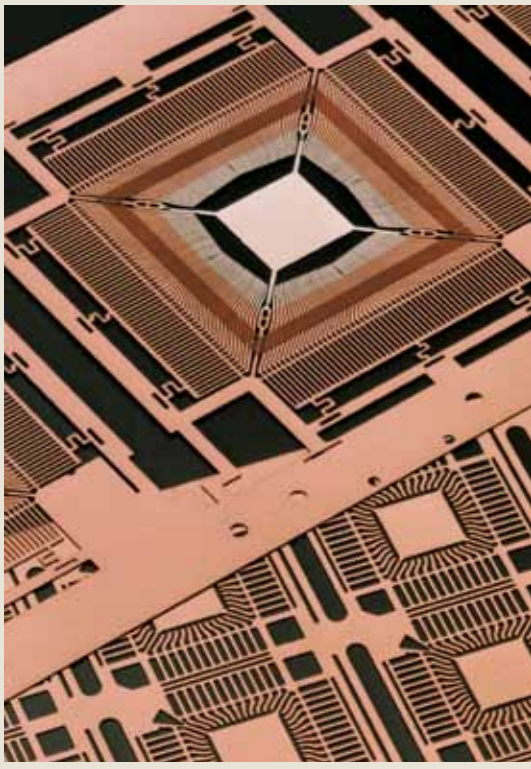
Wieland

Strip for semiconductor packages



The Wieland Group

Wieland-Werke AG, Ulm, Germany

The Wieland Group, headquartered in the southern German city of Ulm, is one of the world's leading manufacturers of semi-finished and special products in copper and copper alloys: strip, sheet, tube, rod, wire and sections as well as slide bearings, finned tubes and heat exchangers.

The Company can trace its history right back to the 19th century. Its founder, Philipp Jakob Wieland, took over his uncle's fine art and bell foundry in Ulm in 1820, and by 1828 he was already fabricating sheet and wire from brass.

Today, Wieland's output reaches about 500,000 tonnes a year in copper alloy products. The starting point of the production process is Europe's biggest foundry for copper alloys at Wieland's Vöhringen/Iller location.

The Wieland Group has more than 6,500 employees in its manufacturing companies, slitting centres and trading firms in several European countries as well as the USA, South Africa, Singapore and China.

Wieland supplies over 100 different copper alloys to customers in many different markets, first and foremost the electric and electronic sector, but other important consumers include the building trade, the automotive industry and air-conditioning and refrigeration engineering.

Wieland produces strip in all major economic regions of the world: in Germany in the three rolling mills in Vöhringen, Velbert-Langenberg and Villingen-Schwenningen. Further manufacturing companies are based in Great Britain, Singapore and the USA. A global network of slitting centres ensures swift and flexible product deliveries worldwide.

