3 Innovation

The Best Partner for Our Customers

"Innovation" is one of the driving forces for Nanya's growth and competitiveness and one of our four core values. We shall strengthen product research, development, and manufacturing to satisfy customers' diverse demands and become the best memory partner for the smart generation.

13.8%

R&D expenses accounted for 13.8% of revenue and R&D personnel accounted for 27.1% of employees. These demonstrate Nanya's focus on technological development.

NT$360 million

A total of 90 AI applications were developed as of the end of 2022 and the annual benefits reached NT$360 million.

812 cases

A total of 812 patents were granted in 2022, an increase of 347 cases or 75% compared to 2021

Strategy and Performance of Material Topics

R&D and Innovation

Strategy
1.Design new next-generation products
2.Develop 10nm process technologies
3.Entered the high-density server module market
4.Smart factory

2022 Goals	2022 Performance	2023 Goals
Complete the verification of 10nm DRAM technology for product shipment	1.1.First generation 10nm DRAM process 8Gb DDR4 products reached shipment verification standards 1.2.Second generation 10nm DRAM process 8Gb DDR4 products completed product specifications and yield certification	1.1.Second generation 10-nm DRAM process 8Gb DDR4 products reach shipment verification standards 1.2.Complete design of second generation 10nm 16Gb DDR5 products and have pilot-run wafers outputs
Cultivate a total of 400 engineers with AI theories and development capabilities	Cultivated a total of 400 engineers with AI theories and development capabilities	Cultivate a total of 450 engineers with AI theories and development capabilities
Complete 90 items for AI application development	Completed 90 items for AI application development	Complete 110 items for AI application development

Eco-friendly products

Strategy
1.Technology improvements: Research and develop advanced and highly efficient products to assist consumers in lowering energy consumption and reducing carbon emissions during the usage of products
2.Consider product life cycle: Improve the environmental friendliness of products on the environment
3.Hazardous substance management: Continue to promote replacement plans for hazardous substances in the production process

2022 Goals	2022 Performance	2023 Goals
Ratio of 20nm and other advanced processes accounted for 88% and above	88.5%	Ratio of 20nm and other advanced processes accounted for 96% and above
Complete product life cycle inventory on 100 percent of products	100%	Complete product life cycle inventory on 100 percent of products
100 percent of products conform to hazardous substance free regulations and customers' specifications	100%	100 percent of products conform to hazardous substance free regulations and customers' specifications
100 percent of materials contained zero perfluorooctanoic acid (PFOA) or related substances	100%	100 percent of materials contained zero perfluorooctanoic acid (PFOA) or related substances

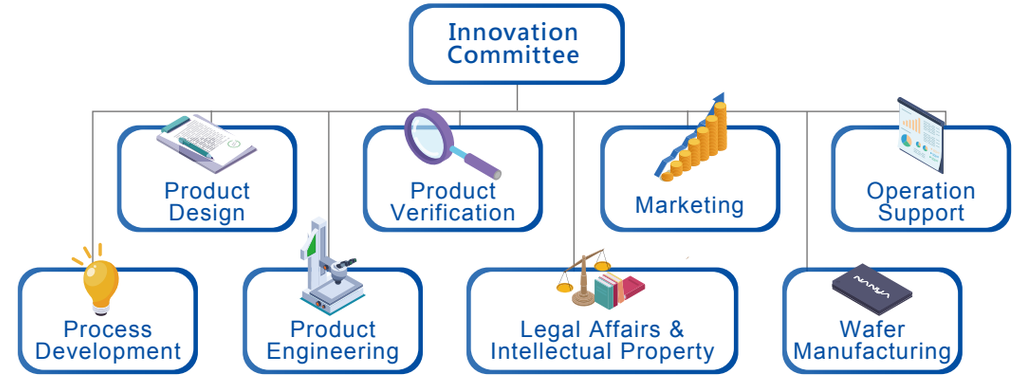
Exceeded Achieved Partially achieved

3-1 R&D and Innovation

Smart products have been completely improving the quality of life for human beings and helping energy conservation and carbon reduction. Therefore, every year, Nanya invests large amounts of resources in technological development of new types of DRAM products, next generation processes, and advanced 3D stacked packaging. The developments provide customers with value-added services, reinforce protection for intellectual property and trade secrets, and accelerate the move towards product diversification and smart factory. Moreover, we have set a vision for innovative development to introduce the second generation 10nm DRAM process into mass production in 2025, develop the third generation 10nm DRAM process and the next-generation DDR5 and LPDDR5 products, and manufacture 16Gb high density products at large scale so as to enter fast-growing markets (artificial intelligence (AI), data centers, automotive and the Internet of Things), and set up high-efficient production lines with an AI-aided system.

