

**Ordinance
on Vocational Education and Training in the Occupation of Microtechnologist¹
promulgated on 6 March 1998**

Whereas by reason of § 25 Paragraph 1 of the Vocational Training Act of 14 August 1969 (Federal Law Gazette, BGBl., I p. 1112) as amended by Article 35 of the Ordinance promulgated on 21 September 1997 (Federal Law Gazette, BGBl., I p. 2390) and in conjunction with the Federal Ministry for Education, Science, Research and Technology, the Federal Ministry of Economics and Labour does decree:

§ 1

State recognition of the training occupation

The training occupation of Microtechnologist is accorded state recognition.

§ 2

Duration of training

Duration of training is three years.

§ 3

Training profile

The following skills and knowledge shall constitute the minimum object of the vocational education and training:

1. VET, employment and collective wage agreement law,
2. Structure and organisation of the company providing training,
3. Health and safety at work,
4. Environmental protection
5. The use of technical documentation,
6. Planning and organising of work,
7. Documenting work, operation of data processing equipment, data protection
8. Quality management,
9. Provision and disposal of work materials,
10. Securing and testing of clean room conditions,
11. Retrofitting, testing and preventative maintenance of production facilities,
12. Adjusting of process parameters,
13. Optimising of the production process,
14. Manufacturing and assembly processes,
15. Process monitoring tests,
16. Conducting of final tests,
17. Securing of process procedures within the area of deployment.

§ 4

General training plan

(1) Due consideration shall be accorded to the main focus areas of “semiconductor technology” and “micro-systems technology” in imparting the skills and knowledge pursuant to § 3 in accordance with the instructions contained within the Annex in respect of the content and time structure of the vocational education and training (general training plan). Content and time structure of training content which deviates from that contained within the general training plan is permitted in particular to the extent to which specific company practices necessitate such a deviation.

¹ The present Statutory Ordinance constitutes a training regulation within the meaning of § 25 of the Vocational Training Act. The training regulations and the coordinated skeleton curriculum resolved by the Standing Conference of the Ministers of Education and Cultural Affairs of the Länder in the Federal Republic of Germany will shortly be published as an Annex to the Federal Gazette.

(2) In the main focus area of semiconductor technology, the skills and knowledge pursuant to § 3 are to be used and extended in one of the following areas of deployment:

1. Discrete semiconductors,
2. Power semiconductors,
3. Integrated semiconductors,
4. Customer specific circuits (ASICs),
5. Opto semiconductors,
6. Opto electronic display systems.

(3) In the main focus area of micro-systems technology, the skills and knowledge pursuant to § 3 are to be used and extended in one of the following areas of deployment:

1. Thick film technology,
2. Thin film technology,
3. Hybrid technology,
4. Assembly technology of surface mount devices (SMD),
5. Lithographic deep etching,
6. Galvano and second cast technology.

(4) The area of deployment is to be stipulated by the company providing training. Other areas of deployment may also form the basis of training insofar as these provide equivalent breadth and depth of the skills and knowledge to be imparted.

The skills and knowledge stated in the present Ordinance are to be imparted in such a way so as to enable trainees to exercise a qualified occupational activity within the scope of § 1 Paragraph 2 of the Vocational Training Act, this particularly to encompass autonomous planning, execution and checking of work. Evidence of this competence is also to be provided in the examinations pursuant to §§ 7 and 8.

§ 5

Training plan

The general training plan is to constitute the basis by which those providing training are to draw up a training plan for trainees.

§ 6

Written record of training

Trainees are to keep a written record of training in the form of a report book. They are to be afforded the opportunity of maintaining their report book during training time. Trainees are to review the report book on a regular basis.

§ 7

Interim examination

(1) An interim examination shall be conducted for the purpose of ascertaining the status of training. The interim examination shall take place in the middle of the second year of training.

