Freiburg Location

“Preserving what we value“

TDK-Micronas

Environmental *Statement* 2016

to EMAS/ISO 14001

"Sustainable environmental protection also under a new roof"

Foreword from the Management Board

The global trend towards lowering CO_2 emissions is and will remain vital for each and every one of us. During the 2015 UN Climate Conference in Paris, the decision was taken to limit global warming to well below 2 °C – if possible to 1.5 °C – by reducing net greenhouse gas emissions to zero between 2045 and 2060. In 2035, TDK will celebrate its 100th anniversary, and, to mark the occasion, the company has set itself an ambitious target in terms of global warming: it is aiming to reach the target of the UN Climate Conference by its anniversary year. For this, in conjunction with the TDK environment vision, we formulated in 2016 an environment protection, health and safety action plan (page 4). As a German supplier to the automotive industry under Japanese flag, we have committed ourselves to help reduce global emissions.

TDK-Micronas implements this both in the design of its components and in their production. Since the takeover by the Japanese parent company, we are also responsible for marketing TMR sensors. These sensors are based on the so-called magneto-resistive effect and are used for magnetic field measurement, for example as an electronic compass, as a path and angle measuring system or as small potential-free electricity sensors. TDK thus offers its customers from the field of automotive electronics the widest possible selection of sensor products, which are helping in their respective application to save energy and lower a vehicle's fuel consumption.

To improve the CO_2 balance, emissions must also be reduced in other business processes. Increasing importance will therefore be attributed in future to the application of our products in systems that are built into the end-product, whether a car or other industry products. Only by using our products in energy-saving systems can the CO_2 emissions that necessarily occur in production, logistics etc. be compensated. We at TDK-Micronas pay strict attention to sparing the environment and resources when manufacturing our products. We are well aware of the fact that the manufacture of semiconductor products is energy-intensive. We are therefore always on the search for new ideas to further improve our production procedures with regard to energy consumption. Particularly in the last three years, a large number of energy and CO_2-saving projects have been launched, as we report every year in the publication of our Environmental*Statement* or Environmental*News*. In total, approx. 700,000 kWh and 6,150 t CO_2 is saved every year through finalized energy projects.

In addition to low CO_2 emissions, safety is also high on the list of priorities for car makers. The trend with new vehicles is towards autonomous driving. Since the invention of the cruise control, modern driver assistance systems have developed at a rapid pace. Nowadays, intelligent sensors check the distance from the vehicle in front and induce the car to brake accordingly or to accelerate up to the allowed maximum speed. TDK recognized the enormous potential of sensor systems a long time ago. This applies not only to automotive electronics but also to applications in industry and the home.

Particularly the market for magnetic field sensors – the main area of business of TDK-Micronas – is growing fast. To exploit this potential to the full, TDK decided to pool its existing sensor activities in a single company: On April 1, 2017, the Sensors Systems Business Company (SSBC) was launched, which also includes TDK-Micronas. In SSBC, all sensor products and resources will be brought together that are currently manufactured in different parts of the company within TDK. SSBC thus covers TDK's entire sensor range, currently marketed under the product brands TDK, EPCOS, Micronas and Tronics.

Climate protection affects us all. We at TDK-Micronas do not just want to act passively, but intend to set an important mark in overcoming climate change.

Wolfgang Bossinger
Vice-President Quality

TDK Vision, Contents

TDK VISION 2035

TDK was founded in 1935, based on the founder's vision and belief – "contribute to the advancement of the society through the commercial production of ferrite, a magnetic material which originates from Japan".

TDK achieved four world-class innovations including "ferrite, magnetic tape, multilayer materials, magnetic heads", and has been offering products to support the advancement of the society. TDK will continue to strive to achieve further innovation and create value for customers through the delivery of outstanding quality products and services, by utilizing the diverse global resources.

Based on TDK's corporate motto, TDK will continue to "contribute to culture and industry through creativity", by revitalizing and protecting the global environment and creating a pleasant and safe society.

TDK CORPORATE MOTTO

"Contribute to Culture and Industry through Creativity"

Vision

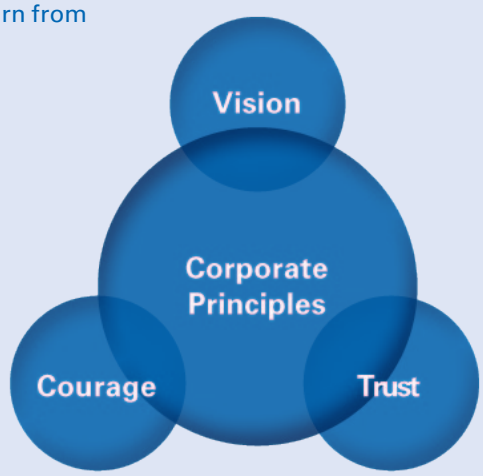
Always take a new step forward with a vision in mind.
Creation and construction are not born without vision.

Courage

Always perform with courage. Performing power is born by confronting contradiction and overcoming it.

Trust

Always try to build trust. Trust is born from a spirit of honesty and service.



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Vision Courage Trust

Corporate Principles

TDK VALUE

Customer Focus

We have:

- Strong determination to contribute to our customers' success
- Passion to be a trusted partner for our customers

Therefore we can:

- Deliver inspirational value by standing in the customer's shoes
- Offer outstanding quality products, services and technology to satisfy our customers

Challenge

We have:

- Culture to turn adverse challenges into chances to develop ourselves
- Strong determination to accomplish our business goals by overcoming adversity

Therefore we can:

- Accept challenges to make innovative breakthroughs and continue to create new value
- Lead our colleagues and collaborate as a team by sharing the same value

HR Development

We have:

- Aspiration to continuously improve ourselves
- Motivation to contribute to the advancement of society and growth of businesses

Therefore we can:

- Define clear vision/goals and drive ourselves to achieve them
- Support the development of our colleagues and build enthusiastic teams

Diversity

We have:

- A global network with diverse culture
- Teams which respect each other and teamwork which encourages development

Therefore we can:

- Clearly express our opinions with sincerity through open discussions

TDK Environmental Vision 2035

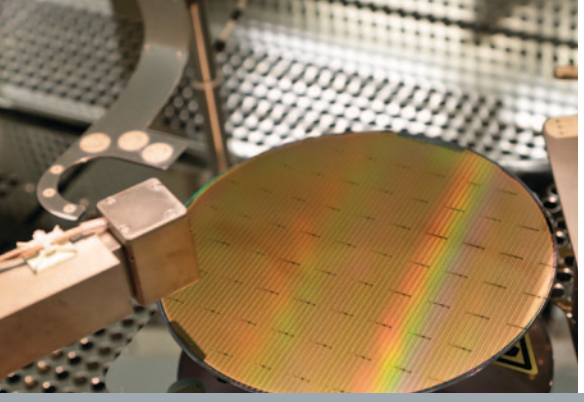
In "Vision 2035", TDK pledge to strive to achieve further innovation and create value for customers through the delivery of outstanding quality products and services, by utilizing the diverse global resources.

Based on this corporate motto, TDK will continue to "contribute to culture and industry through creativity", by revitalizing and protecting the global environment and creating a pleasant and safe society.