Innovation Committee

In order to implement innovation management, create a culture of innovation, and enhance the company's innovative energy and value, Nanya specially set up the Innovation Committee, a cross-departmental unit, formed by the senior management and chaired by Executive Vice President (EVP). The Innovation Committee is positioned to coordinate and plan the overall innovation strategy, setting short, medium and long-term goals. The committee periodically convenes meetings to examine the progress of important projects, including management indicators of open innovation projects, product innovation projects, and process innovation projects. Goals for material topics were all completed in 2022, such as: First generation 10nm DRAM process 8Gb DDR4 products reached shipment verification standards, and second generation 10nm DRAM process 8Gb DDR4 products completed product specifications and yield certification. In AI applications, we cultivated a total of 400 engineers with AI theories and development capabilities, and developed 90 AI applications between 2019 and 2022.



Investment in Innovative R&D

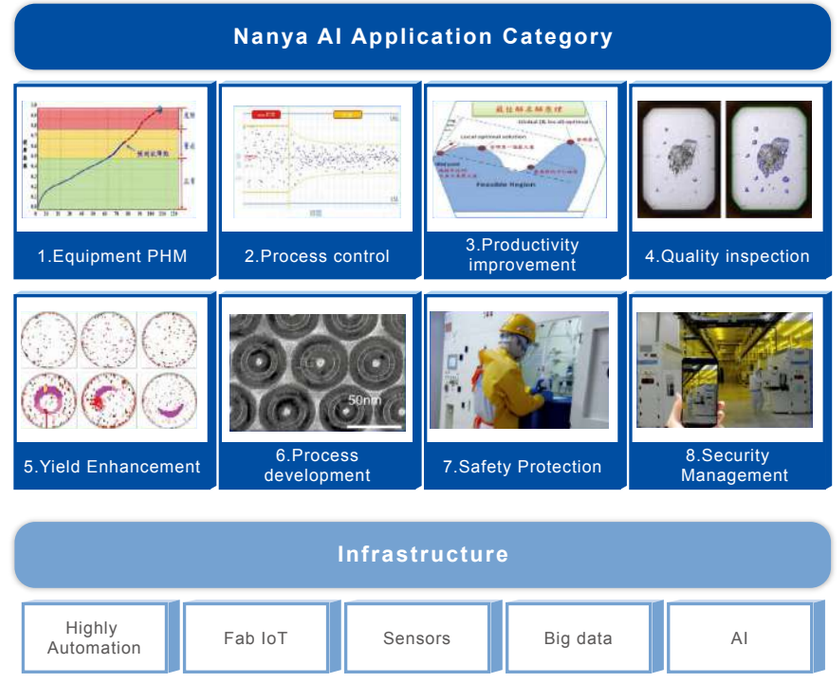
	2019	2020	2021	2022
Operating revenue (A) 100 Million NTD	517	610	856	570
R&D and innovation expenses (B) 100 Million NTD	49.3	51.4	75.0	78.4
R&D expenses as a percentage of operating revenue (B/A)	9.5%	8.4%	8.8%	13.8%
Total number of employees (C)	3,307	3,542	3,554	3,685
Total number of R&D personnel (D)	639	922	953	1,000
R&D personnel as a percentage of all employees (D/C)	19.3%	26.0%	26.8%	27.1%

Nanya Smart Factory

Smart Factory Infrastructure and Applications

Nanya's 12-inch fab has all essential infrastructure that a smart factory requires, including highly automated production lines, Fab IoT, large numbers of sensors, and big data integration. The fab utilizes AI technology in eight important categories, including Equipment Prognostic & Health Management, Process Control, Productivity Improvement, Quality Inspection, Yield Enhancement, Process Development, Safety Protection, and Security Management.

Currently, Nanya has developed several innovative applications in production line, including the machinery diagnosis, advanced process control, optimization of production scheduling, wafer quantity prediction, smart handling, wafer probe testing, defect image recognition, and wafer pattern recognition. These applications can effectively enhance overall operation efficiency, and make important contributions to manufacturing key indices - Yield, Quality and Output.



AI Development Benefits and Promotion

By the end of 2022, Nanya has completed 90 AI applications that can effectively improve yield and quality, reduce wafer scrap ratio, increase tool utilization, lower equipment maintenance costs and raw material consumption, increase production capacity and flexibility, and more effectively use human resources. Annual benefits reach NT$360 million. As we continue to develop new AI applications, we expect total benefits to reach NT$2 billion in the next 5 years (up to 2027).

Innovation and promotion are mainly carried out through three major platforms – AI application development, AI technology research, and AI education.

AI application development platform

Integrated domain experts, IT experts and statistics experts, a total of 60 engineers to systematically develop AI systems

AI technology research platform

Strengthened AI team's technical capabilities, and systematically implemented machine learning, deep learning (CNN , RNN , object detection), and edge computing technologies.

