SCHOTT Electronics International Holding GmbH

Y O U R C A S E F O R E L E C T R O N I C S

E L E C T R O N I C P A C K A G I N G

G L A S S - T O - M E T A L S E A L S

SCHOTT

glass made of ideas

Contents

1. Introduction

SCHOTT Electronics International Holding GmbH is a worldwide supplier of herm e t i cpackages for electrical and electronic components, as well as for current feed-throughs in the glass-to-metal technique. With over fifty years of experience in glass technology and ongoing development in close cooperation with our customers, SCHOTT is one of the leading suppliers of glass-to-metal seals. Our know-how is backed by the research activities of SCHOTT covering all aspects of glass technology.

This brochure is designed to give users of our products a basic understanding of the technology of glass-to-metal seals and offers solutions to specific design and application challenges.

SCHOTT Electronics International Holding GmbH offers more than 5,000 different products,produced in Germany, Singapore and the Czech Republic. Our particular strength lies in compression seals that are primarily developed for custom applications. The main application areas of the hermetic packages are:

- Opto-electronics
- Telecommunications
- Automotive electronics and electrics
- Sensors
- High-safety electrical and electronics engineering.

Here are some examples of our extensive range of products:

- Transistor packages
- Quartz crystal packages
- Housings for photodiodes
- Hybrid packages
- Diode housings
- Automotive engine and chassis controls
- Airbag ignition feed-throughs
- Battery feed-throughs
- Power feed-throughs for nuclear reactors
- Sensor packages.

These widely diversified products have a number of characteristics in common, including:

- Excellent electrical insulation
- Hermeticity
- Pressure resistance
- Chemical resistance and corrosion protection
- High operating temperature
- Mechanical strength
- Good heat absorption, grounding and electromagnetic shielding by means of metal elements
- Suitability for bonded, soldered or glued connections
- Easy integration of seals into packages, for example by welding or soldering.

Depending on the application, certain characteristics can be stressed and optimized to create custom solutions.

The sum of the advantages of glass-to-metal seals and the industry's growing demands in terms of reliability, life expectancy and cost make glass-to-metal seals the solution of choice that will continue to be preferred over other solutions, such as ceramics or plastics.

The following chapters provide information about the design of glass-to-metal seals, materials, processing techniques, quality issues and characteristics. The SCHOTT Electronics International Holding GmbH team will be pleased to answer any questions not covered in this brochure.

2. Glass-to-Metal Seals

Glass-to-metal seals are vacuum-tight assemblies of glasses with metals used to feed electrical conductors through the walls of hermetically sealed packages. They have proven successful in electronic and electrical engineering and cover a wide range of applications in which the sealing glass serves as an excellent insulator. A typical glass-to-metal seal consists of an external metal part into which a pre-formed sintered glass element is sealed. The sintered glass element in turn encloses one or more metal leads that are sealed into it.

Because of the different expansion coefficients of various glasses and metals, mechanical stresses during the melting process are inevitable. By adopting special design principles it is possible to obtain glass-to-metal seals in which these stresses do not result in a weakening of the structure but, on the contrary, are used to obtain particularly stable devices. In terms of these design principles, matched glass-to-metal seals and compression glass-to-metal seals are distinguished.