Wieland-Werke AG, Velbert-Langenberg, Germany

North America

USA

Wieland-Werke AG, Vöhringen, Germany

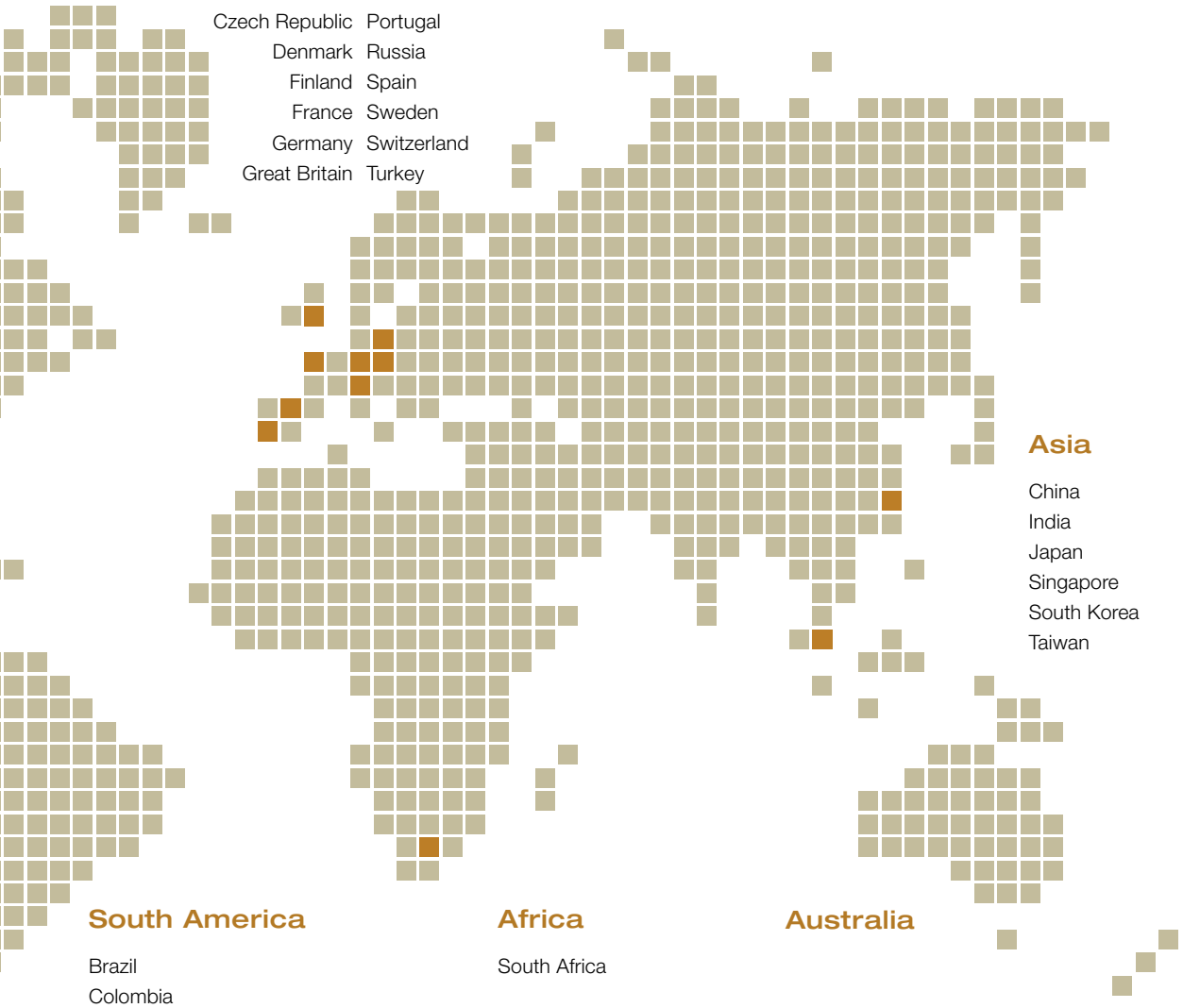
Wieland-Werke AG, Villingen-Schwenningen, Germany

Sites of the Wieland Group and its trading agencies

Europe

Austria
Belarus
Belgium
Croatia
Czech Republic
Denmark
Finland
France
Germany
Great Britain
Greece
Hungary
Italy
Poland
Portugal
Russia
Spain
Sweden
Switzerland
Turkey

Rolling mills and slitting centres



Asia

China
India
Japan
Singapore
South Korea
Taiwan

South America

Brazil
Colombia

Africa

South Africa

Australia

Wieland Metals, Inc. Wheeling, IL, USA

Wieland Metals Shanghai Limited, Shanghai, China

Wieland Metals Singapore Pte Ltd., Singapore

Leadframe strip for semiconductor packages

Introduction

The delivery program of the Wieland Group provides a broad variety of alloys used for semiconductor packages, such as strips for IC leadframes, strips for discrete packages as well as for power transistors and heatspeaders.

Requirements for leadframe strip used for IC's & discrete packages

Strips for IC leadframes and discrete semiconductor packages call today for specially tailored copper alloys requiring the following properties:

- special leadframe surface qualities to meet plating and wire bonding requirements
- material properties adjusted to today's semiconductor packaging assembly processes
- high strength copper alloys allowing to produce matrix leadframes in large width
- standardized alloys and tempers allowing high volume production and productivity
- softening resistant alloys suitable for high die bonding temperatures
- alloy and temper properties allowing to etch strips with high productivity
- alloys with good solderability
- tight dimensional tolerances
- low internal tension allowing to stamp or etch high pin semiconductor frames with excellent lead co-planarity.