(2) The interim examination encompasses such skills and knowledge as are listed for the first year of training in the Annex and also includes teaching material to be imparted at vocational school insofar as such material is integral to the vocational education and training.

(3) In the practical part of the examination, candidates shall be required to complete a work related task in not more than four hours. In the written part of the examination, candidates shall be required to complete the relevant work planning and documentation for the work related task in not more than 90 minutes. Particular consideration is accorded to the following areas of application:

Retrofitting, testing and maintenance of production facilities, in particular mechanical facilities, vacuum technology facilities, electrical facilities, facilities for the supply and disposal of media; conduct in the clean room; handling gases, chemicals and other work materials; production

organisation, in particular correlations between technology, work organisation, safety and health and safety at work, environmental protection and economic efficiency.

§ 8

Final examination

(1) The final examination encompasses such skills and knowledge as are listed in the Annex and extends to include teaching material to be imparted at vocational school insofar as such teaching material is integral to the vocational education and training.

(2) In part A of the examination, candidates are to execute and document two company orders in a maximum total time of 35 hours and conduct a specialist oral examination not exceeding a total duration of 30 minutes in respect of these orders. Particular consideration is accorded to:

1. Putting a production plant into operation and establishing the manufacturing capability of such a plant including work planning and

2. Execution of a stage of a process, including work planning, establishing the processing capacity of the plant, materials logistics, supply and disposal of work materials, operation and loading of the plant, process monitoring tests, quality management.

The execution of the orders shall be documented using practically related paperwork. The aim of conducting the orders and documenting such is for candidates to demonstrate that they are able to plan and implement work processes and partial tasks in a target oriented manner whilst acting autonomously and in line with manufacturing requirements whilst according due consideration to economic, technical, organisational and time stipulations as well as drawing up, collating and modifying documentation in a professional way. The aim of the specialist oral examination is for candidates to demonstrate that they are able to present specialist related problems and the solutions to such problems, display the specialist backgrounds relevant to the orders and justify the approach adopted towards executing the orders.

Tasks assigned including time planning are to be submitted to the examination board prior to the execution of the orders for the purpose of approval. A weighting of 50 percent each shall be applied to the result of the execution of the orders and to the specialist oral examination.

(3) Part B of the examination comprises the three examination areas of securing quality standards, securing of technical procedural processes and business and social studies.

(4) In the examination area of securing quality standards, particular consideration shall be accorded to one of the following tasks:

1. Description of the approach to be adopted for the systematic identification of an error in a plant, in particular in MSR technology, vacuum technology, clean room technology or in supply engineering for media. Candidates should demonstrate that they are able to evaluate functional correlations, interpret signals at interfaces, deploy diagnostic systems and identify the reasons for errors;

2. that they are able to organise and document work processes and quality management measures. In this field, candidates should demonstrate that they are able to use standard software, record facts and circumstances in writing, conduct calculations, prepare graphics, record, statistically process and evaluate measurement data and collate such data in the form of protocols and items of documentation;

3. that they are able to plan the supply and disposal of media and tools for production plants. In this field, candidates should demonstrate that they are able to accord due consideration to logistical, shelf-life, safety and environmental criteria relating to the storage, testing, and provision of media and tools and to the disposal of residual materials as well as being able to apply relevant regulations. In the examination area of securing technical procedural processes, particular consideration shall be accorded in the main area of semiconductor technology to one of the following tasks:

1. Analysing the results of process monitoring tests and the test results from semiconductor components. The aim here is for candidates to demonstrate that they are able to analysis process procedures, evaluate correlations between the properties of semiconductor components and process parameters, process stages and structures, conclude which process parameters need to be changed and make proposals for improvements in the field of defect density, throughput time, quality and production;

2. Planning and organising of process procedures for the manufacture of semiconductor components. The aim is for candidates to demonstrate that they are able to accord due consideration to economic efficiency, quality, health and safety at work and environmental protection in evaluating production planning stipulations and process regulations, providing the required templates, equipment, materials, media and other process appliances, coordinating human resources deployment and stipulating preventative maintenance and work and testing procedures.