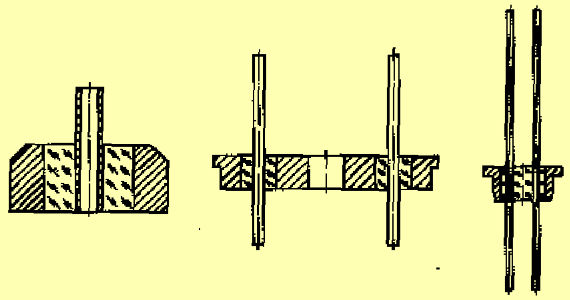
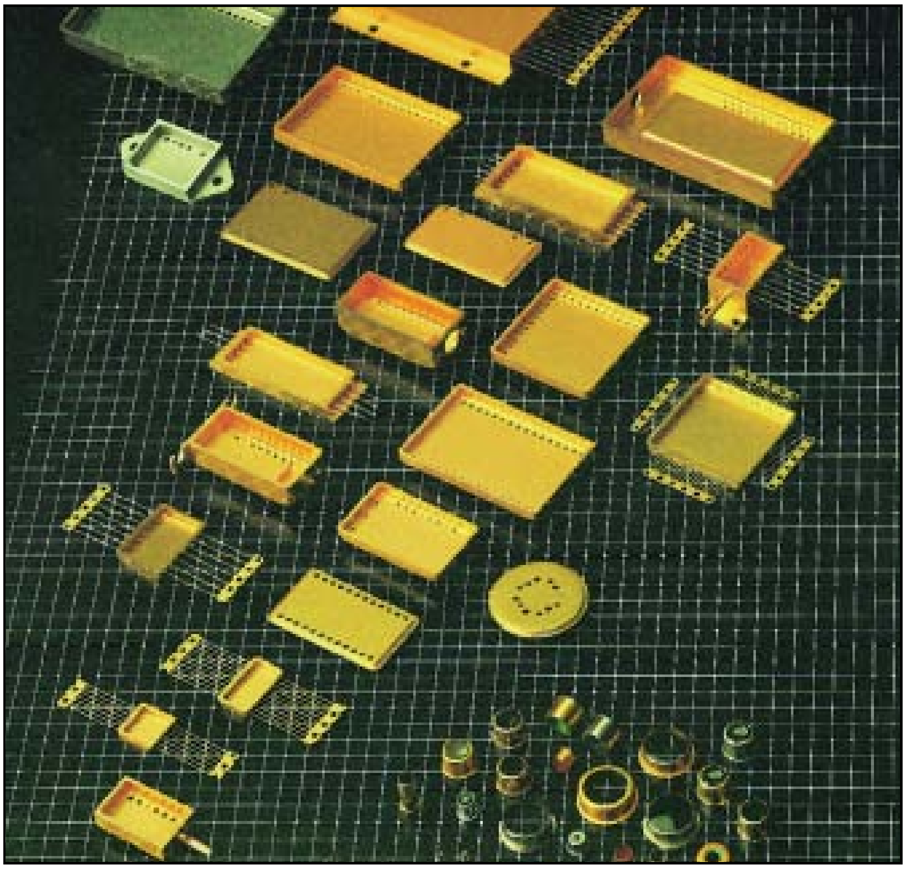


Fig. 2: Typical designs of compression glass-to-metal seals

Matched Glass-to-Metal Seals

For dilathermally matched glass-to-metal seals, the thermal expansion coefficient α of both the glass and the metal must closely coincide at any temperature between ambient temperature and the transformation temperature of the glass (fig. 3). That way, mechanical stresses in the seal never exceed the stress limit of the glass while the glass-to-metal



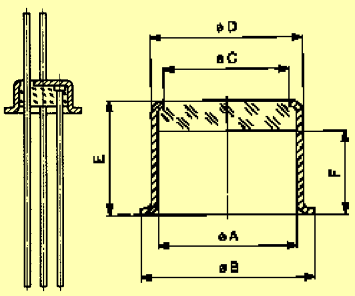


Fig. 1: Typical design of matched glass-to-metal seals

seal cools from the setting temperature of the glass (viscosity ranging from 10^{13} to $10^{14.5}$ dPas) to ambient temperature. Manufactured under optimal processing conditions, these glass-to-metal seals are practically stress-free at ambient temperature.

Fig. 4 shows the stress/temperature curve for two glass/metal combinations. The mechanical stress σ is linked to the stress-optical path difference s through the stress-optical constant K by $\sigma = s\,K^{-1}$.

Matched glass-to-metal seals are divided into two sub-categories:

- Matched glass-to-metal seals with hard glasses ($\alpha \sim 5\times10^{-6}$/K). Well-known combinations for this type are: glass 8250, metal: molybdenum, NiCo 29 18 (also see tables 2 and 3 where the corresponding materials specifications are listed).
- Matched glass-to-metal seals with soft glasses ($\alpha \sim 8.5\text{-}10.5\times10^{-6}$/K). For this type, glasses 8630, 8350, 8421, 8422 are used in appropriate combinations with different sealing alloys.

The outer electrodes of matched glass-to-metal seals are primarily manufactured from thin sheet metal (0.2 - 0.5 mm) in the shape of shells, caps, discs with apertures, and tube cuttings. Due to the absence of stress in the seal, glass-to-metal seals can be designed in a variety of different ways. For example, the glass may protrude far beyond the sealing plane to obtain long electrical creep distances. An advantage of matched glass-to-metal seals is their relatively low weight. However, their sensitivity to mechanical stresses is a disadvantage. For high thermal shock loads and severe selective heating of the external metal element, which may result from assembly conditions, hard-glass seals should be given preference over soft-glass seals.

Compression glass-to-metal seals

The compressive strength of glass is generally 10 to 20 times as high as their tensile strength, which ranges from 20 to 80 MPa. This fact is utilized in compression glass-to-metal seals by applying uniform compressive stress to the glass element, which prevents the occurrence of tensile stress in the seal, even when exposed to relatively severe mechanical and thermal loads.