With the horizon of "Vision 2035", we envision business operations under the environmental load within natural circulation. According to this idea, the goal of "to halve the CO_2 emission basic-unit in a life-cycle perspective by 2035" has been formulated as "TDK Environmental Vision 2035".

This stance stems from the belief that minimizing the environmental load in business activities, and revitalizing the natural environment, is the duty of companies that supply products designed to contribute to its customers and the society. Moreover, modeled on the United Nations Climate Change Conference (COP 21) Paris Agreement, which seeks to curb global warming by achieving a balance between greenhouse gas emissions and absorption sources, this is also considered the ideal corporate posture for all TDK activities.

TDK Environmental Vision 2035



"Four billion Hall-effect sensors sold!"

In March 2016, Micronas was taken over by TDK Corporation. As a result, it was renamed TDK-Micronas and is now part of the TDK Sensor Systems Business Company. As an independent subsidiary of TDK, TDK-Micronas will continue to market its Hall-effect sensors and embedded motor controllers under the brand name Micronas.

TDK-Micronas will further expand the global TDK corporate strategy with regard to magnetic field sensors. The combination of the technological expertise of TDK and TDK-Micronas, especially in the area of magnetic field measurement, matches up perfectly with the demands of the automotive market: TDK-Micronas has wide-ranging know-how in the field of sensors and their integration with regard to Hall-effect sensors and embedded motor controllers, while TDK is specialized in magnetoresistance (MR) technology, particularly in sensors based on the (tunnel magnetoresistance (TMR) effect. The combined expertise will thus allow the development of innovative technologies, new products and creative solutions.

Through intelligent, top-quality sensor and actuator system solutions, TDK-Micronas supports the two megatrends of efficiency and environmental protection. For us, combining economic efficiency with sustainability is not a contradiction in terms, but a motivation.

Integrated into the chain of automotive suppliers, the products from TDK-Micronas have to meet the highest specifications on measuring accuracy and electromagnetic compatibility (EMC). For this reason, the HAC 37xy direct-angle sensor was developed, which on the one hand offers high angle measuring accuracy and, on the other, guarantees high EMC performance through the integrated blocking capacitors. The HAC 37xy sensor family allows angle measurements of up to 360° and path measurements of up to 40 mm through the use of two-pole rod magnets with a length of approx. 5 mm.

These new sensors are especially suitable for modular solutions without a circuit board in automotive applications, such as turbochargers, exhaust gas recirculation and throttle flaps. In these applications, both the efficiency and the system reliability are enhanced by the HAC 37xy. For such applications, these sensors offer a high level of flexibility through different output formats. The HAC 37xy sensors supply a linear, ratiometric analog output signal, PWM or SENT.

The HAC 37xy was developed especially for applications such as exhaust gas recirculation (EGR valve) and turbocharger actuators. With this new product, TDK-Micronas supports its customers in reducing fuel consumption and CO_2/NO_x emissions in vehicles.

Under the roof of the TDK group, TDK-Micronas has around 900 employees in Freiburg, where the Research and Development, Marketing, Production and Sales departments are located. This is one of the main strengths of TDK-Micronas, which develops and produces its semiconductor solutions under one roof.

Future-looking ideas from top engineers are implemented in the production plant, which is only a few meters away: In wafer manufacture and testing, and in assembly and final testing. TDK-Micronas operates worldwide and has branches all over the world.

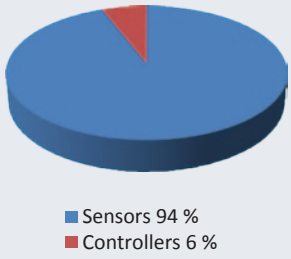
FACTS AND FIGURES

TDK in 2016:

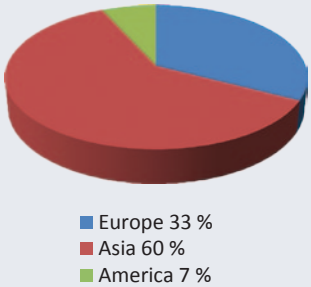
- Sales of USD 10.2 billion[1)]
- 92,000 employees worldwide

TDK-Micronas in 2016:

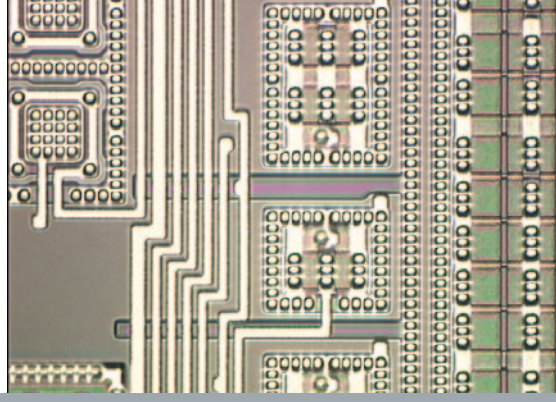
- Since March 2016, renamed TDK-Micronas GmbH, a company of the TDK-Group
- Operational Management and production in Freiburg (Germany).
- 928 employees worldwide, of which 822 are based at the operational headquarters in Freiburg.
- Test center in Glenrothes, Scotland, with 77 employees.
- Sales of EUR 145 million
- Take-over offer from TDK Corporation – Micronas will, as the sensor competence center, assume responsibility for magnetic field sensors within the combined company.
- Investments and ongoing expenses in the company's environmental protection facilities: EUR 1.7 million.
- Sales by products:



- Sales by markets:



[1)] TDK's financial year begins on April 1 and ends on March 31.



"Hundreds of single processes"

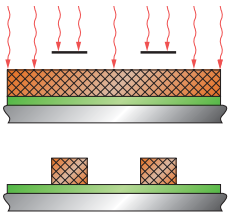
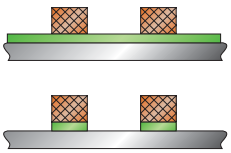
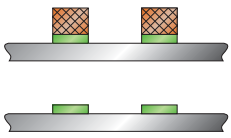
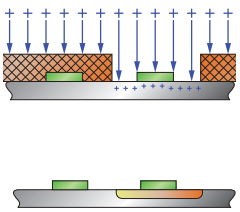
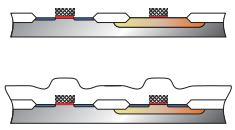
Production and Environment

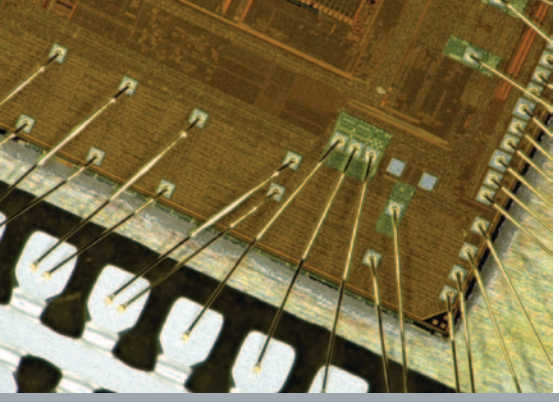
Just as complicated as the products themselves is the production process: Some 300 individual physical and chemical processes are required to produce the electronic circuits – or silicon chips – on an ultrapure, monocrystalline silicon wafer. The tiny structures measure less than 0.5 µm and are thus less than 1/100th of the diameter of a human hair. They can just about be detected in an optical microscope.