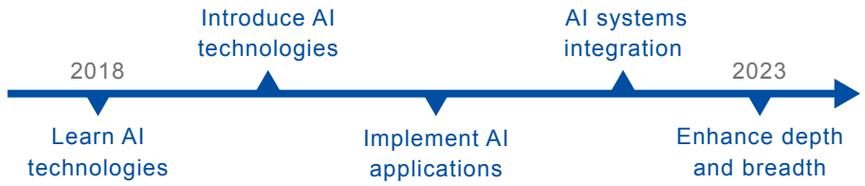
AI education platform

AI training courses were conducted by internal and external instructors, and trained a total of 400 engineers with AI theories and practical technical abilities.

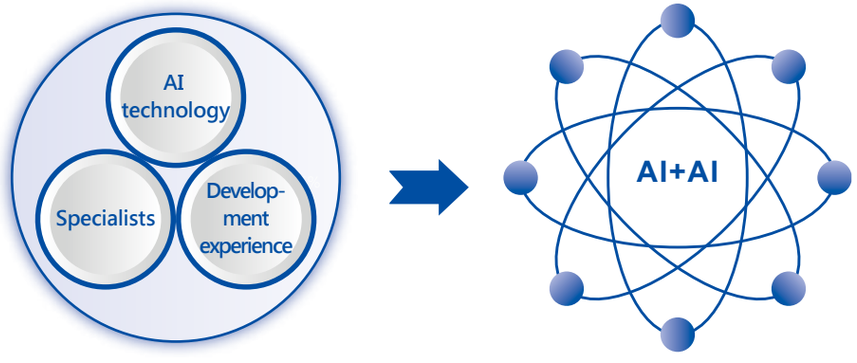
1.CNN: Convolutional Neural Networks
2.RNN: Recurrent Neural Networks

AI Application Development Plan

Nanya established an AI applications team in 2018, learned and introduced AI technology, gradually implemented AI in various departments, and connected more smart systems, such as yield enhancement system, smart production system, and general image recognition system that can make production line operate more effectively. In the future, we will continue to strengthen AI development, adopt advanced AI technologies, and expand AI applications to different departments. With that, Nanya can comprehensively improve overall manufacturing performance.



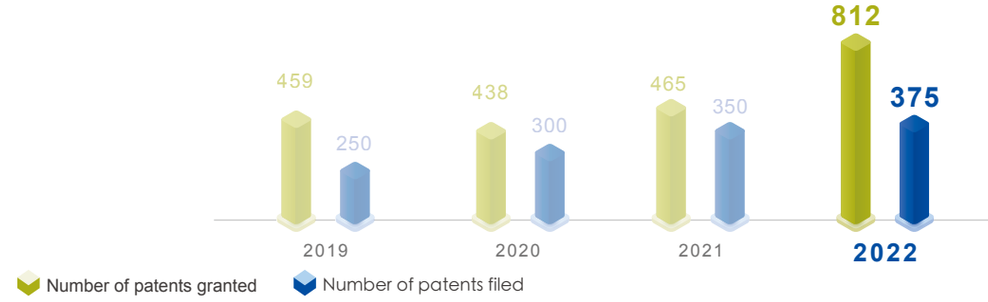
Accumulate development ability **Connect AI systems**



Status and Strategy of Intellectual Property

Besides working with world class talent to adopt advanced technologies, Nanya has spared no effort in the development of proprietary technologies, and has accumulated considerable intellectual property over the years. As of the end of 2022, Nanya has accumulated over 5,900 patents, protecting technological development results and securing a competitive advantage, while flexibly utilizing intellectual property rights to effectively defend against frivolous patent lawsuits. This provides a powerful tool for technology and business competition.

Nanya's patent performance



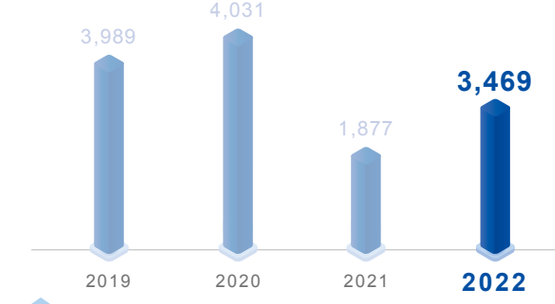
Critical legal cases related to intellectual property involving Nanya were as follows:

The U.S.-based Monterey Research LLC. accused Nanya and subsidiaries Nanya Technology USA and Nanya Technology Delaware in the U.S. District Court for the District of Delaware for patent infringement in November 2019. We have engaged counsels to properly handle the case to protect our rights and interests.

Nanya intellectual property strategy

Create the most favorable R&D and production environment with intellectual property, and then use the results of excellent production and R&D to recreate intellectual property rights that are practical and good.	Make full use of intellectual property to create a favorable environment for the Company and the industry.	Manage intellectual property with a suitable system, and protect trade secrets with a rigorous network for information security.

In addition to patents, trade secrets are also an extremely important intellectual property in the semiconductor industry. Nanya has been actively implementing advanced process technologies and developing new products and innovative sales models in recent years. Besides applying for patents to protect the intellectual property, any technology, method, process, formula, program, design, or other information that can be used for production, sales, or business are trade secrets of Nanya strictly protected by information security systems, as long as they are confidential and possess economic value.