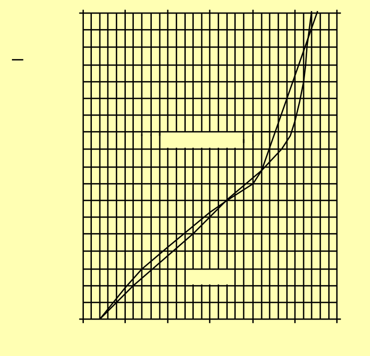
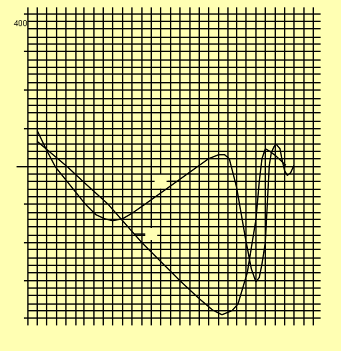


Fig. 3: Relative thermal expansion of the components of a matched glass-to-metal seal (glass 8250 - NiCo 2918).

A general characteristic of compression glass-to-metals seals is that the thermal expansion coefficient of the external metal element considerably exceeds that of the sealing glass and the internal metal leads. After the glass is sealed, the external metal element, because of its much greater contraction, shrinks to form a compression ring around the glass element.



aFig. 4: Stress-optical path difference as a function of temperature determined for the sealing of
a) molybdenum and glass 8250
b) NiCo 2918 and glass 8250
at a heating rate of 4 K/min.

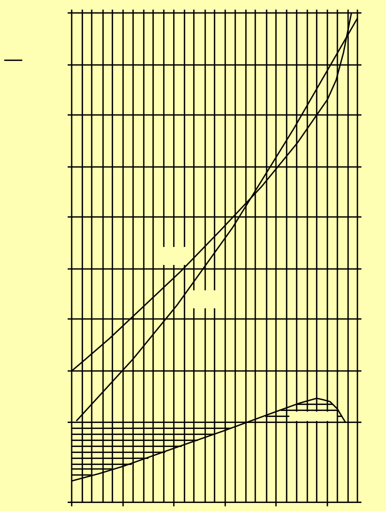


Fig. 5: Relative thermal expansion of the glass and metal (compression ring) of a compression glass-to-metal seal.

The compressive stress thus exerted on the glass must be compensated by the tensile stress of the compression ring.

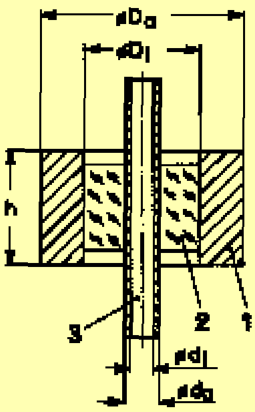


Fig. 6: Schematic representation of a compression glass-to-metal seal

1 = External lead, 2 = Glass, 3 = Internal lead

To ensure that the stress applied to the external lead does not exceed its elastic limit, compression rings with sufficient wall thicknesses and appropriate material combinations are used.