Frontend Processes

During the production process at Frontend which is explained in the table below, between 2,000 and 20,000 Hall sensors are, depending on the type of sensor, formed on a 200 mm wafer. Every Hall sensor has between 5,000 and 100,000 transistors, resistors, capacitors and diodes. The frontend processes take place in a clean room, which allows max. one particle larger than 0.5 µm in a cubic foot (35 ℓ) of clean air.

The first step involves scribing the wafers with a laser and subsequent cleaning. In a recurring sequence of coating, lithography, etching, implantation, cleaning and high-temperature treatment to create the structures and adjust the electronic properties of the active elements, the silicon chips are produced on the wafer.

Frontend processes	Main environmental impact	Remedial measures
 **Lithographic processes:** For the structuring of layers by photolithography, i.e. the transfer of structures from a photo mask to the photo resist on the wafer	Use of solvent-based photo resists and developers, plus the formation of resist residues and spent solvent mixtures	Environmentally relevant photo chemicals have been replaced by less hazardous ones. Photochemical residues and spent solvent mixtures are sent for energy recovery. Solvent vapors are conveyed to a waste air treatment plant.
 **Dry etching processes:** To transfer photo resist structures to the oxide and metal layers beneath by etching	Use of combustible, corrosive, toxic and environmentally hazardous process gases, emissions of gases with high greenhouse gas potential and formation of waste gases.	The volume of process gas has been reduced by making improvements to the process control. Exhaust gases are conveyed to a waste air treatment plant.
 **Cleaning processes:** For wet-chemical cleaning the wafer surface and remove the resist **Wet chemical etching processes:** To transfer photo resist structures the layers beneath	Use of hazardous substances, i.e. acids, alkalis, special chemicals, solvents and the formation of spent chemical and solvent mixtures.	The use of chemicals has been reduced by making improvements to the process control and by introducing an automatic, accurately controlled dosage system. Hazardous chemicals have been replaced by non-hazardous ones. Spent chemicals are recycled or reused. Chemical vapors are conveyed to a waste air treatment plant.
 **Ion implantation processes:** For doping certain areas with foreign atoms such as arsenic **High-temperature processes:** For the production of extremely pure oxide and doped layers to adjust the electronic properties of the transistors	Use of flammable gases and small quantities of toxic gases, plus formation of waste gases.	Safety gas cylinders are used for toxic gases. Exhaust gases are conveyed to a waste air treatment plant.
 **Coating processes:** For the deposition of insulating oxide and conductive metal layers	Use of flammable, corrosive, toxic and environmentally hazardous process gases, emissions of gases with high greenhouse gas potential and formation of waste gases.	The volume of process gas has been reduced by making improvements to the process control. Exhaust gases are conveyed to a waste air treatment plant.



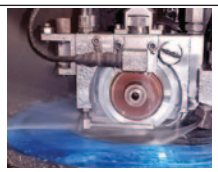
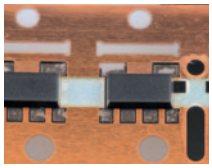
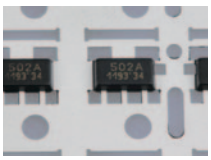
"Processes, Impact, Action"

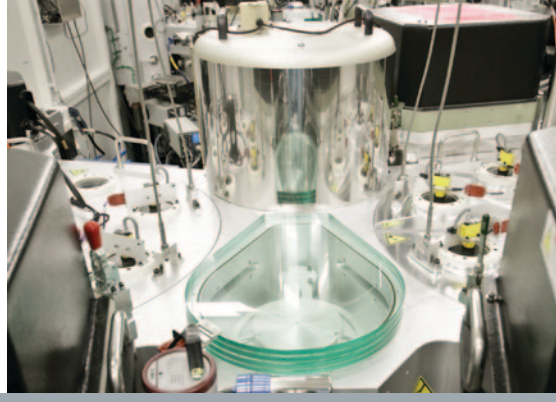
Backend Processes

From the waferfab, the wafers are delivered to Backend and tested. There, the output measurement of the waferfab is the electrical parameter test on test structures on every wafer. At the chip assembly stage, the wafers are first sawn into individual chips. These are bonded to a copper leadframe, and the electrical contacts of the chip are connected to the leadframe by means of a 25 µm thick gold wire. Subsequently, the chips are encapsulated by a compression molding compound and the copper leadframes tinplated in a galvanizing process. Finally, the outer electrical copper contacts coated with tin are shaped in line with the standard specifications. After checking the electrical functions during final measurement, the products are packed ready for dispatch. The weight of a Hall sensor is, depending on the type of housing, typically between 34 mg and 230 mg.

Supply of the Production Area

In the recent past, a number of successful projects have been carried out in the field of media and energy supply. In order to increase the availability of resources and reduce CO_2 emissions, the cogeneration unit has been in operation for three years. Energy was saved, e.g. through more efficient cold generation with turbo-cooling units combined with a refrigerating plant network and the installation of frequency inverters in pumps.

Backend processes		Main environmental impact	Remedial measures
	**Parameter and probe test of the chips: All chips on the wafer are tested for their proper functioning.**	Electricity consumption	Implementation of various electricity saving projects.
	**Grinding / sawing of the wafers: The wafers are ground to a final thickness and then sawn up into individual chips in fully automatic precision units.**	Use of water and formation of waste water	In water supply for production, reduction of water usage through efficient steering of the water/effluent flows in the 5-step waste water treatment plant and through the use of reclaim water e.g. in recooling plants.
	**Contacting (bonding): The individual chips are bonded to a copper leadframe (die bonding), the electrical contacts of the chip are contacted to the copper leadframe by means of a thin gold wire (wire bonding).**	Electricity consumption, use of gold wire	Use is made of the latest bonding technology with lower electricity consumption per chip. Various electricity saving projects are being implemented.
	**Molding: The chips are encapsulated on the copper leadframe with a molding compound to protect them from environmental influences during use.**	Use of molding compounds plus generation of dust and plastic scrap	Molding compounds are fed to the compression molding tools free of dust. Filtered dust is conveyed for special external waste treatment. Use of "green" molding compounds is being continuously increased. Waste of mold compound is sent to energy recovery. Saving of reusable materials and electricity through the deployment of new cleaning agents.
	**Galvanizing: The copper leadframe with the chips is coated with tin so that the products can be soldered by the customer.**	Use of hazardous substances and production of galvanic waste water, production of waste metal	In the galvanizing units, metals are deposited electrolytically from the working solutions. Metals from the galvanic rinse water are precipitated in the central waste water treatment unit. Metal waste from working solutions and rinse water is recycled. Galvanic solutions are either treated in the central waste water treatment plant or disposed of externally.
	**Forming, final testing, packaging: The external electrical contacts are formed, the products measured and packed.**	Production of plastic scrap, electricity consumption	Trays are cleaned and reused. Packaging waste is sent to energy recovery. Various electricity and energy saving projects being implemented.