Often high pin count IC leadframes are annealed after stamping for better co-planarity of the leads requiring special softening resistant alloys & tempers. Further details on this are given in the data sheets for the various materials.

Requirements for copper strip used for heatspreader

- copper with very high electrical and thermal conductivity
- good surface properties to allow perfect plating and marking
- good stamping and forming properties

All of Wieland's alloys offered for semiconductor packaging applications meet the RoHS mandatory requirements.

Material properties

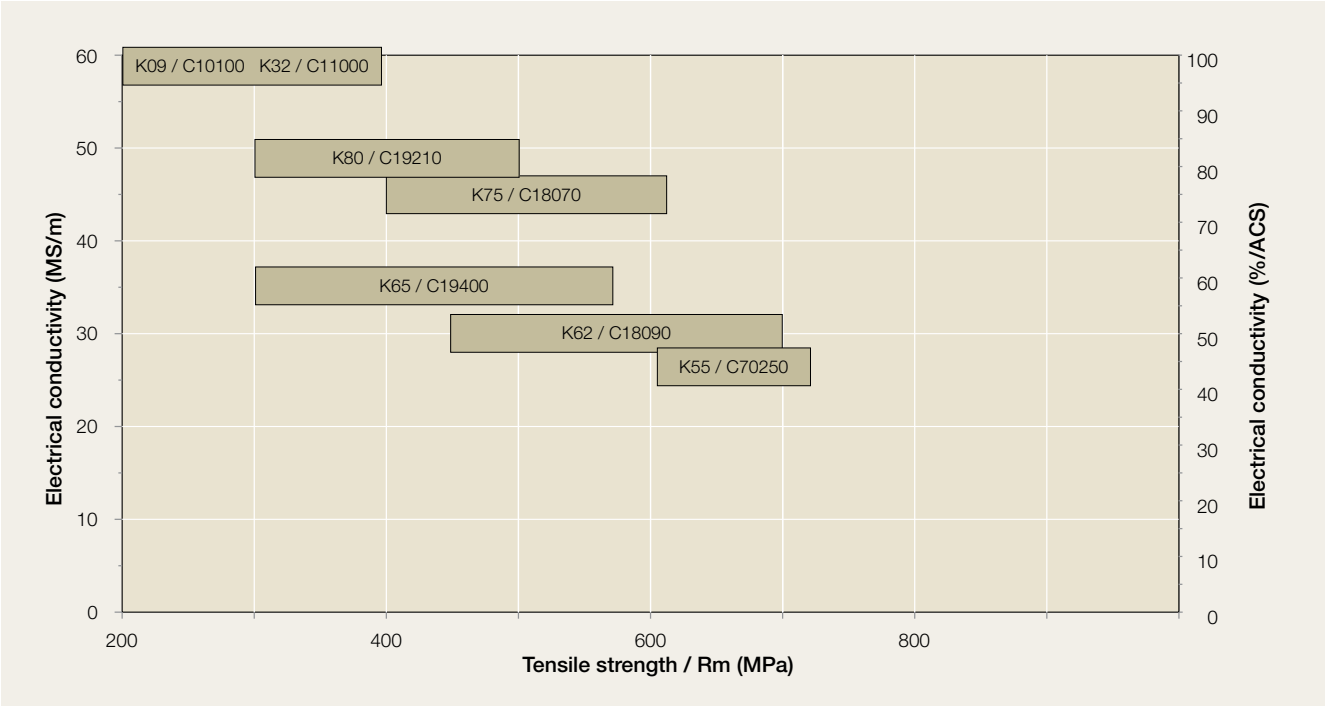
Wieland materials for semiconductor packages comply with established international standards such as EN, ASTM and JIS. The following table provides an overview of the mechanical and physical properties of Wieland alloys used in semiconductor packaging. For further details kindly refer to the specific datasheets.