*Note: The number declined in 2021 due to the change of archive rules.

Incentives for Innovation

"Innovation" is one of the driving forces behind Nanya's technological growth and competitiveness enhancement and one of our core values. To encourage employees to propose innovative ideas, Nanya holds annual innovation competitions, offers patent rewards and rewards for improvement proposals, and organizes essay competitions and the best team competitions. We recognize and reward innovative ideas proposed by each employee, hoping that all employees will internalize the spirit of innovation.

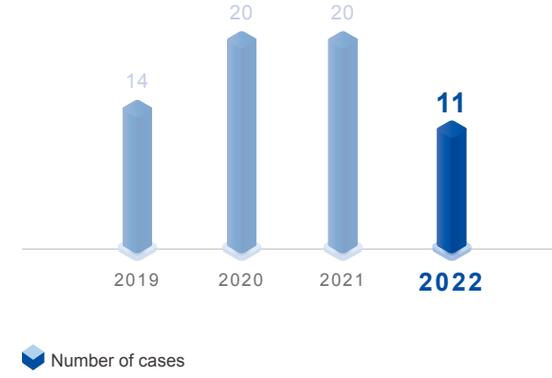
Incentive innovation mechanism

Results of innovative activities

	2019	2020	2021	2022
Patent rewards: Number of patents granted	459	438	465	**812**
Rewards for improvement proposals: Number of proposals	225	207	207	**212**
Rewards for improvement proposals: Actual annual benefit(NT$)	368,721,600	1,583,318,400	882,517,200	**756,744,060**
Technological essay competitions: Number of entries	65	79	93	**103**
Best team competitions: Number of entries	15	17	13	**17**

In addition, we attach great importance to technology R&D. We incorporate external innovation into our R&D in open and innovative ways, and accelerate and expand technology R&D. We have worked on basic research, product design, and product testing for next generation memory with National Taiwan University, National Tsing Hua University, National Yang Ming Chiao Tung University, National Central University, Chang Gung University, Industrial Technology Research Institute, and testing equipment suppliers. We have also partnered with manufacturers of masks and machinery in joint development of 10 nm process and materials. Through customized Wafer Level Packaging and multiple application products developed rapidly with downstream system developers, Nanya has launched new open innovation programs every year in the past four years in coordination with the Company's short, medium, and long-term R&D plans.

Technology R&D open innovation program



3-2 Green Product Development

Nanya and clients both aim to protect a green planet. We implemented the Life Cycle Thinking (LCT) and the Design for Environment. For a long time, we have made an effort to research and develop advanced and highly efficient eco-friendly products. We not only have helped clients develop products with low energy consumption design, but also have engaged in hazardous management and Conflict-free minerals and Responsible Mineral Sourcing Management through our influence on supply chains. In order to continue improving the environmental friendliness level of products, we have formulated environmental health and safety performance indicators, promoting various waste reduction and resource reuse, greenhouse gas reduction and other projects. In coordination with the Green Product Promotion Committee (GPPC) on green product management, right from the start of product development, we consider seven aspects of environmental impacts, including procurement, manufacturing, transportation, product use, disposal, and recycling in order to identify improvement opportunities to increase environmental benefits.

Nanya green design matrix

	Procurement	Manufacturing	Transportation	Product use	Disposal and recycling
Energy efficiency	●	●	●	●	
Greenhouse Gas Emissions	●	●	●	●	
Material reduction	●	●	●		
Responsible Mineral Sourcing Management	●				
Hazardous substances	●	●			●
Waste reduction		●			●
Water resources reduction		●			

Life Cycle Assessment

In response to the EU's new wave of requirements for environmental issues, we used the Simapro, a life cycle assessment tool, to conduct life cycle assessment on 100% of our products, calculated environmental footprints of products, and identified directions for future improvements. In the meantime, the company would use the product environmental data and coefficients accumulated through analysis processes to build a decision support system for green product development. The company gave multiple considerations on the requirements, and conducted quantitative life cycle assessment on products in each life cycle stage. Pursuant to the contents of quantifying and communicating requirements and guidelines for the Product Environmental Footprint of the life impact assessment under the ISO 14040s series, the company participated in product environmental footprint declarations, and referred to the regulations of ISO 14064-1 Greenhouse Gas Inventory and ISO/TS 14067 Carbon Footprint International Standard to execute the declarations. The analyzed products were various DRAM we manufactured, and boundaries of the life cycle system included raw materials manufacturing, transportation, wafer manufacturing, packet packaging, module packaging, product use, and recycling/disuse. Because the company's main production was memory wafer manufacturing, other system boundaries were outsourced. Therefore, the main system boundary was wafer manufacturing. Among 14 measures to improve environmental footprint sources, reductions in greenhouse gas emissions from the three main sources listed in the results of the 2021 product life cycle assessment are as follows:

