- Increasing needs for ultra-miniaturization (ArF and EUV photoresists)
- Growing needs for cutting-edge packaging technologies (2.5D, 3D semiconductor packaging)
- Volume of data growing due to AI and IoT
- New semiconductor needs from launch of 5G communications systems

Threats (T)
- Rising cost of development due to increasing technological difficulties
- Deterioration in market environment with U.S.-China trade friction and tensions between Japan and South Korea
- Increased investment outlays for inspection and production equipment in connection with ultrahigh purification
- Higher costs of next-generation exposure equipment

In EUV photoresists, an end has come into sight for its development on the 7nm process, so we are shifting development resources to the 5nm and 3nm processes. TOK is working to have its ArF excimer laser photoresists adopted in newly emerging opportunities through miniaturization by 1nm. KrF excimer laser photoresists are almost finished for 96-layer 3D-NAND, so we are turning our attention to the development of these photoresists for 128-layer 3D-NAND. We are also advancing the development of high-heat-resistant photoresists for next-generation power semiconductors (see page 47) and chemically amplified i-Line photoresists for 5G applications.

Creation of new value using a super clean room

At our new R&D Building (Sagami Operation Center) being completed in September 2019, we will concentrate on open innovation in existing businesses, such as photoresists and high-purity chemicals for cutting-edge semiconductor processes, in addition to open innovation in new business development. This new R&D Building features the latest equipment for addressing various technological needs, seeds, ideas, and concepts, as well as security to protect confidential secrets between TOK and its development partners. The new building also functions as a value creation site where people form long-term relationships and external stakeholders can better understand the exciting technologies of the TOK Group.

The new R&D Building has a super clean room with world-leading levels of cleanliness to handle hazardous substances. We expect this super clean room to contribute greatly to the development of materials for next-generation miniaturization products, such as EUV photoresists for 5nm and 3nm semiconductors. Having successfully developed materials for the 7nm process recently, we are seeing new benefits emerge, such as knock-on effects in the development of materials for the 5nm process. TOK will continue to concentrate resources on development in cutting-edge fields of miniaturization.

Addressing new customer needs for cleanliness

In the development of materials for cutting-edge semiconductor processes, needs for higher levels of cleanliness have begun to increase for eliminating contaminants* to extreme levels, in addition to higher levels of purity that reduce impurities as much as possible.

For example, introducing this concept of cleanliness is one reason why TOK was able to successfully develop clean solutions that were adopted by a major customer producing 10nm-level semiconductors. The super clean room in the new R&D Building will take these initiatives to the next level, advancing the creation of new value in clean materials with contaminants reduced to the lowest possible level.

* Contaminants are substances that are theoretically unnecessary in chemical reactions.

New C-1 Building (under construction) at the Sagami Operation Center will have a super clean room

New B-6 Building at the Sagami Operation Center for open innovation

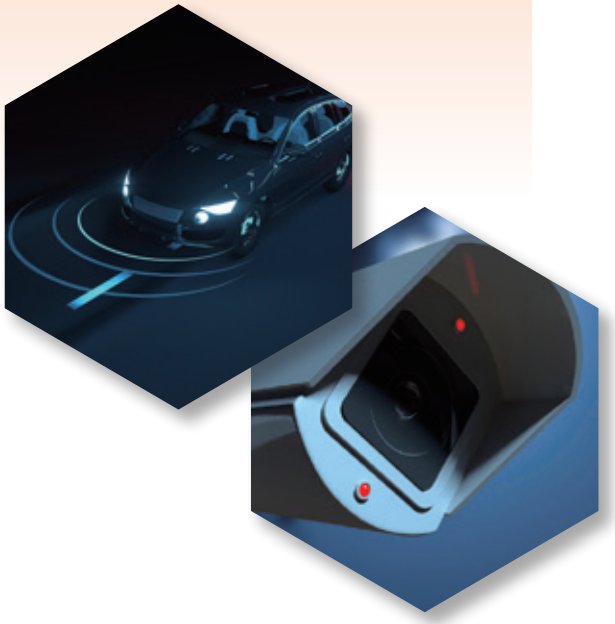
Initiatives in light-controlling technologies

TOK and its customers in the semiconductor and electronic components industries are making every effort to advance semiconductors and various devices in terms of miniaturization, higher purity, higher density, and better yields. Recently, needs have begun to increase for new technologies to control light. Below, we introduce TOK's initiatives in light-controlling technologies.