Alloy	EN	UNS	Chemical composition (nominal) wt [%]	Physical properties*		Mechanical properties**			
				Electrical conductivity [%] IACS	Thermal conductivity [W/(mK)]	Tensile strengh [MPa]	Yield strengh [MPa]	Elon-gation A50 [%]	Hard-ness HV
K09	Cu-OF	C10100	Cu > 99.99	101	394	240–300 (Fullhard)	≥ 180	≥ 8	65–95
K32	Cu-ETP	C11000	Cu > 99.99	100	390	240–300 (Fullhard)	≥ 180	≥ 8	65–95
K55	CuNi3SiMg	C70250	Ni 3 Si 0.65 Mg 0.15 Cu balance	40	190	608–725 (Halfhard)	550–650	≥ 6	180–220
K62	–	C18090	Sn 0.6 Ni 0.4 Cr 0.3 Ti 0.3 Cu balance	50	240	540–620 (Fullhard)	≥ 450	≥ 6	160–200
K65	CuFe2P	C19400	Fe 2.4 Zn 0.12 P 0.03 Cu balance	60	280	480–530 (Springhard)	≥ 430	≥ 4	140–160
K75	CuCrSiTi	C18070	Cr 0.3 Si 0.02 Ti 0.1 Cu balance	75	310	530–610 (Springhard)	≥ 460	≥ 2	150–190
K80	CuFeP	C19210	Fe 0.1 P 0.03 Cu balance	90	350	360–440 (Halfhard)	≥ 260	≥ 3	100–130

** for reference only* *** typical temper shown; for more details see alloy data sheets*

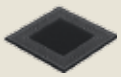
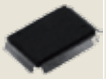
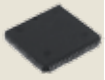
Alloy performance table

The following diagram shows typical Wieland leadframe alloys with information on temper range and electrical conductivity.



Typical applications

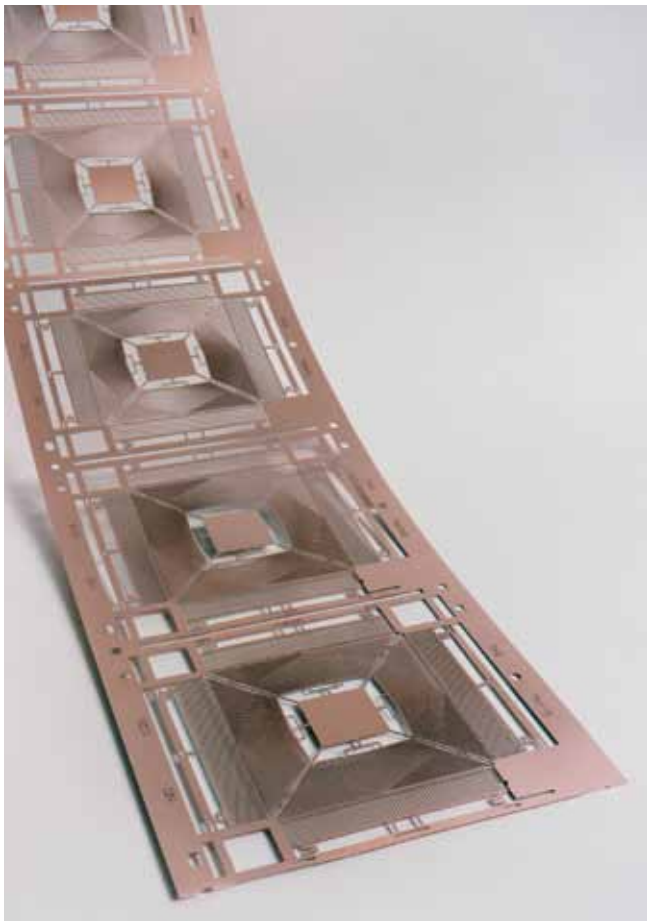
The following table provides an overview of the usage of Wieland alloys within the semiconductor packaging industry.

Application	Heatspreader	Integrated circuit (IC)					Discrete					
	BGA/LGA/PGA	QFN	QFP	PLCC	TSOP	DIP	SOT	To-92	TO220	TO247	LED	DPAK
Package												
K09	•											
K32	•											
K55		•	•		•							
K62							•				•	
K65		•	•	•	•	•	•				•	
K75							•				•	
K80								•	•	•	•	•

Pricing

Besides the technical properties, price is of course an important criterion for the selection of a material. Here the value of the metal makes up a substantial part of the end price of the strip. Non-ferrous metals such as copper, nickel and tin are traded on commodity exchanges and are therefore subject to price fluctuations, which can be quite considerable. That's why the price ratios among the various alloys are only valid for a specific date.