"All demands met"

Environmental Management

Environmental and Safety Officers of TDK-Micronas

TDK-Micronas has for many years had environmental and safety standards in place that go well beyond those required to comply with the relevant legislation. In the year 2000, an environmental management system was introduced at the central TDK-Micronas development and production site in Freiburg. As well as corporate environmental protection, the system also covers the fields of industrial safety and fire protection and is referred to in short as the "ESF System".

The key aspects of the system are compliance with statutory requirements, a process of continuous improvement, preventive and defensive fire protection, and the implementation of risk analyses and hazard assessments in all sectors of the Freiburg site. Since 2002, the TDK-Micronas test center in Glenrothes, Scotland (TDK-Micronas Ltd., 77 employees) has also had its own system for corporate environmental protection, based on the ESF. Both systems are certified to the international ISO 14001 standard, while the ESF Management System in Freiburg also meets the approval of the European EMAS regulation[1)] (Eco-Management and Audit Scheme).

The main elements of the ESF Management System to ISO 14001/EMAS are described below in more detail.

The management has defined the TDK-Micronas environmental policy in its Principles of Action. The ESF organization currently comprises

- four full-time ESF staff, including the Environmental Management Officers,
- 23 environmental and safety compliance officers,
- 24 members of the internal emergency response team,
- 21 safety officers,
- 49 company paramedics and
- 62 responsible officers on duty in all areas of production.

The staff are given regular trainings, internally or externally, according to their respective function in the ESF system. In Glenrothes in Scotland, the Quality and Environmental Management Officer, backed by a team of 18 colleagues, is responsible for the "Integrated Management System for Environmental Protection, Health, Safety and Quality".

The elements of the ESF Management System are described in the ESF handbook and also in the relevant process instructions and standard operating procedures, and can be referred to on the Intranet by all the employees. They constitute the rules for compliance with the company's environmental policy.

TDK-Micronas operates a process that ensures that all legal obligations and customer requirements are adhered to. Foreseeable developments in environmental protection and in legislation are channeled into planning at an early stage. All environmental and safety officers, managerial staff and plant managers are actively involved in this process. TDK-Micronas cooperates in full with the regulatory authorities. All the necessary licenses and approvals have been obtained and two applications according to the Bundes-Imissionsschutzgesetz (Federal Immission Control Act) are currently in the approval process. This offers not only legal certainty but also pays off economically. It avoids extra costs caused by late reactions, and also enhances the trust and confidence of TDK-Micronas stakeholders, in other words, the employees, customers, suppliers, regulatory authorities, risk insurers, site neighbors and the general public, and, of course, the parent company TDK.

As part of the process of setting its environmental targets, TDK-Micronas first evaluates the relative importance of direct and indirect environmental aspects. Direct environmental aspects are, for example, the CO_2 emissions resulting from the consumption of electrical and fossil energy, or from chemical consumption. Indirect environmental aspects are, for example, product life cycle-related aspects (design, development, packaging, transport, use and reuse/disposal of waste), the environmental contribution of suppliers or emissions of commuters. After this, an assessment is made of the extent to which the main environment aspects can be influenced through the execution of environmental projects to reduce consumption and/or emissions. The list of the environmental projects can be found on page 10.

One of the most important ways to ensure transparent internal and external communications is the regular publication of the Environmental *Statement* and Environmental *News*, in which we document the company's environmental performance. Environmental management is not a one-off effort, but a continuous objective, because the conformity of the system is monitored every year by an independent auditor. Apart from that, regular internal audits are also carried out to ensure that the procedures defined in the ESF system are being adhered to.

[1)] Regulation (EC) No 1221/2009 on the voluntary participation by organizations in a Community eco-management and audit scheme.

PRINCIPLES OF ACTION

Relating to Environmental Protection, Industrial Safety, Fire protection (ESF) and Energy

Statutory Basic Conditions

We are committed to compliance with all applicable environmental energy and industrial safety legislation. In order to achieve this commitment, an effective internal and external system of approval management, risk analysis, and emergency precautions is implemented and developed. Our primary goal is to prevent and avoid environmental impacts and safety risks during normal operation, and in the event of an emergency, rather than limiting effects and/ or damage.

Motivated, Responsible and Competent Personnel

For efficient environmental protection, we need motivated and environmentally aware employees, with management providing a good example. By encouraging open communication, our employees are informed about all projects and activities in relation to both our local environmental management system and corporate environmental protection. Moreover, extensive training for our employees in environmental protection, industrial safety and fire protection is performed regularly.

Clear Structures

With clearly defined responsibilities and processes for all activities related to the environment, and the health and safety of employees, we have created the infrastructure for efficient and effective environmental protection, industrial safety and fire protection and development. In this context, we attach special value to interdisciplinary teamwork.

Availability of Information and Resources

We ensure that the information and resources of the environmental, safety and energy management, which are necessary to achieve the strategic and operative targets, are available.

Principle of "Sustainability"

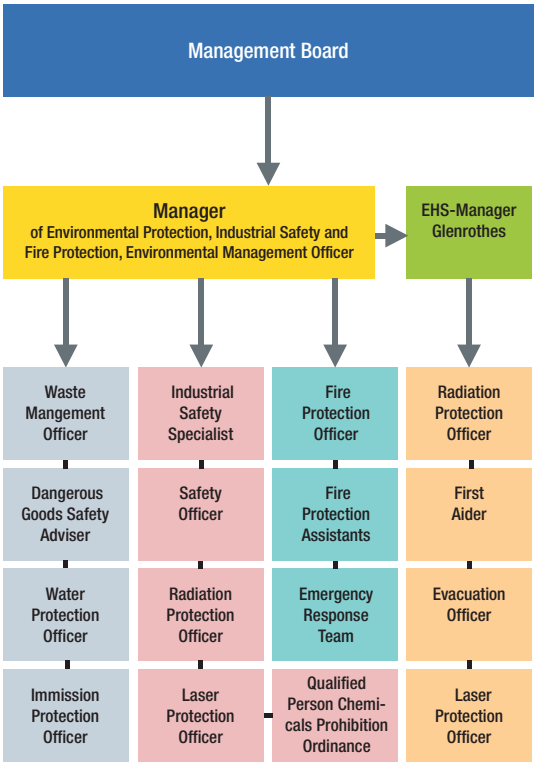
In assuming its responsibility for future generations, Micronas regards avoidance or minimization of environmental pollution as the top priority. This requires making optimum use of the resources we consume, such as materials and energy. This applies to all the phases of our product lifecycles we are able to influence, including processes within the company, and requires a forward-looking assessment of potential environmental impacts in all cases.

Cooperative Dealings with our Interest Groups

We take precautions to ensure that all contractors working on our factory site comply with our environmental and safety standards. In cooperation with our suppliers, we explicitly encourage them to implement the same environmental standards as Micronas. Furthermore, we advise our customers regarding all the environmentally relevant characteristics of our products. As a matter of course, we also promote close cooperation with authorities, and conduct a dialog with interested members of the public. We communicate openly our environmental and energy policy, the environmental impacts from our company and the environmental and energy performance.

Continuous Monitoring and Effectiveness Control

We regularly perform system audits to ensure the continued development and monitor the effectiveness of our ESF and energy management system. Any deviation from these principles or goals results in the immediate application and monitoring of appropriate corrective action. We regularly collect, record and evaluate environmental and energy-related indicators, in order to monitor our environmental and energy performance to achieve our set targets through measures for continuous improvement. We make sure we acquire efficient products and services that contribute to the conservation of resources and the improvement of our energy-related performance.