In the examination area of securing technical procedural processes, particular consideration shall be accorded in the main area of micro-systems technology to one of the following tasks:

1. Analysing the results of process monitoring tests and the test results of microtechnological products. Candidates should demonstrate that they are able to analyse procedural processes, evaluate correlations between the properties of microtechnological products, process parameters and structures, conclude which process parameters need to be changed and make proposals for improvements in the field of throughput time, quality and production;

2. Planning and organising of process procedures for the manufacture of micro-systems. The aim is for candidates to demonstrate that they are able to accord due consideration to economic efficiency, quality, health and safety at work in evaluating production planning stipulations and process regulations, providing the required tools, materials, media and other process appliances, coordinating human resources deployment and stipulating preventative maintenance and work and testing procedures.

In the examination area of business and social studies, which should relate to practically related cases, particular consideration shall be accorded to the following areas:

General business and social contexts from the world of employment and work.

(5) The following maximum time limits should apply to Part B of the examination:

1. Examination area securing quality standards: 90 minutes,
2. Examination area securing of technical procedural processes: 90 minutes,
3. Examination area business and social studies: 60 minutes.

(6) Within Part B of the examination, the examination areas of securing quality standards and securing of technical procedural processes shall each be accorded double the weighting accorded to the examination area of business and social studies.

(7) On application of the candidate or by the judgement of the examination board within individual examination areas, Part B of the examination may be replaced by an oral examination in individual areas of the examination if this can prove decisive for the passing of the examination. In calculating the result for this examination area, the previous result and the result of the supplementary oral examination shall be accorded weighting in the ratio of 2:1.

(8) The examination shall be deemed to have been passed if at least sufficient fulfilment of requirements has been achieved in Parts A and B of the examination. In the event that overall examination performances in the execution of the company orders including documentation, in the specialist oral examination or in one of the three examination areas are awarded a mark of unsatisfactory, the examination shall be deemed not to have been passed.

§ 9 Entry into force

The present Ordinance enters into force on 1 August 1998.

The Federal Minister of Economics and Technology
per procurationem
Bürger

Annex
(to § 4)

General Training Plan
for Vocational Education and Training in the Occupation of Microtechnologist

Section I: Joint training content

No.	Part of the training occupation profile	Skills and knowledge to be imparted encompassing autonomous planning, execution and checking	Guidance times in weeks in the training year		
			1	2	3
1	2	3	4		
1	VET, employment and collective wage agreement law (§ 3 No. 1)	a) Explain the significance of the training contract, in particular conclusion, duration and termination b) State mutual rights and responsibilities arising from the training contract c) State opportunities for advanced vocational training d) State essential parts of the training contract e) State essential provisions contained within the collective wage agreements applying to the company providing training	to be imparted throughout the course of training		
2	Structure and organisation of the company providing training (§ 3 No. 2)	a) Explain structure and tasks of the company providing training b) Explain the basic functions of the company providing training, such as procurement, production, sales and administration c) State the relationships of the company providing training and its staff to organisations of trade and industry, professional bodies and trade unions d) Describe the basic principles, tasks and way of working of labour-management relations or staff representative organs within the company providing training			
3	Health and safety at work (§ 3 No. 3)	a) Ascertain health and safety risk in the workplace and adopt measures for the avoidance of this b) Deploy occupationally related health and safety and accident prevention measures c) Describe behaviours when accidents occur and institute initial measures d) Deploy regulations for preventative fire protection; describe behaviours in the event of fire and initiate fire fighting measures			
4	Environmental protection (§ 3 No. 4)	Contribute to the avoidance of instances of environmental pollution caused by the company within the occupational sphere of influence, in particular a) Explain possible instances of			