Your requirements – our solutions



Leadframes

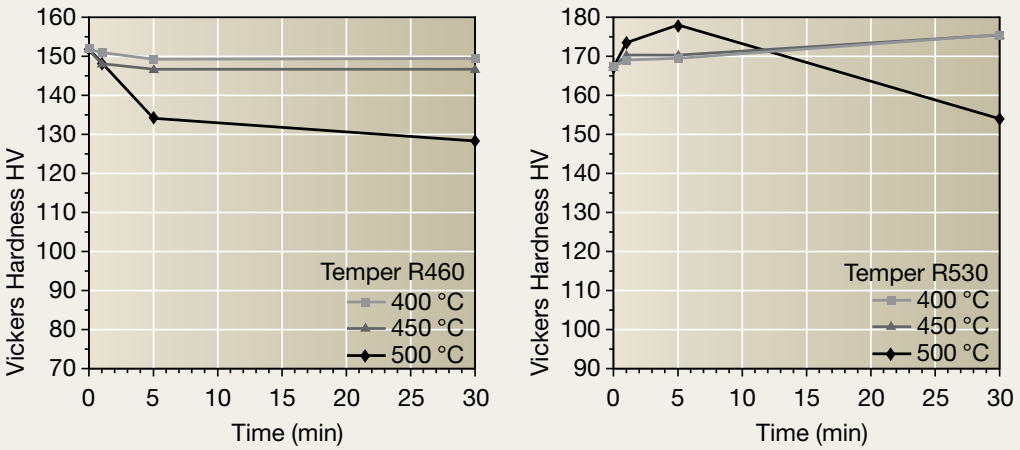
Leadframes for IC or discrete semiconductors are either stamped or etched. Each process requires different strip properties. As such Wieland delivers optimized strip qualities for stamped and etched leadframes.

While stamping qualities are typically delivered in a slightly oiled condition to enhance the stamping process, etched strips typically require dry surfaces. Both qualities require base materials with an optimized stress distribution in order to allow stamping and etching of high pin count leadframes with convincing results.

Many new semiconductor packages like QFN require in their production half etching processes, meaning that the strip thickness is reduced by the etching medium. In order to achieve a proper solution even for such requirements special qualities have been developed to guarantee best half etching results. These qualities are limited to certain alloy/thickness combinations.

Many of today's discrete leadframes require a die bonding attachment process at temperatures exceeding 400 °C. In addition high pin IC leadframes are often annealed after stamping at temperatures exceeding 450 °C requiring special softening resistant alloys and tempers. For these applications Wieland developed special softening resistant alloys with convincing irreversible lengthening properties.

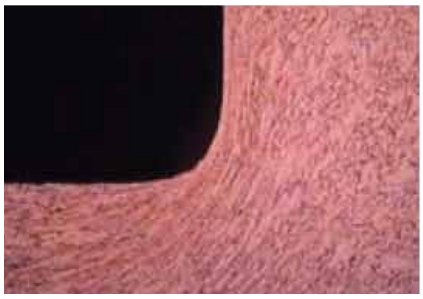
Example: Softening resistance of Wieland-K75



Vickers Hardness after heat treatment (typical values)

Power transistors

Power transistors combine typically a leadframe with an integrated heatspreader. As such contour milled materials are commonly used. In order to produce such profiles multiple processes are used within the industry, such as coining, milling, rolling and skiving.