EMAS Freiburg

ISO 14001 Freiburg

Fire Prevention Certificate (SISTA) Freiburg

ISO 14001 Glenrothes

Overview of current and planned environmental projects

Environmental Projects

Subject	Goal	Measure	Department responsible	2016	2017
Waste management	Reduce the amount of spent acids for disposal	Elimination of spent acids in the event of a production stoppage	Waferfab	●	●
	Reduce the metal concentration in the waste water, enhance process safety and maintain constantly low metal concentration	Optimization of electro-chemical metal removal	Electroplating	●	
Energy management	Electricity savings of approx. 35,000 kWh / year (6 t CO_2 / year)	Heating of exhaust air pump lines from CVD process plants with hot nitrogen instead of with heating sleeves	Waterfab	●	
	Electricity savings of approx. 10,000 kWh / year (2 t CO_2 / year)	Electricity savings through relocation of hazardous substances in the warehouse and optimization of the electric power consumption of the fan	Plant Engineering and Facilities	○	○
	Electricity savings of approx. 10,000 kWh / year (2 t CO_2 / year)	Switch to LED technology in all buildings		●	●
	Natural gas and electricity savings of approx. 400,000 kWh / year (76 t CO_2 per year)	Renovation of office buildings 9 and 12			●
Resource management	Annual savings of approx. 14 t chemicals, 385 m^3 water, 500,000 kWh electricity and natural gas (62 t CO_2)	Replacement of immersion tanks by spray cleaners	Waferfab		●
	Savings of approx. 25,000 m^3 municipal water / year	Removal, use and infiltration of groundwater for cooling purposes	Plant Engineering and Facilities		●
Fire prevention	Obtain SISTA fire protection certificate from the damage insurer for the high quality of the safety measures to meet insurance requirements	Continuous improvement in preventive and organizational fire prevention, regular fire protection audits by damage insurer	Plant Engineering and Facilities Environmental Protection, Occupational Safety and Fire Protection	●	
Legal certainty	Implementation of a legally secure and standardized archive of documents (e.g. operating permits)	Configuration of a filing system in the archives of the operating area, subsequently archiving of valid documents	IT Operations Environmental Protection, Occupational Safety and Fire Protection	●	
	Daily updating of total quantity of all hazardous substances in the production area of TDK-Micronas, dependent on the hazardous properties	Utilisation of SAP booking data, definition of static quantities of hazardous substances in stores, allocations and production areas in SAP and daily configuration and easy-to-understand representation in a business intelligence software		●	
Health protection	Improve the health of the employees	Health campaigns: Offer measurements on various functional diagnostics (e.g. balance check, vein function) on one campaign day	Working group on health protection	●	
		New offer: Mediation in conflicts		●	
		Health campaigns: Participation in the "Industry bikers in the north industrial zone", Course on successfully losing weight, Tips on mindfulness training			●

Key: ● Implementation ○ Extension ● Completed, goal achieved

Raw materials from hazardous and non-hazardous waste

Waste Management

Large volumes of chemicals are used every year for the production of integrated circuits (see also diagrams on page 13). After production, we are left with spent chemicals and waste, which means that an important part of environmental protection is the intermediate storage and disposal of these materials.

For many years now, two company employees have been responsible for this field: Ralf Schäfer, head of the Waste Management department, and Peter Hess, Waste Management Officer and Dangerous Goods Safety Advisor. They work hand in hand and have a full insight into the production processes and the chemicals used there. Julian Wegener, who joined us three years ago in the Occupational Safety and Environmental Protection department, is Dangerous Goods Safety Advisor and is also deputy Waste Management Officer.

Ralf Schäfer ensures that waste is transported to and stored safely in the intermediate waste storage area. Peter Hess is in charge of making sure that the many legal regulations are adhered to. The entire "waste management team" is pictured in Fig. 1.

Fig. 1: Waste management team, from left to right: P. Hess, W. Streitberg, R. Schäfer, S. Vonderstraß, J. Wegener

Together with the "internal waste producers", their aim is to prevent, wherever possible, waste from being produced in the first place, to ensure that the waste that is produced is stored safely, to train the involved employees how to handle the waste safely and to bring back used chemicals and waste into the loop.

At present, there are 40 fractions of hazardous waste and 27 fractions of non-hazardous waste being produced on the company's production site. The main fractions and their respective tonnages are shown in the diagrams on page 15. In 2016, all acids were recycled. Standardization to the annual gross value added fluctuated by around ±10 %. If, however, the volume of waste is related to the manufactured silicon surface area, the quantity of hazardous and non-hazardous waste has declined since 2013 by 21% and 20% respectively.

That ecology and economy often go hand in hand is well enough known, and is also reflected in the German Kreislaufwirtschaftsgesetz (law on waste and recycling management), which states five measures for avoiding and managing waste in order of priority. TDK-Micronas sticks to them wherever expedient.

They are:

1. Avoidance,
2. Preparation for reuse,
3. Recycling,
4. Other forms of reutilization, especially energy recycling and landfilling,
5. Disposal

The process engineers responsible have carried out a number of successful projects in the last few years. In line with the substitution requirement in the German Gefahrstoffverordnung (law on hazardous substances), they have replaced several hazardous chemicals with non-hazardous ones. Furthermore, they have improved process formulations to avoid and reduce the use of chemicals. This reduces not only procurement costs but also disposal costs.

Recycling also saves costs by, for example in the use of spent mixed acid to regulate the pH in the neutralization facility, which prevents the purchase of acid for this purpose. For the recycling of wood, plastics and metals, for example, costs are reduced or income can be accrued.

The energy recycling of solvents and mold compound waste also has the advantage that the recycling costs are below the disposal costs.

At the end of the day, since 2016, only 0.7% of all waste cannot be sent for recycling and therefore has to be disposed of. This is shown in Fig. 2.

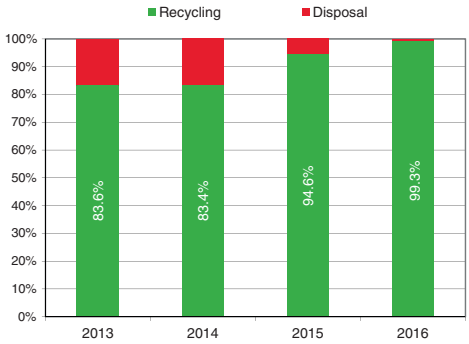
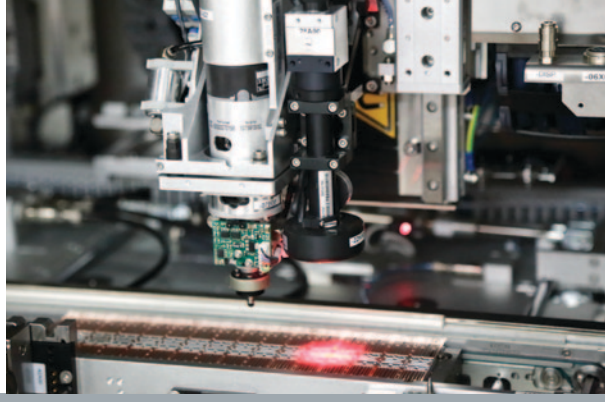


Fig. 2: Increase in the proportion of waste being recycled (% by weight) over the last four years.