Light-Controlling Technologies to Become a New Core Competency

In the era of 5G and IoT, large volumes of optical sensors are likely to be incorporated into various devices, such as imaging devices for autonomous vehicles or security cameras. Current optical sensors convert light into electric signals at an efficiency that depends greatly on the strength of the incoming light. By controlling the refractive index of light, this conversion efficiency can be improved, creating new value.

In the era of 5G and IoT, needs are likely to increase for optical sensors effective in weak light situations, such as autonomous vehicles and security monitoring at night. TOK will contribute to the advancement of light-controlling technologies through the development of materials that can flexibly control the refractive index.



Inorganic Materials Key to Breakthroughs

Light-controlling technologies are very similar to the microprocessing technologies that TOK has accumulated over many years in the photolithography field, and the Company's accumulated know-how in high purity and yield improvement can be utilized in the process of turning these materials into products.

As materials that control the refractive index of light, TOK provides its customers with photoresists for IoT sensors and panel manufacturing. These photoresists are mainly composed of organic materials. Since organic materials alone are insufficient to attain exceptional features, in April 2018, TOK invested about ¥220 million in Pixelligent Technologies, LLC in the U.S., a company that excels at developing inorganic materials with high refractive indexes. The two companies then commenced open innovation. TOK is assisting with R&D at Pixelligent Technologies, one of the world's leading manufacturers with the technology to mass produce zirconium oxide capped nanoparticles, a high refractive index inorganic material, with sub-10nm diameters. By combining the two companies' strengths, we aim to help solve various issues in a 5G and IoT society by scaling up production of inorganic materials with high refractive indexes and developing high refractive index material markets.

pixelligent
THE CLEAR SOLUTION™

Outline of Pixelligent Technologies, LLC

- Location: Maryland, U.S.
- Representative: Craig Bandes
- Business description: Development, manufacturing, and sales of optical materials
- Established: 1999
- URL: http://www.pixelligent.com/

Beneficial for Lower Power Consumption

One more reason why TOK is focusing on the development of materials for light-controlling technologies is because high refractive index materials improve light extraction efficiency, in addition to improving the performance of various optical devices. This also brings benefits in the form of lower power consumption. The Company also aims to help solve the problem of climate change by adding to its lineup of environmentally friendly products, including i-Line photoresists for power semiconductors and power device manufacturing equipment.

Equipment Business

Manufacturing, sales and maintenance of semiconductor manufacturing equipment and panel manufacturing equipment

Shonan Operation Center

Tsukasa Honkawa
Officer, Department Manager,
Process Equipment Manufacturing Dept.

Equipment Business Performance

(Millions of yen)

	FY2017/3	YoY*	FY2017/12 Result*	FY2017/12 Calendar year adjustment*	FY2018/12 Result		
						Change	%
Net sales	2,252	1,943	1,921	2,237	2,697	+459	+20.5%
Segment income (loss)	(750)	(333)	(664)	(1,073)	(883)	+189	—
Segment income margin	—	—	—	—	—	—	—
Segment assets	3,296	—	3,026	—	4,245	—	—
Depreciation	45	—	24	—	63	—	—
R&D costs	546	—	423	—	497	—	—

* Due to the change in fiscal year-end, adjusted results for the fiscal years ended December 2016 and December 2017 are presented as adjusted figures for nine months' (April–December 2016) earnings of companies that ended their fiscal years in March 2017 (the Company and its domestic consolidated subsidiaries). Revised results for the fiscal year ended December 2017 are presented as adjusted figures for 12 months' (January–December 2017) earnings of companies that end their fiscal years in March (the Company and its domestic consolidated subsidiaries).