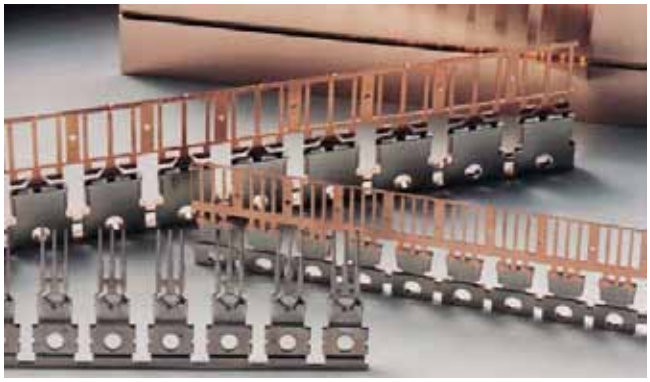
Micrograph section of a rolled profile strip: the deformation of the structure is obvious

Micrograph section of a milled profile strip: the structure of the base material is the same

Milling shows the following benefits:

Advantages for leadframe production
- low stamping forces due to homogeneous mechanical properties
- higher stamping speed
- more simple and less costly stamping tool
- lower stamping cost
- less die wear

Advantages for assembly of the semiconductor package
- less material used per meter due to contour milled profile
- low internal tension compared to rolled profiles
- nearly no limits for the profile design (matrix design and milling angels up to 86°)
- no changes in electrical properties due to identical mechanical properties within the profile



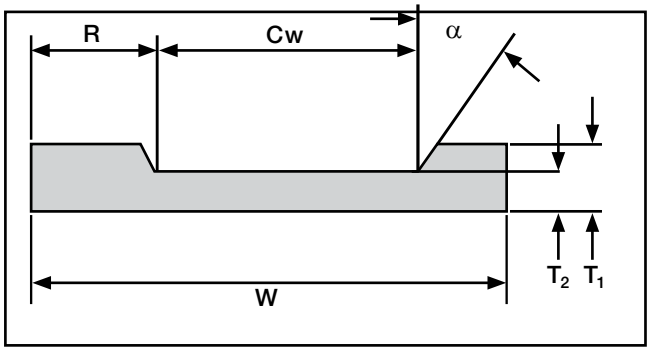
Surface of the milled strip

Surface roughness	Standard	Tightend
R_a (of unmilled surface)	< 0.20 µm	< 0.16 µm
R_a (of milled surface)	< 0.40 µm	< 0.20 µm

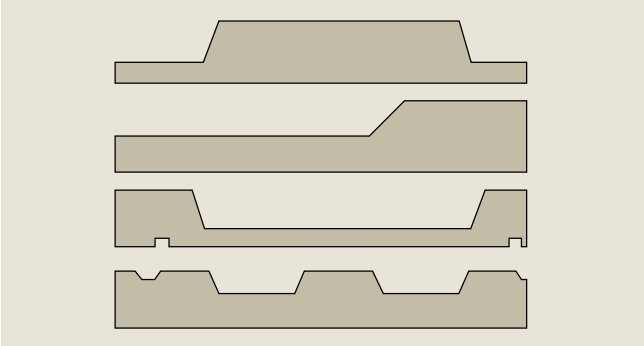
	Sizes	
W	Strip width	20–140 mm
T_1	Strip thickness	0.5–3.0 mm
T_2	Thickness of milled area	≥ 0.20 m
Cw	Width of milled channel	0.6–100 mm
α	Angle of milling flanks	≥ 2°

Tolerances		
	Standard	**Tightend**
Cw	± 0.02 mm	± 0.01 mm
R	± 0.05 mm	± 0.03 mm
T_1	± 0.02 mm	± 0.01 mm
T_2	± 0.012 mm	± 0.008 mm
α	± 1°	± 1°

Guide values for dimensioning



W	*Strip width*	*Cw*	*Width of milled channel*
T_1	*Strip thickness*	*α*	*Angle of milling flanks*
T_2	*Thickness in milled area*		



Cross section of different configurations

Surface qualities

Leadframe strips for semiconductor packages require surfaces without imperfections such as scratches, pits, dents, rolling marks and defects that may cause functionality problems on the final application.

Different alloys and thicknesses however lead to different surface appearances. In order to exceed the stringent surface requirements for bondable semiconductor packages Wieland has developed several surface qualities providing a unique solution for each leadframe application.