Electricity use

Percentage of product carbon footprint

82.86%

Improvement plan

Implement energy conservation improvement plans

2022 Operation result

- Completed 25 energy conservation management plans under ISO 50001, energy conservation benefits: 4378 MWh
- Purchase 7.88 million kWh of renewable energy

Direction for further improvement

- Continue to implement the ISO 50001 Energy Conservation Plan
- Continue to purchase renewable energy according to plan

Use 12-inch production wafers

Percentage of product carbon footprint

3.18%

Improvement plan

Require foundries to implement energy conservation and carbon reduction management plans

2022 Operation result

- Completed the energy conservation plan and saved 5,355 MWh
- Suppliers joined the SBTi and plan to reduce Scope 1+2 emissions by 25% in 2030.

Direction for further improvement

Continue to require foundries to implement energy conservation and carbon reduction management plans

Liquid oxygen

Percentage of product carbon footprint

1.70%

Improvement plan

Require liquid oxygen suppliers to implement energy conservation and carbon reduction management plans

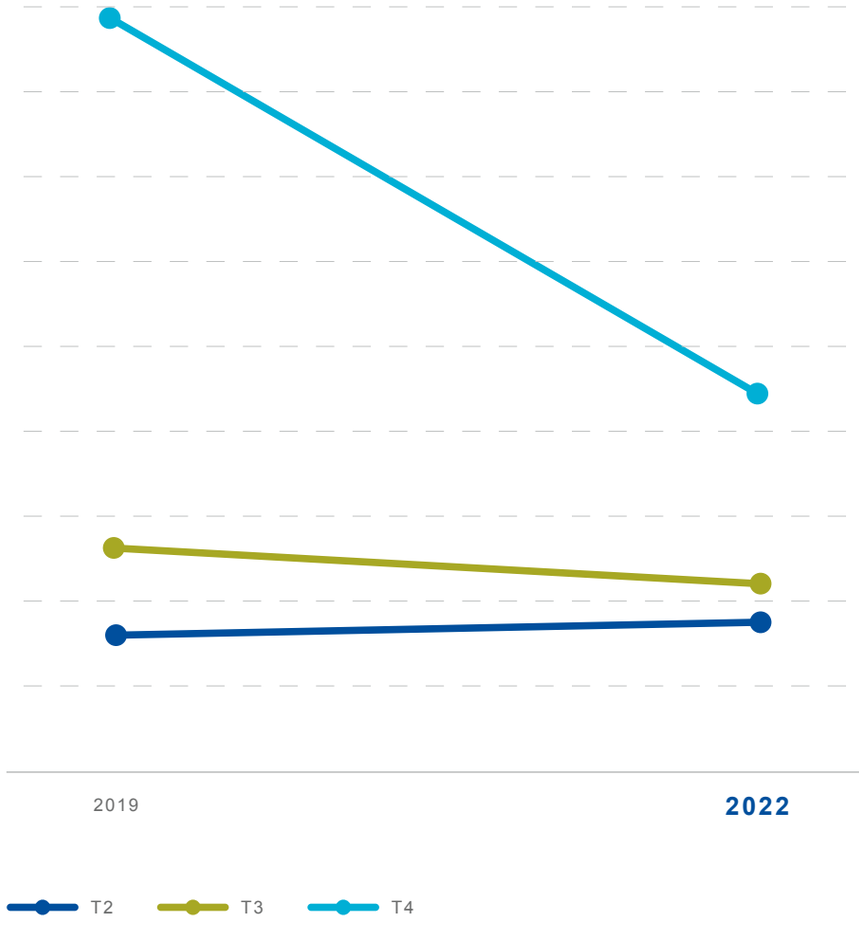
2022 Operation result

Suppliers joined the SBTi and plan to reduce Scope 1+2 emissions by 25% in 2030.

Direction for further improvement

Continue to require liquid oxygen suppliers to implement energy conservation and carbon reduction management plans