No.	Part of the training occupation profile	Skills and knowledge to be imparted encompassing autonomous planning, execution and checking	Guidance times in weeks in the training year		
			1	2	3
1	2	3	4		
		<p>environmental pollution caused by the company providing training and its contribution to environmental protection using examples</p> <p>b) Deploy environmental protection regulations as these apply to the company providing training</p> <p>c) Take opportunities to use energy and materials in an environmentally friendly manner</p> <p>d) Avoid waste; make substances and materials available for environmentally friendly disposal</p>			
5	Use of technical documentation (§ 3 No. 5)	a) Read and use German and English language operating instructions and manuals, assembly and maintenance plans, drawings, flow charts and circuit documentation	4		
		<p>b) Read and use German and English language sources of information, particularly documentation, handbooks, specialist reports and company documentation</p> <p>c) Use and evaluate occupationally related national and European regulations and technical rules</p>		4	
6	Planning and organising of work (§ 3 No. 6)	<p>a) Set up workplace according due consideration to operational stipulations and ergonomic rules</p> <p>b) Select, store, source and make available materials, spare parts, tools and equipment</p> <p>c) Make machines and technical equipment available for operation, maintain and check machines and technical equipment, initiate measures to eliminate malfunctions in the event of their occurrence</p> <p>d) Stipulate stages of the work process and estimate necessary completion times</p>	6		
		<p>e) Plan work processes and partial tasks in compliance with statutory, economic and schedule stipulations, set priorities in the event of deviations from planning</p> <p>f) Analyse problems and define these as a task, develop and evaluate alternative solutions</p> <p>g) Recognise opportunities for improvement in the work processes and in cooperation between the individual functional areas and make proposals for the improvement of work processes</p> <p>h) Organise and coordinate human</p>		6	

No.	Part of the training occupation profile	Skills and knowledge to be imparted encompassing autonomous planning, execution and checking	Guidance times in weeks in the training year		
			1	2	3
1	2	3	4		
		resources deployment and work tasks within the group i) Use meetings, chairing and presentation techniques			
7	Documentation of work, operation of data processing equipment, data protection (§ 3 No. 7)	a) Use standard software, particularly word processing programmes, spreadsheets and graphics and planning software b) Keep and interpret statistics c) Access, enter and secure production data d) Document data for operational cost accounting e) Conduct correspondence and calculations, draw up protocols, visualise data and facts and circumstances, prepare graphics f) Apply data protection regulations	4		4
8	Quality management (§ 3 No. 8)	a) Monitor and minute processes, conduct measurements and final checks b) Collate and check work results, evaluate results according due consideration to operational costing factors c) Check achievement of targets, conduct quality management measures, document quality controls and technical tests d) Evaluate measurements results using statistical quality control tools e) determine influences on product quality and make proposals for improvement	4		8
9	Provision and disposal of work materials (§ 3 No. 9)	a) Label materials, store materials appropriately in accordance with shelf-life, safety, quality and environmental criteria, make materials available for use and check materials are suitable for deployment b) Select and deploy laboratory equipment to handle materials c) Handle gaseous materials, in particular extract gases and measure pressure levels d) Deploy gas detection procedures e) Handle chemicals and chemical dilutions, particularly etching solutions and photochemical solutions, produce such solutions in accordance with concentration stipulations f) Dispose of materials, particularly gases and chemicals g) Ensure purity of materials, avoid, check and remove impurities	15		3
10	Securing and testing of clean room conditions (§ 3 No.	a) Comply with company guidelines in respect of clean room clothing and conduct in the clean room			