Julian Wegener ensures that all waste is transported safely for recycling or, if necessary, for disposal. All hazardous material freights are controlled, and there were no complaints about any of the 95 transport assignments in 2016.

Because TDK-Micronas is responsible for the waste from its initial production to its final disposal, the waste management officers recurringly carry out audits at disposal specialists. The last such audit was made in 2016.



Environmental Data 2016

Environmental Data 2016

As part of the process of defining environmental targets, TDK-Micronas has evaluated the relative importance of possible direct and indirect environmental impacts / influences.

Direct environmental impacts

Important direct environmental influences are:

- CO_2 emissions from the consumption of electricity, fossil energy sources and PFC[1)] gases,
- the consumption of process chemicals and, connected with this, the resultant production of hazardous spent acids

TDK-Micronas strives, as part of its continuous improvement process, to reduce the impact of these environmental effects. The environmental data for 2016 for the Freiburg site are given below. With these key figures, we comply with the requirements of the EMAS regulation. This report covers both the absolute consumption figures and the consumption figures standardized to the total gross value added. These core indicators are related to the year 2016. Standardization to the total gross value added over the last four years provides the required comparability of the consumption data.

Energy efficiency

The consumption of electricity and fossil energy resources – almost exclusively natural gas – together represent the core indicator "energy efficiency".

In 2016, just under 40% of the electricity for inhouse consumption was generated by the cogeneration unit for combined heating, cooling and power generation built in 2014. The rest was purchased from the local power supplier, Badenova. The primary energy factor, the CO_2 emission factor of the purchased power and the proportion of renewable energies in TDK-Micronas' total energy consumption are calculated from the legally required annual electricity labeling of the power supplier. However, because the electricity labeling for the year 2016 is not published until November 2016, the primary energy factor, the CO_2 factor as well as the proportion of renewable energies are not available. In order to nevertheless be able to calculate the core indicators, it is assumed that the consumption figures do not change significantly from one year to the next so that it would appear legitimate to base the calculation for the 2016 figures on the primary energy factor and CO_2 emission factor from 2015, and in the same way for the previous years.

In the period from 2014 to 2016, energy efficiency projects were carried out that led to savings of approx. 700,000 kWh of electricity or 150 t of CO_2 a year. The cogeneration unit for combined heating, cooling and power generation built in 2014 alone results in a reduction in CO_2 emissions of approx. 6,000 t/year, if the emission factor of the German electricity mix is taken as the basis.

The photovoltaic unit installed in 2011 supplied just under 240,000 kWh in 2016, saving around 135 t of CO_2 emissions.

Material efficiency

The consumption of chemicals and process gases constitutes the core indicator "material efficiency". Chemical consumption is made up of process chemicals for production and chemicals for water treatment and waste water treatment. In the past, chemicals were saved by optimizing recipes for wet or dry-chemical processes. At the same time, hazardous substances were substituted by non-hazardous substances. Here, however, the processes have reached a level of maturity that can no longer be significantly improved. One highly promising project is the introduction of spray cleaner for cleaning the silicon wafers, which can replace immersion processes and thus save electricity, ultra-pure water and chemicals.

Water efficiency

Municipal water is used for the production of ultra-pure water for production, for sanitary and cooling purposes, and in waste air water scrubbers. To reduce water consumption and use the water more efficiently, increasing use has been made in recent years of reclaim water. Reclaim water is very slightly contaminated rinse water from process equipments and waste water from the ultra-pure water treatment plants. The rinse water is collected and reused in process cycles where less stringent demands are made on water quality. Water can also be reclaimed and recycled via optimized steering of the water/waste water flows in the ultra-pure water treatment systems.

One large project involves the removal, utilization and infiltration of groundwater for cooling purposes. Here, the groundwater is conveyed to a heat exchanger in order to pre-cool the reclaim water used for cooling purposes. The aim of the project is to increase the efficiency of the reclaim water cooling performance and save municipal water that was previously additionally used for pre-cooling purposes in the summer months. The project is currently in the approval phase with the supervisory authorities.

Emissions

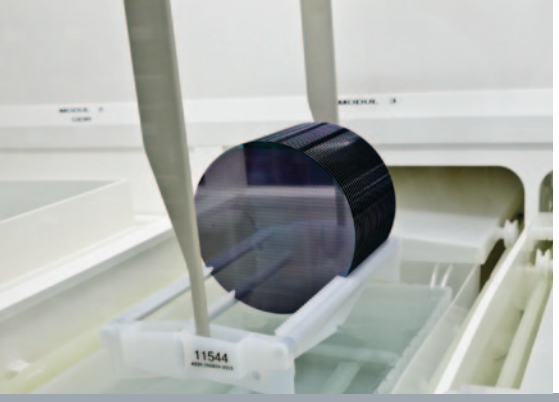
The core indicator "emissions" is, according to EMAS, made up of two parts. Total annual "emissions into the air" from 2013 to 2016 increased, because of the higher gas consumption due to the cogeneration unit, from 39 kg to 99 kg sulfur dioxide (SO_2), from 2,200 kg to 5,500 kg nitrogen oxides (NO_x) and from 27 kg to 68 kg dust. Because of the low quantities involved, standardization to the total gross value added was dispensed with.

Total annual "emissions of greenhouse gases" is calculated from the consumption of electricity, fossil energy sources and the emission of PFC gases[1)]. The proportion of CO_2 emissions caused by electricity consumption varies heavily with the relevant CO_2 factor of the purchased electricity. In recent years this has fluctuated between 123 and 215 g/kWh and was thus well below the German average of over 500 g/kWh. Greenhouse gas emissions of methane (CH_4) and dinitrogen monoxide (N_2O) are negligible.

Biodiversity

The core indicator "biodiversity" refers to the land use, expressed in square meters of built area. In 2016, the figure was approx. 12,300 m^2, which is nearly 25% of the site area.

[1)] Perfluorinated compounds are perfluorinated carbon compounds such as tetrafluoromethane (CF_4) and hexafluoroethane (C_2F_6) but also nitrogen trifluoride (NF_3) and sulfur hexafluoride (SF_6) with a high greenhouse gas potential used in semiconductor manufacture as process and cleaning gases.