In the semiconductor manufacturing equipment and display manufacturing equipment fields, TOK's business specializes in niche domains

Zero Newton bonding machine
An integrated machine able to bond carrier plates and silicon wafers with high precision

TIPS series UV curing machine
Orders came in for a new model that provides excellent film qualities with a more efficient process

Review of the "TOK Medium-Term Plan 2018"

Foothold gained in new fields, but many issues remain

In the Equipment Business, under the "TOK Medium-Term Plan 2018" (fiscal year ended March 31, 2017 to fiscal year ended December 31, 2018), the Company has concentrated management resources on three fields: the through-silicon-via (TSV) equipment field, a multilayering technology that layers semiconductor wafers in 3D, using a through-silicon process to pass between the layers; the UV curing machine field for OLED display manufacturing; and the next-generation display manufacturing equipment field.

In the TSV equipment field, TOK has advanced the introduction of TSV technologies by approaching foundries and OSAT manufacturers, and working on the development of applications for fan-out wafer level packages (FOWLP) and fan-out panel level packages (FOPLP). In the UV curing machine field, the Company has worked on approaching new applications and new lines. In the next-generation display manufacturing equipment field, the Company approached prototype development lines for flexible displays. Furthermore, TOK focused efforts on increasing sales of components and materials, as well as after-sales services like repair and remodeling, in these three fields.

As a result, in the TSV equipment field, TOK made some progress toward getting OSAT manufacturers to adopt its products as its efforts to "maintain and create consistently competitive businesses (technologies)" had an impact. In FOPLP, TOK's coating machines have secured a position on the world's first mass production lines.

In the UV curing machine field, the Company won orders for a new model in the TIPS series that provides excellent film qualities with a more efficient process while balancing detachability with performance improvements in heat resistance and dry etching resistance.

In the next-generation display manufacturing equipment field, however, delays were encountered in the development of mass production versions of flexible display manufacturing equipment, leading to the restructuring of the development structure. In the other two fields as well, target markets did not expand to an extent where the Company's technological advantages could be fully applied.

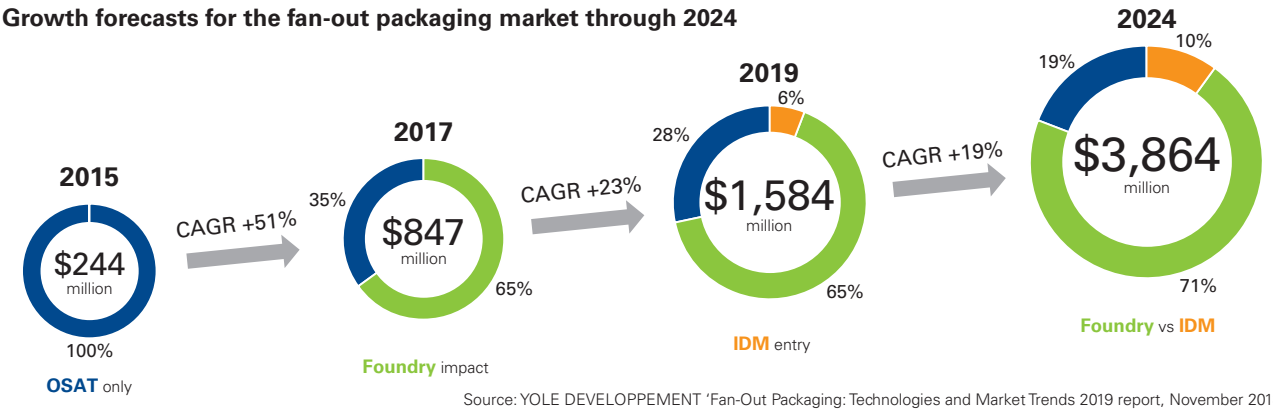
Issues that need to be addressed going forward include strengthening the supply chain to prepare for growth in sales, and slow progress establishing high-margin businesses, such as components.

Key Measures of the First Year of the "TOK Medium-Term Plan 2021"

Translate success in previous medium-term plan into steady order growth

As mentioned earlier, there are signs of slower-than-anticipated expansion in markets targeted by this segment, such as the semiconductor 3D packaging market, the FOPLP market, and the flexible display market. However, growth potential is strengthening in all of these markets. During the "TOK Medium-Term Plan 2021," the Company will develop business centered on its Materials & Equipment (M&E) strategy that entails proposing "processes" for equipment to draw out the unique characteristics of materials based on its deep understanding of materials.