	PSQ	LFQ Brushed	LFQ	LFX
Description	Power Strip Quality	Leadframe Quality Brushed	Leadframe Quality	Leadframe Extra
R_{max}	max 3.0 (max 1.8*)	max 1.0	max 1.0	max 1.0 (max 0.8*)
R_a	max 0.16	max 0.13	max 0.13	max 0.13 (max 0.10*)
Specifics	standard surface quality for power	standard surface quality for smart power	standard surface quality for IC	further improved surface quality compared to LFQ
Defect tolerances	All materials shall be, in the commercial sense, free of defects and in general free of surface imperfections such as oxidation, laminations, dents and defects that may cause funtionality problems on final application. In general the material should be macroscopically free of any pits, humps or roller marks and scratches, visible to the naked eye.			
Defect guide-line for pits, humps and roller marks	10 - 5 - 10** (t ≤ 0.9 mm) 15 - 5 - 10*** (t > 0.9 mm) (only for K80)	5 - 2 - 5****	5 - 2 - 5****	5 - 2 - 5*****
Alloy	K09, K32, K80	K62, K75, K80	K55, K65	K55, K65
Standard thickness	0.495–2 mm	K62 = 0.1–0.4 mm K75 = 0.1–0.4 mm K80 = 0.25–0.508 mm	K55 = 0.102–0.254 mm K65 = 0.1–0.508 mm	K55 = 0.127–0.203 mm K65 = 0.127–0.254 mm
Application (example)	Power	Smart Power Discrete	IC (stamped parts)	IC (high end etched strip & stamped parts)
Package (example)	TO220, TO247, DPAK, D2PAK, Heatspreader	QFP, SOT, LED	QFN, QFP, DIP, PLCC, TSOP	QFN, QFP, TSOP, TSSOP
Price index	 lower		normal	higher

* Achievable with additional work
** A depth or height of 5–10 micrometers (µm) with a maximum frequency of 10 (if thickness < 0.9 mm) per 1 meter based on a sample width of 50 mm is allowed
*** A depth or height of 5–10 micrometers (µm) with a maximum frequency of 15 (if thickness < 0.9 mm) per 1 meter based on a sample width of 50 mm is allowed
**** A depth or height of 2–5 micrometers (µm) with a maximum frequency of 5 per 1 meter based on a sample width of 50 mm is allowed
***** A depth or height of 2–5 micrometers (µm) and a max diameter of 25 micrometers (µm) with a maximum frequency of 5 per 1 meter based on a sample width of 50 mm is allowed

Tolerances

At Wieland's customers, the finished strip is processed using high-precision equipment which makes particular demands on the tolerances and the geometric properties of the strip.

Thickness and width tolerances can be restricted to the tightest of margins compared with the relevant standards. Special measures can likewise be taken during strip production in order to minimise shape deviations such as longitudinal camber, coil set or cross bow. With this, the particular requirements of the tool can be anticipated and accounted for.

Strip thickness tolerances

Strip thickness (mm)		Strip thickness tolerance (mm)		
		Precision level acc. to production costs		
over	up to	I	II	III
0.10	0.30	+/– 0.010	+/– 0.007	+/– 0.005
0.30	0.50	+/– 0.015	+/– 0.010	+/– 0.007
0.50	0.80	+/– 0.020	+/– 0.015	+/– 0.010
0.80	1.30	+/– 0.025	+/– 0.020	+/– 0.015
1.30	1.50	+/– 0.030	+/– 0.025	+/– 0.020
1.50	on request			

Strip width tolerances

Strip thickness (mm)		Width tolerance according to EN 1652 (mm)		
		Strip width (mm)		
over	up to	up to 50	over 50 up to 100	over 100 up to 200
0.1	1.0	+0.20 / –0	+0.30 / –0	+0.40 / –0
1.0	2.0	+0.30 / –0	+0.40 / –0	+0.50 / –0
2.0	2.5	+0.50 / –0	+0.60 / –0	+0.70 / –0
2.5	3.0	+1.00 / –0	+1.10 / –0	+1.20 / –0
3.0	4.0	+2.00 / –0	+2.30 / –0	+2.50 / –0

For strip thicknesses of up to 0.6 and strip widths of up to 100 mm, tolerances of half the values listed above can be supplied on request.