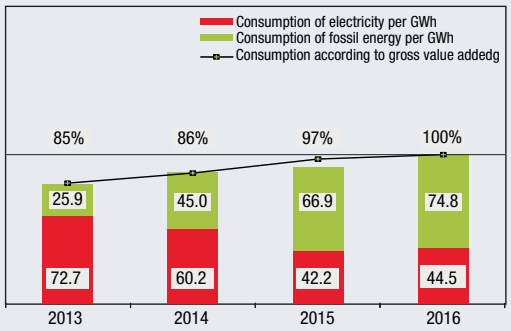


Environmental Data 2016

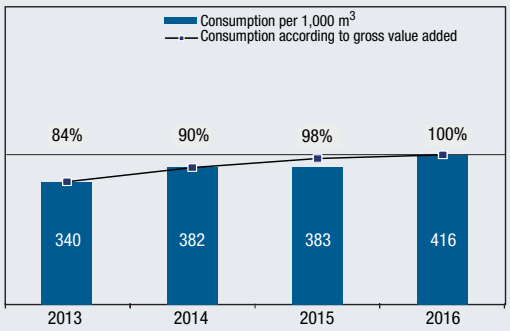
TDK-MICRONAS FREIBURG

Absolute consumption resp. CO_2 emissions
Consumption resp. CO_2 emissions referring to the gross value added in %, normalized to the year 2016

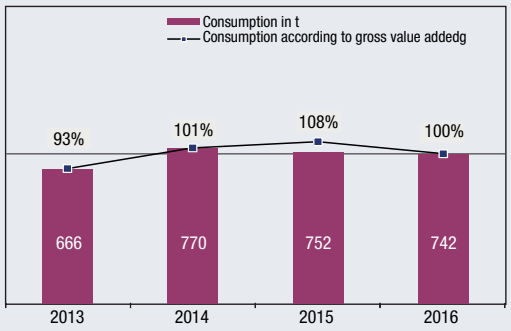
Consumption of electricity and fossil energy sources, taking into account the respective primary energy factor.



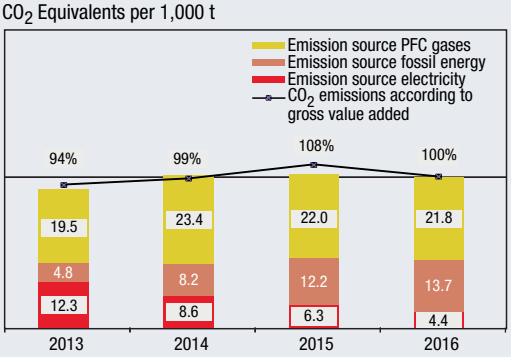
Water



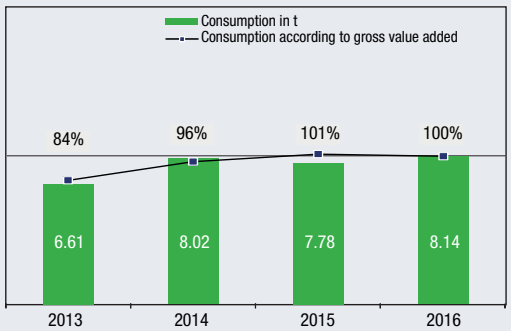
Chemicals



CO_2 Equivalents per 1,000 t



Process Gases



Operation of the cogeneration unit from mid-2014 leads to higher CO_2 emissions with gas and lower emissions with electricity .

Year	Total energy consumption in GWh (without primary energy consumption)	of which from renewable sources (proportion of total energy consumption)
2013	80.7	37.7 (47%)
2014	90.6	36.5 (40%)
2015	95.6	25.4 (27%)
2016	103.7	24.7 (24%)

Direct Environmental Impacts at Glenrothes

Before delivery, a functional test is run on the finished chips – a large proportion in the Test Center in Glenrothes. The test equipment uses electricity, i.e. the most significant direct environmental impact is energy consumption and the associated CO_2 emissions.

Key Figures 2016:

- Energy consumption: 2.7 GWh electricity (corresponding to 1,321 t CO_2)
- Main waste fractions: 3.7 t paper, cardboard, 2.5 t plastic waste and 10.5 t metal scrap for recycling; 1.5 t plastic waste and 3.5 t household-type commercial waste for disposal
- Notifiable accidents: none

Investment and current expenses in corporate environmental protection (waste management, water protection, soil decontamination, noise reduction, air pollution control, climate protection, nature protection, landscape conservation and energy production and control) in Freiburg.

	Million Euro
2013	1.4
2014	5.8
2015	1.6
2016	1.7

Environmental Data 2016

Non-used areas are – wherever possible – left to their own devices. As a result, the wild fields and meadows that become quickly overgrown with grasses and flowers offer new habitats to insects like bees and butterflies. A small garden has also been laid out with various herbs and other useful plants.

Waste

In terms of waste legislation, the core indicator "waste" consists of both hazardous and non-hazardous waste. More than 90% of the hazardous waste is made up of acids and solvents, of which a large proportion is recycled. For this reason, the saving in chemical consumption also leads to a similar reduction in hazardous waste. The recycling rate for hazardous and non-hazardous waste rose in the years from 2013 to 2016 to 99.3%, because, since 2015, the spent hydrofluoric acid can be sent for material recycling.

Production yield

Another important contribution to improving all core indicators is made by raising the production yield. The yield is an important statistic in the semiconductor industry. The fewer chips on a wafer that subsequently fail due to defects, the fewer wafers have to be started in the Waferfab, and the less electricity, media, materials etc. must be used in total. In turn, less waste has to be disposed of. This applies to the same extent to the production yields in Assembly and Test. Projects put in place with the aim of raising yields are at the same time environmental projects for improving the core indicators.

Indirect environmental impacts

The main indirect environmental factor is the application of our products by our customers. Sensors from TDK-Micronas enable reduced fuel consumption e.g. in electric power steering (EPS), electronic throttle control (ETC), the automatic grille module (AGM) and the electricity sensor in vehicle start/stop systems.

We endeavor to ensure that the suppliers of materials that are used in our products or exert an influence on the quality, such as process gases and chemicals, have an environmental management system in place. At TDK-Micronas, 90% of all material suppliers have a certified environmental management system installed.

Another indirect aspect which is repeatedly evaluated as part of the environmental management system is that of due diligence in the procurement of conflict minerals (gold, tungsten, tin, tantalum) with the aim of ensuring that no raw materials are used that help to finance the armed conflict in the Democratic Republic of the Congo or a neighboring country. TDK-Micronas needs gold, tungsten and tin to manufacture its products and has obtained confirmation from its suppliers that the purchased metals stem from certified smelting works. The European Union is preparing a Regulation that could introduce a reporting and self-certification obligation for smelting works and refineries.

The following section describes the achievements in the fields of industrial safety and fire protection.

Industrial safety

The approval process for new plants and reconstruction projects guarantees that the environmental and safety officers and staff of the Plant Engineering and Facilities department are also involved in the planning at an early stage. Following installation and before final approval, hazard assessments are performed at the various workplaces. Where workplaces involve contact with hazardous substances, operating procedures are drawn up in accordance with the regulations on hazardous substances. These provide the supervisor with an instruction document for the employees. Trained staff and officers regularly carry out inspections to ensure that the legal requirements are being adhered to, and, if necessary, derive corrective measures to be implemented by the persons responsible. Hazardous substances at TDK-Micronas are divided into various storage classes according to their physical and chemical properties, and stored separately. All store rooms and chemical supply plant rooms are equipped with modern water-safety devices to avoid chemical release – e.g. with twin-wall pipes, catch basins, and leakage sensors. At TDK-Micronas in Freiburg, the accident figures are well below the comparable index of the Employers' Liability Insurance Association. In 2016, there was one minor reportable accident.