Product's Carbon footprint by processes

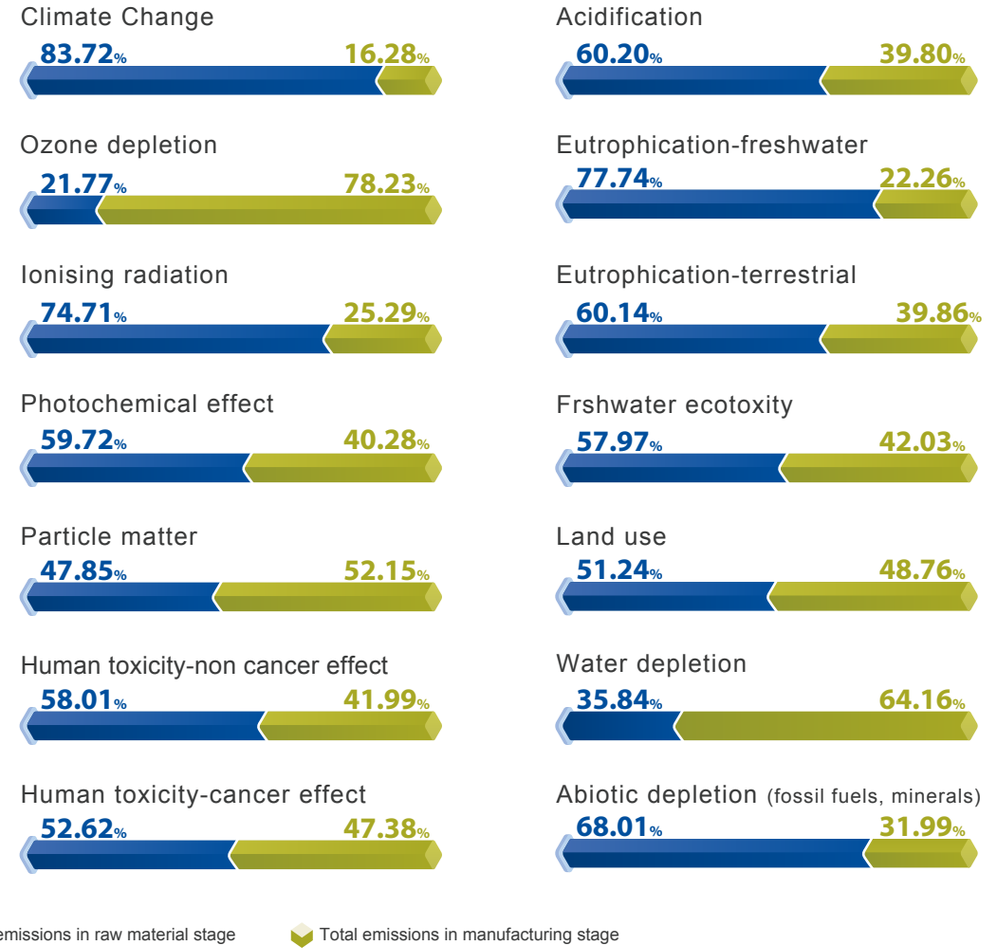


Advanced process T2 has a benefit of lower carbon footprint than T3/T4 process

Stages of raw materials and manufacturing process of SA30

Product life cycle inventory for 2022 was completed. We used staple product SA30 memory to show the ratio of 14 items of environmental footprints in stages of raw materials and manufacturing process. Manufacturing process at factories accounted for about 83.8% of greenhouse effect, and procurement of raw materials accounted for around 16.2% of greenhouse effect.

Ratio chart of product(SA30)'s 14 items of environmental footprints in stages of raw materials and manufacturing process