Growth forecasts for the fan-out packaging market through 2024



Source: YOLE DEVELOPPEMENT 'Fan-Out Packaging: Technologies and Market Trends 2019 report, November 2018'

SWOT Analysis — Equipment Business —

Strengths (S)
- Track record in TSV equipment adoption, resulting advantage in technology and technological improvement
- Provides high-performance equipment for coating and stripping
- Knowledge of materials developed in the Material Business
- Lower break-even point using the fabless production method

Weaknesses (W)
- Still in the development phase, so business scale and profit contribution remain small (insufficient cash cycle)
- Large impact on profits from investments in development of prototypes, etc.

Opportunities (O)
- Growth in 3D packaging market from diversification of high integration technology
- Expansion of next-generation display market
- Equal opportunities for products to be adopted in a new market

Threats (T)
- Full-scale entry by major companies as competitors catch up
- Deterioration in market environment with U.S.-China trade friction and tensions between Japan and South Korea
- Introduction of high integration processes aside from 3D packaging

In the TSV equipment field, inquiries have increased from customers, especially in Asia, who are considering an entry into the back-end processing business of semiconductor manufacturing. With the number of requests to process samples including processing wafers using our equipment and to provide samples, on the rise, we are keen to lock in orders for our equipment.

In FOPLP equipment, TOK aims to solidify its position providing mass production equipment obtained through initiatives under the "TOK Medium-Term Plan 2018," by concentrating efforts on further refining the completeness of equipment and preparing to ramp up production for when the market starts to expand. Under the M&E strategy, TOK aims for its photoresists to be used in panel level packaging, by leveraging its high market share in FOWLP packaging photoresists.

In flexible display production equipment, which had encountered development delays, TOK is rebuilding the development structure with a plan to commence sales in the first year of the "TOK Medium-Term Plan 2021." This equipment is based on a single-wafer-type system (processes wafers one by one), not a batch-type system (processes multiple wafers collectively) that is currently the industry standard. Single-wafer-type systems make it easier to change process settings for each wafer, making it relatively simple to build processes for finishing coated layers at levels required by customers. In particular, the Company plans to finish this system with superior transparency in the films themselves, as needed by customers.

Taking steps to improve earnings

With the aim of improving earnings in this segment, we are taking the following steps to mitigate the high cost structure inherent in customizing each system as "one-of-a-kind" equipment.

First of all, the Company will redouble efforts to stabilize earnings though after-sales services, such as the provision of related materials, consumables and components, and equipment remodeling or overhauls. Although all of the equipment supplied by TOK are "one-of-a-kind" in principle, some fields of our equipment allow for economies of scale when multiple units are delivered in a single order. We are therefore focusing on expanding sales in such fields.

To accelerate development, TOK has reinforced development and design functions under the previous medium-term plan, and to increase development efficiency, the Company set up the Design Development Group as a new organization in 2018 to improve analysis and debugging in data simulations before prototypes are fabricated in a bid to reduce costs.

TOK's Human Resource

Hsiao-Wei Yeh

Bonding/Debonding Technology Business Unit
TOK TAIWAN CO., LTD.

Aiming for Long-term Sustainable Growth with Excellent Solutions That Meet Customer Requirements

I sell equipment in Taiwan's semiconductor market, and the most important thing to me is providing excellent solutions that satisfy customer requirements. I believe this will lead to the sustainable growth of TOK over the long term. When a customer adopted Zero Newton for sensing devices, the Shonan Operation Center in Japan and TOK TAIWAN CO., LTD. worked closely together to solve any issues in hardware and processes when customers launched plants. This has translated into good relationships of trust built over the long term between the customer and TOK. This has been an invaluable experience for me. In the future, I will aim for win-win outcomes by devoting myself to work with the intention of maintaining good cooperative relationship between the customer and the team at the Shonan Operation Center.