Fire protection

Because the fire protection officer is a member of the approval management team, he must be informed early of any new facilities and rebuilding measures. He defines the protective targets after previous analysis of the buildings and surrounding area in agreement with the risk insurer and, if necessary, with the regulatory authority. He adapts the organization of the fire protection facilities and escape routes, and monitors the implementation of the fire protection systems as far as the equipment and construction work is concerned. Finally, he updates the technical documentation and the regular testing schedules.

Emergency protection

Despite all the previously described preventive measures, emergencies can still arise, the effects of which have to be kept to a minimum. In an emergency – e.g. smoke or fumes – a smoke detector automatically sends an alarm to the emergency call center, where two watchmen are on duty, 24/7. They immediately alert the investigation team in line with the alarm plan and, if necessary, notify the emergency task force, which then puts the required emergency measures into place. Part of the task force is the internal emergency response team, which also includes trained firefighters. The head of the emergency response team regularly organizes exercises in realistic scenarios (e.g. smoke, leakage of hazardous gases and liquids). The safety officer on duty then takes charge of the operation and deals with the emergency together with members of the emergency response team and the company paramedics.

The fire protection concept and the emergency plans also include alerting the Freiburg fire department in critical emergency situations. Once the fire department has received an alarm, it can be on the TDK-Micronas factory site within a few minutes. As in the past, further detailed tours of

the site will be arranged with members of the Freiburg fire department so that they can obtain a better picture of the main hazard areas and the type of incidents that could occur.

As a matter of course, all alarm exercise and alarm incidents are subsequently evaluated to identify any weak points, take corrective measures and continuously improve.

Training measures

In addition to the legally prescribed training, such as training at the workplace, instruction of external employees and the handling of hazardous substances, regular training is also carried out on the hazardous properties, toxicology and handling of chemicals and gases as well as suitable protective measures. Every year, as part of the emergency planning, training is given to the safety officers on duty in all production areas. Delegated officers take part regularly in courses to update their knowledge and to obtain qualifications relating to industrial safety, fire protection, immission control and water protection.

TDK-Micronas Technology Park

In the last few years, the TDK-Micronas site has developed into a technology park with nine external companies renting facilities to perform research, development and production in various fields. There are a number of synergies here because all firms require similar infrastructures – infrastructures that TDK-Micronas maintains and offers to outside companies. TDK-Micronas has signed an agreement with all these companies on aspects of environmental protection, industrial safety and fire protection. This so-called ESF agreement defines the responsibilities of both TDK-Micronas and the external companies in matters of e.g. personal and building protection, receipt of hazardous substances, and waste disposal, and defines the interfaces of processing plants with incoming and outgoing products and materials. The outside companies are integrated into the TDK-Micronas fire protection concept and emergency plan.

Health protection

The working group for health protection, which comprises members of the company's medical service, the works council, the HR department and industrial safety, carries out projects to encourage health care.

Consultation services are offered on vaccination, giving up smoking, diet, hygiene, skin care and skin protection, difficult situations, health days, and health insurance schemes.

Support for sport and social activities include running groups, mountain biking, regular health activities such as massage, yoga, shiatsu, muscle development, and a portal for leisure activities.

Travel to work has also been tackled with environmentally friendly solutions:

- the rail/bus network timetables have been regularly made available to company employees since 1991 in a campaign to promote environmentally friendly travel
- the "Regiocard" is an annual ticket for use on all public transport in the region, subsidized by the employer
- car-share / ride-share system
- JobRad – bike, Pedelec or E-bike leasing system subsidized by the employer

The company's health-care service is available on working days and Saturdays. Other projects organized by the working group are described on page 10.

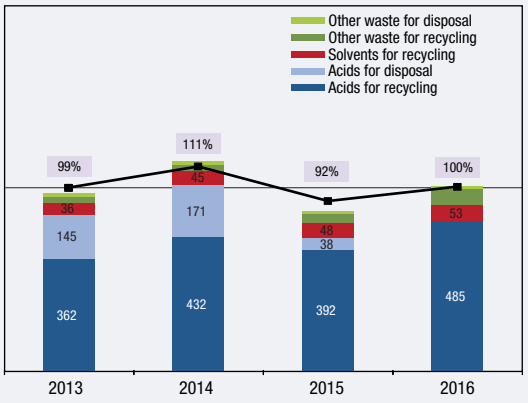
Environmental Data 2016

WASTE

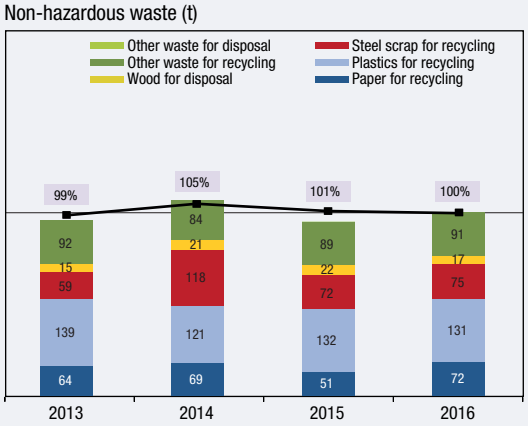
Waste in t

Waste referring to gross value added in %, normalized to the year 2016

Hazardous waste (t)



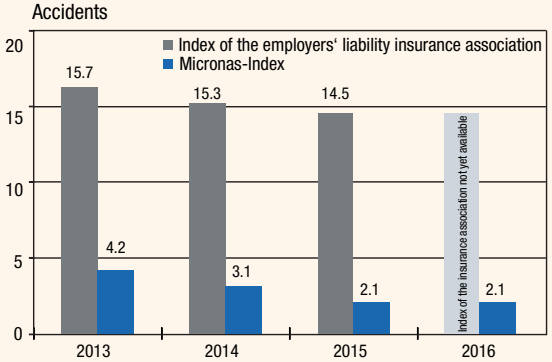
Non-hazardous waste (t)



ACCIDENTS

Notifiable accidents per 1,000 employees

Accidents



EMAS
GEPRÜFTES
UMWELTMANAGEMENT
DE-126-00053

Environmental Statement

The next consolidated Environmental Statement will be submitted for validation at the latest in July 2020. The next updated Environmental News will be submitted for validation in July 2018.

Environmental Verifier

Dr.-Ing. R. Beer (Permit no. DE-V-0007)
Intechnica Cert GmbH (Permit no. DE-V-0279)
Ostendstr. 181
90482 Nuremberg, Germany

Validation

Dr. Reiner Beer, with EMAS environmental verifier registration number DE-V-0007, accredited or licensed for the scope 26.1 (NACE Code Rev. 2), Manufacture of electronic components and boards, declares to have verified whether the site as indicated in the consolidated environmental statement with registration number D-126-00053 meets all requirements of Regulation (EC) No 1221/2009 of the European Parliament and of the Council of 25 November 2009 on the voluntary participation by organizations in a Community eco-management and audit scheme (EMAS).

By signing this declaration, I declare that:

- the verification and validation has been carried out in full compliance with the requirements of Regulation (EC) No 1221/2009,
- the outcome of the verification and validation confirms that there is no evidence of non-compliance with applicable legal requirements relating to the environment,
- the data and information of the consolidated environmental statement of the site reflect a reliable, credible and correct image of the site activities, within the scope mentioned in the environmental statement.

Nuremberg, July 2017

Dr. Reiner Beer, Environmental Expert

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