Camber

Strip thickness (mm)		Camber according to EN 1654 (mm/m)			
		Strip width (mm)			
over	up to	> 3–6	> 6–10	> 10–20	> 20–350
0.10	0.50	12	8	4	2
0.50	1.00	–	10	6	3

Increased work in manufacturing allows the camber of a strip to be reduced to the following tolerances:

Strip Thickness (mm)		Camber (mm)			
		Strip width (mm)			
over	up to	> 3–6	> 6–10	> 10–20	> 20–350
0.10	0.50	7	5	3	1.0
0.50	1.00	–	6	4	1.5

Delivery formats

Due to the very high surface requirements for semiconductor strips the material is delivered only in coil form. Furthermore coils are the simplest and therefore the most economical delivery format for strip. They are packed horizontally on square or round pallets, the size of which is matched to the outer diameter of the coils. In order to support high productivity for our customers we deliver as well big coils with outer diameter of up to 1,450 mm providing several kilometers of strip length.

	Inner diameter [mm]	Outer diameter [mm]	Specific pancake weight [kg/mm]	Pancake width [mm]
K09	300 400	max 1450	max 13.5	max 400
K32		max 1450	max 13.5	
K55		max 1300	max 10.5	
K62		max 1300	max 10.5	
K65		max 1300	max 10.5	
K75		max 1300	max 10.5	
K80		max 1450	max 13.5	

Technical service

Wieland supplies quality products and, what is more, tries to be a reliable partner to its customers.

The experts of Wieland's Technical Marketing will be pleased to discuss with you at an early stage of engineering any question you may have with regard to alloy, temper, sizes, tolerances, material qualities, packing, etc.

They have the knowledge and the experience to supply useful information and help you achieve optimal production results. For the development of new alloys and new or improved Wieland products, as well as specific metallurgical problems, we can draw on the experience of the scientists and technicians in the Research and Development Department.

The test laboratories in the R&D department are accredited to DIN EN 45001 and DIN EN ISO 9001.

Please contact us!

Quality assurance

For many years, customers all over the world have been relying on Wieland for consistent high-level quality. Wieland products are subject to stringent control throughout the production process, beginning with incoming of raw materials and ending with shipment of the finished product.

Within the system of operator inspection, responsible members of the staff are in charge of checking the product very carefully at every stage of its manufacture according to well-established procedures and schedules to ensure that the specified quality requirements are met. The finished product is not released for shipment unless it complies with the order confirmation in every respect.

Work schedules and test results are stored and available when needed, a prerequisite for consistent high-level quality.

The quality management of Wieland-Werke AG is based on DIN EN ISO 9001. In addition, the quality system of the Rolled Products Division, including the plants at Vöhringen, Villingen and Langenberg, complies with the requirements of the valid version of TS 16949.

BUREAU VERITAS QUALITY INTERNATIONAL (BVQI), an independent certification body operating worldwide, has thoroughly analysed Wieland‘s Quality System and certified that it complies with the above mentioned standards.

The certificate is subject to revision audits through BVQI’s own auditors once a year. The approval of Wieland’s Quality System by BVQI means reliability for our customers, since we are able to always supply material which corresponds with their order.

Environment

As a manufacturer of semi-finished products in copper and copper alloys, we have an obligation to protect the environment. Our production are energy-intensive. We therefore strive to use electricity and gas as sparingly and efficiently as possible. Environmental protection plays an important role in corporate decisions. Therefore, all four plants of Wieland-Werke AG are certified in accordance with DIN EN ISO 14001:2005.

ElektroG (RoHS & WEEE)

According to § 5 of the ElektroG (German Electrical and Electronic Equipment Act), the following maximum concentrations of the below-mentioned substances contained in homogeneous materials are applicable as of 1 July 2006:

- 0.1 percent by weight for lead, mercury and hexavalent chromium
- 0.01 percent by weight for cadmium.

Wieland meets this requirement for all of its lead-free alloys.

Wieland-Werke AG **www.wieland.com**

Graf-Arco-Str. 36, 89079 Ulm, Germany, Phone +49 (0)731 944-2030, Fax +49 (0)731 944-4257, info@wieland.com

0541-02 032/08.13 Bm 0,5 ODH (GSW/Ri)