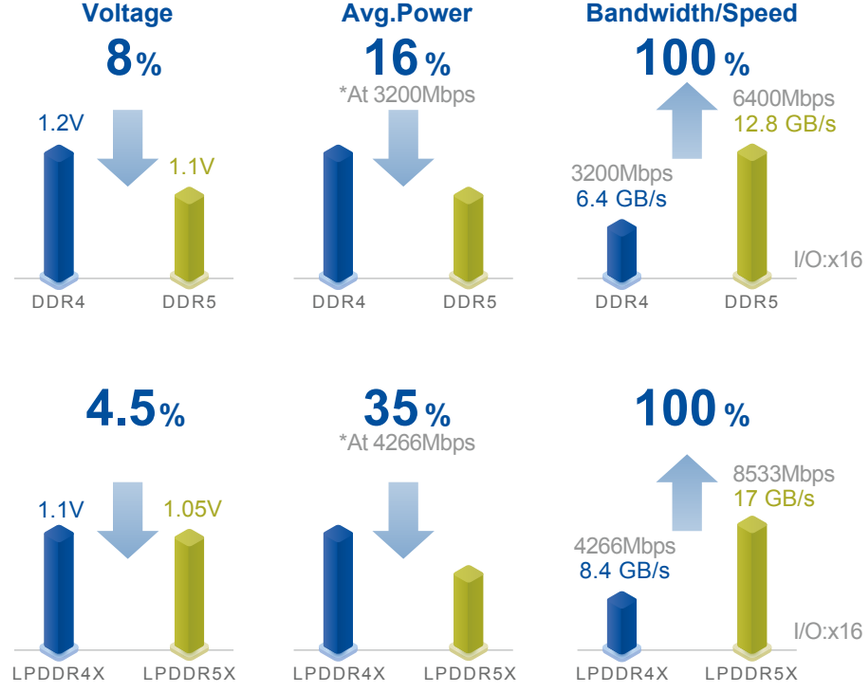


Green Product Design

Nanya has been dedicated to the research, development, manufacturing, and sales of DRAM, becoming the fourth largest DRAM company worldwide. Moving towards the smart era, DRAM is a key component to be used in the applications of smart city, smart home, smart office, unmanned vehicles, internet of things (IoT), cloud, artificial intelligence (AI). With continuous promotion of independently developing process technology, Nanya started researching and developing 1A-nm and 1B-nm technologies in 2017, and planned to develop products with high integration, faster speed, and lower energy consumption, such as DDR4/DDR5. Different from the past methods of cooperating with other DRAM companies on technology development or technology licensing, Nanya independently developed 1A/1B technologies. Product verification for 1A-nm technology is expected to be completed in 2022. This is the first 10nm DRAM technology of a Taiwanese company, and proves that Taiwan's DRAM technology development ability is among the top companies across the world. Meanwhile, we have constantly expanded our existing product lines into diverse applications, providing clients with whole product solutions to become the become the best memory partner in the smart era.

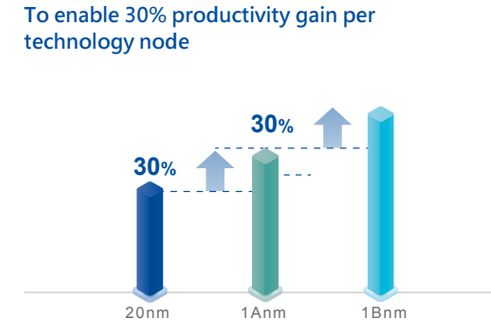
Driven by the demand for 5G communications, cloud, AI, and smartphone memory upgrade, DDR5 and LPDDR5 (low power double data rate memory) became the main supply of new generation memory. Compared with current mainstream memory, new generation memory possesses faster transmission efficiency while saving energy due to lower operating voltages. When comparing DDR4 with DDR5, average power is about 16% lower, but bandwidth is doubled.

DDR5&LPDDR5X provides specifications that save more electricity with high bandwidth/high speed



Nanya has focused on the development of advanced processes, and began independently developing 1A-nm process technology in 2017; trial production began in 2022. 1A-nm process technology will significantly shrink the size of chips and increase the capacity of a single wafer by 30%. Furthermore, we also began developing 1B-nm process technology in 2019 and expect to begin small-scale production in 2023. 1B-nm process technology further shrunk chips made using 1A-nm process technology and increased the capacity of a single wafer by 30%. This will allow factories to further achieve energy conservation and carbon reduction goals while achieving the same production capacity.

Nanya DRAM Technology Strategy



Environmental external benefits

When we develop new products, the environmental impact of the entire life cycle is considered. To electronic products, the energy consumption in use is one of the most significant indicators in environmental impacts. Nanya actively researches and develops low energy consumption products, and assist clients lower demand for energy during their usage of electronic products so that greenhouse gas emissions can be reduced.

Over 621.69 million kWh of electricity saved

Product:
low power DRAM and 20nm consumer DRAM

Scope:
total sales volume of 2022

Calculation:
Based on the quantity of products sold in one year, and compared the energy consumption of the aforementioned DRAM products with that of the previous generation

Benefits:
Saved the annual electricity consumption of 172 thousand households Note 1 and reduced greenhouse gas emissions by 316,440 ton-CO_2e Note 2, which is the equivalent of 814 times the carbon absorption of Daan Forest Park in an entire year Note 3.

Note 1: Estimated based on the actual monthly electricity consumption of 3,619 kWh/year by housing units in the statistics for housing units and small stores on the website of Taiwan Power Company (2023/1/16)
Note 2: The carbon emission factor of electricity is based on the announcement of the Bureau of Energy in 2021: 0.509 kg CO_2e/kWh
Note 3: According to the Bureau of Energy, Ministry of Economic Affairs: The CO_2 absorption of Daan Forest Park used for calculation is 389 tons per year

R&D Policy for Low Energy Consumption Products

Nanya continues to develop advanced manufacturing processes, so the energy consumption of new generation products developed with new processes is reduced by 15% compared with the previous

Nanya cooperates with major chip customers, adopting the method of multi chip package (MCP) to reduce back-end assembly and testing as well as energy consumption

Nanya strengthens the development of low energy consumption product lines and enlarges product portfolios in order to satisfy the need of various mobile devices and electronic products

Hazardous Substance Free Product Management

In 2005, Nanya established the Green Product Promotion Committee (GPPC) to promote hazardous substance free (HSF) management. During the product manufacturing process, we continued to prevent pollution, save energy, reduce wastes, and avoid hazardous substances. Through concatenating suppliers and subcontractors to well managed of raw materials, manufacture process materials, package assembly materials, DIMM Module materials and packaging materials, Nanya built an effectively green product supply chain to managed raw material provider, process material provider, back-end assembly house subcontractor and shipment packing material provider and its materials to meet green product policy and conform to the laws and regulations of current global environmental protection trend. Through the GPPC, we referred to laws and regulations of the EU and countries in other regions and the hazardous substance management specifications of major international customers to stipulate the General Rules of Environmental Management Substances for Components and Materials, continuing to effectively control and manage the sources of raw materials and related materials in order to achieve standards of green products and mitigate impacts on natural environment during manufacturing process of products. We followed the General Rules of Environmental Management Substances for Components and Materials and all products are required to comply with international regulations and customer requirements. Through the establishment of a HSF management system for materials, we ensured that the wafers, IC packaging, and DIMM module products comply with international regulations and related specifications of clients towards HSF management.