No.	Part of the training occupation profile	Skills and knowledge to be imparted encompassing autonomous planning, execution and checking	Guidance times in weeks in the training year		
			1	2	3
1	2	3	4		
	10)	<p>b) Check and document electrostatic risk of components (electrostatic sensitive devices safety), initiate measures to eliminate problems in case of deviations</p> <p>c) Check function of filters and conduct particle measurements of the air in the clean room</p> <p>d) Use product quality as a basis for inferring the emergence and spreading of impurities</p> <p>e) Check quality of laminar flow and alignment of plants, equipment and workplaces in accordance with clean room requirements, develop alternative ways of setting up equipment and plants</p>	4		
				4	
11	Retrofitting, testing and preventative maintenance of production facilities (§ 3 No. 11)	<p>a) Adapt mechanical and electrical components and technical data processing equipment to altered procedural processes and various products, in particular</p> <ul style="list-style-type: none"> - dismantle and assemble mechanical construction components - join pipes, pipe components, hoses, valves and regulators and check for leaks and functionality - fix and connect pre-assembled electrical connections <p>b) Document changes to the plant</p> <p>c) Measure electrical values, check components and test signals at interfaces</p> <p>d) Check technical vacuum equipment, identify malfunctions in plants and processing equipment, report and describe such malfunctions to maintenance staff, in particular</p> <ul style="list-style-type: none"> - identify malfunctions in measuring equipment caused by chemical or physical effects - check equipment for the measuring of temperature, pressure, fluid levels, throughput, volume flow and mass flow - test and adjust sensors - check safety and reporting systems in accordance with testing regulations, draw up test protocols <p>e) carry out preventative maintenance according due consideration to specific production conditions, clean work equipment and plants</p>	15		
					13
12	Adjusting of process parameters	a) Set, adjust and test performance data in accordance with instructions, test			

No.	Part of the training occupation profile	Skills and knowledge to be imparted encompassing autonomous planning, execution and checking	Guidance times in weeks in the training year		
			1	2	3
1	2	3	4		
	(§ 3 No. 12)	documentation and data specifications b) Set reference values for measurements relevant to the process, in particular revolution speed, temperature, pressure and throughput reference values c) Use technical documentation to monitor, test, adjust and document functional and process procedures			4
13	Optimising of the production process (§ 3 No. 13)	a) Identify improvements in the field of defect density, throughput time, quality and production b) Analyse measurement results and discuss potential areas for improvement within the team c) Alter process procedures on the basis of the results of process monitoring checks and in accordance with stipulations, optimisation of the interaction between process and plant d) Be involved in the production process for new or amended products and use own experiences to achieve optimisation			

Section II: Training content within the main focuses of training

1. Main focus area of semiconductor technology

No.	Part of the training occupation profile	Skills and knowledge to be imparted encompassing autonomous planning, execution and checking	Guidance times in weeks in the training year		
			1	2	3
1	2	3	4		
14	Manufacturing and assembly processes (§ 3 No. 14)	Operate and load production plants for the manufacture of semiconductor components, check and monitor processes, in particular a) Carry out surface treatments, in particular fine grinding, chemical and mechanical polishing and tempering b) Create structures via lacquering, exposing, developing and etching c) Create layers, in particular via oxidation, gas separation, epitaxy, evaporation and sputtering d) Conduct doping processes e) Carry out wet chemical processes, in particular cleaning and etching processes f) Separate wafers h) Mount, contact and house chips			18
15	Process monitoring tests (§ 3 No. 15)	a) Conduct optical identification of individual components of integrated circuits on wafers,			