Green products are defined by Nanya as products that comply with the following requirements of BNDCU-0012 General Rules of Environmental Management Substances for Components and Materials:

Comply with requirements of the WEEE and RoHS 2011/65/EC & 2015/863 (recast)

Substance Name	RoHS Restriction
1. Cadmium and its compounds	<100ppm
2. Lead and its compounds	<1000ppm
3. Mercury and its compounds	<1000ppm
4. Hexavalent Chromium and its compounds	<1000ppm
5. Poly-brominated Biphenyls (1-10 PBBs)	<1000ppm
6. Poly-brominated Diphenyl Ethers (1-10 PBDEs)	<1000ppm
7~10. 4 Specific Phthalates (DBP,BBP,DEHP,DIBP)	<1000ppm

Complies with requirements of IEC 61249-2-21 Halogen Free (HF)

Substance Name	Halogen-Free RestrictionName
11.Chlorine (Cl)	<900 (Cl+Br<1500)
12.Bromine (Br)	<900 (Cl+Br<1500)

Complies with requirements of EU Directive 94/62/EC PPWD

Substance Name	PPWD Restriction
1.Cadmium and its compounds	Total sum of 4 heavy metals <100ppm
2.Lead and its compounds	
3.Mercury and its compounds	
4.Hexavalent Chromium and its compounds	

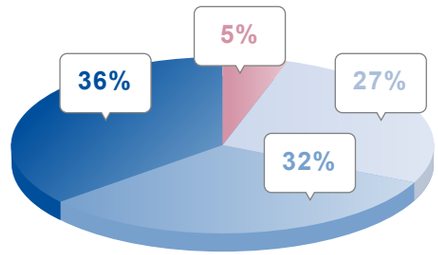
Comply with requirements set forth in Section 6(h) of the U.S. Toxic Substances Control Act to not use 5 PBT (Persistent, Bio-accumulative, and Toxic) substances

Substance Name	CAS No.	Applied Materials Field
Decabromodiphenyl ether (DecaBDE)	1163-19-5	Flame retardant, used in plastics, textiles, communication or electronic equipment wires and other products of TV, computer, audio-visual equipment and other products
Phenol, Isopropylated Phosphate (PIP)(3:1)	68937-41-7	As plasticizer, flame retardant, anti-wear agent, anti-com pression fluid, applied or added to hydraulic oil, lubricating oil, industrial coatings, adhesives, plastic products, etc.
Pentachlorothiophenol (PCTP)	133-49-3	Intermediates or reactants of processing or formulations that may be present in additives such as fuels, gasoline or lubricating oils
Hexachlorobutadiene (HCBD)	87-68-3	Additives or by-products in the manufacture of rubber compounds or lubricants
2,4,6-Tris(tert-butyl) phenol (TTBP)	732-26-3	Applied in rubber process to make it more flexible

Comply with requirements of other customers/ prohibitions in the law/restricted substances, such as prohibited or restricted substances of concern in homogeneous material or finished products in the scope of EU REACH SVHC/EU POP/GADSL

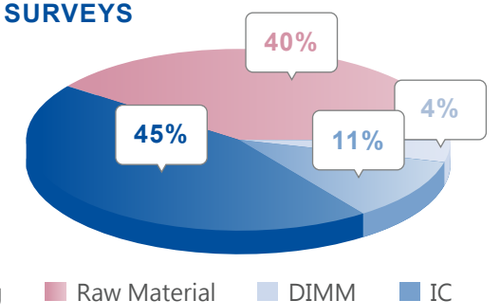
In order to complete the relevant requirements, a total of 1,414 RoHS reports will be reviewed in 2022, and EU REACH SVHC regulatory compliance investigations (once every 6 months) and customer hazardous substance investigations will be conducted 4 times. Complete as follows:

2022 TEST REPORTS



- 100% reviewed 1414 RoHS test reports that collecting from 7 subcontractors and 49 raw material suppliers.

2022 HS SURVEYS



- Two versions of REACH SVHC V.26 & V.27 survey (HS Survey V.43 & V.45) were completed while 158 HS survey reports were reviewed. The completion rate was: 100%.
- Completed 2 versions of HS survey (HS Survey V.46 & V.47) required by clients, while 40 HS survey reports were reviewed. The completion rate was 100%.
- Completed 2 versions of responsible mineral sourcing survey (HS Survey V.44 & V.48), while 38 HS survey reports were reviewed. The completion rate was 100%.