		<p>in particular resistances, diodes, transistors, condensers and contacts</p> <p>b) Accord due consideration to correlations between the properties of micro-technical products, process parameters, process stages and structures</p> <p>c) Conduct particle measurements and oblique light checks</p> <p>e) Monitor adjustment and dimensional accuracy of the structures</p> <p>e) Measure layer thicknesses optically, electrically and mechanically</p> <p>f) Use test structures to measure and test characteristic electrical values of components</p> <p>g) Use test results to infer procedural errors and process parameters which need to be altered</p>		10
16	Conducting of final tests (§ 3 No. 16)	<p>a) Conduct parameter measurements within the wafer testing field</p> <p>b) Conduct electrical functional analysis, in particular with regard to permanent load, changing climate and changing operational voltage</p>		6
17	Securing of process procedures within the area of deployment (§ 3 No. 17)	<p>a) Accord due consideration to technological development trends, in particular with regard to materials, structural sizes and fields of deployment of semiconductor products</p> <p>b) Accord due consideration to the competition situation of the products, in particular with regard to prices and quality</p> <p>c) Procure information on technical and technological conditions and on stipulations relating to production planning and pass on such information to the team</p> <p>d) Establish the production capability of plants and conduct preventative maintenance at the correct point logistically within the scope of the production process</p> <p>e) Ensure the timely supply of templates, media and equipment required and monitor the completeness, comprehensibility and current validity of process regulations</p> <p>f) Monitor the nature and quantity of materials, take samples and make these ready for analysis</p> <p>g) Operate and monitor exhaust gas cleaning and neutralisation plants, determine the Ph value of solutions and neutralise solutions</p> <p>h) Filter process water, operate and monitor processing plants for the complete desalination and purification of process</p>		18

		<p>water, measure conductivity</p> <p>i) Accord due consideration to upstream and downstream process stages in the execution of stages of the process</p> <p>k) Identify malfunctions within the process and secure process procedures by making use of opportunities for intervention within the process chain</p> <p>l) Store and transport primary products and final products</p>		
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2. Main focus area of micro-systems technology

No.	Part of the training occupation profile	Skills and knowledge to be imparted encompassing autonomous planning, execution and checking	Guidance times in weeks in the training year		
			1	2	3
1	2	3	4		
14	Manufacturing and assembly processes (§ 3 No. 14)	<p>Operate and load production plants for the manufacture of micro-technology components, check and monitor processes, in particular</p> <p>a) Manufacture media for components, in particular via thin-film or thick-film technology</p> <p>b) Separate substrates</p> <p>c) Assemble, stick, solder and weld micro-systems components</p> <p>d) Mount metal and plastic micro-systems components</p> <p>e) Mount, contact and house substrates</p>		18	
15	Process monitoring tests (§ 3 No. 15)	<p>a) Differentiate between micro-systems elements, in particular sensors, actuators and mechanical and optical functional elements</p> <p>b) Accord due consideration to correlations between the properties of micro-systems, process parameters, process stages and structures</p> <p>c) Measure layer thicknesses optically and mechanically</p> <p>d) Measure and test characteristic values of components</p> <p>e) Check connections and adjustment in the housing</p> <p>f) Use test results to infer procedural errors and process parameters which need to be altered</p>		6	
16	Conducting of final tests (§ 3 No. 16)	<p>a) Conduct parameter measurements</p> <p>b) Conduct final measurements and load tests</p> <p>c) Carry out system matching</p> <p>d) Conduct functional analysis, in particular with regard to permanent load, changing climate and changing operational</p>		10	

		parameters		
17	Securing of process procedures within the area of deployment (§ 3 No. 17)	<p>a) Accord due consideration to technological development trends, in particular with regard to materials, structural sizes and fields of deployment of micro-systems</p> <p>b) Accord due consideration to the interaction of micro-systems and the overall system</p> <p>c) Accord due consideration to the competition situation of the products, in particular with regard to prices and quality</p> <p>d) Procure information on technical and technological conditions and on stipulations relating to production planning and pass on such information to the team</p> <p>e) Establish the production capability of plants and conduct preventative maintenance at the correct point logistically within the scope of the production process</p> <p>f) Ensure the timely supply of tools, components and media required and monitor the completeness, comprehensibility and current validity of process regulations</p> <p>g) Monitor the nature and quantity of materials</p> <p>h) Accord due consideration to upstream and downstream process stages in the execution of stages of the process</p> <p>i) Identify malfunctions within the process and secure process procedures by making use of opportunities for intervention within the process chain</p> <p>k) Store and transport primary products and final products</p>		18