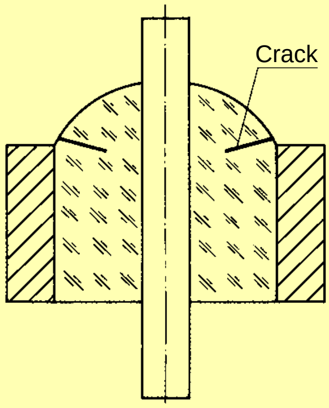
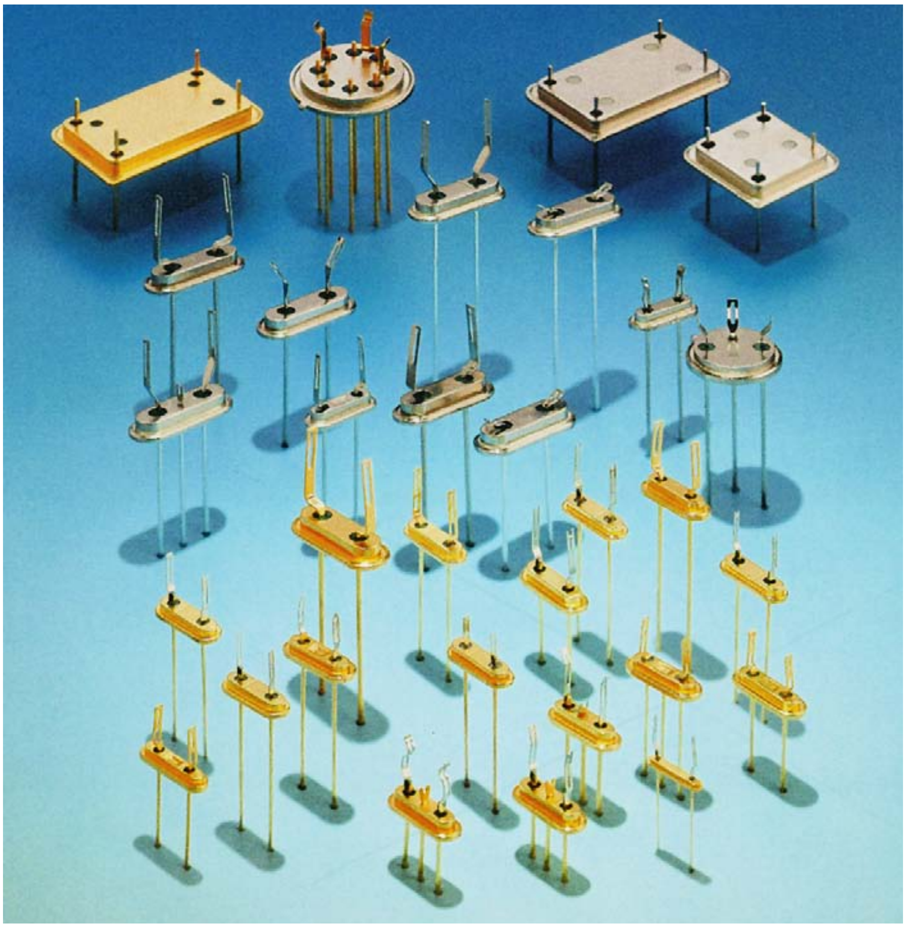


Fig. 7: Cracks in the glass body of a compression glass-to-metal seal in which the glass body is protruding beyond the sealing plane.

To stabilize the compressive stress, certain dimensional criteria must be observed:

If the difference between the thermal expansion coefficients of the compression ring and the glass is $\Delta \alpha \leq 4.5\text{x}10^{-6}$/K, the ratio between the outside diameter D_a of the compression ring and its inside diameter D_i must not be less than 1.3. If the difference is $\Delta \alpha \leq 3\text{x}10^{-6}$/K, it must not be less than 1.2. And if the difference is $\Delta \alpha > 4.5\text{x}10^{-6}$/K, a correspondingly higher diameter ratio must be applied. Even for compression glass-to-metal seals of the smallest dimensions, a minimum wall thickness of the compression ring 0.5 mm and a minimum height h of 1.5 mm should be maintained in all cases. Only in special cases the minimum height can be reduced. The wall thickness of sealed-in tubes should be no less than 0.2 mm. To avoid unwanted edge effects, the sealed-in glass element is frequently recessed in the sealing plane by 0.2 to 0.4 mm in relation to the compression ring (see fig. 6).



Any protrusion of the glass above the sealing plane to increase the electrical creep distance, for example, should be avoided with compression glass-to-metal seals because the resulting imbalance in the stress distribution may cause cracks in the glass (see fig. 7). Due to their high mechanical and thermal stability, all compression glass-to-metal seals are extremely robust and can be post-processed with minimal risk.
The material combinations shown in table 1 have proven to be particular-ly suitable for compression glass-to-metal seals. Tables 2 and 3 (see p. 18 and 19) show the characteristics of the glasses and metals most frequently used for matched and for compression glass-to-metal seals.

Designation	$\alpha_{(20\text{-}300)}$ [10^{-6} K^{-1}]		
	Compression Ring	Glass	Interior Lead
Standard compression glass-to-metal seals	13	9	9
Low-expansion standard compression glass-to-metal seals	9	5	5
Reinforced compression glass-to-metal seals	18 13	9 5 – 7	9 5

Table 1:
Expansion coefficients of common material combinations for compression glass-to-metal seals.

3. Temperature Behavior of Glass-to-Metal Seals

Due to the very low thermal conductivity of glass seals (approx. 1W m^{-1} K^{-1}), soldering or welding glass-to-metal seals for assembly purposes will essentially heat up their metal parts, resulting in high temperature differences between the glass and metal parts. The partially heated external metal element expands more than the glass element, which causes radial and tangential tensile stresses at the external glass/metal junction of matched glass-to-metal seals. In compression glass-to-metal seals the existing compressive stresses are reduced in the initial phase. Thereafter, tensile stresses will occur above the so-called inversion temperature T_i. This inversion temperature is a function of the glass/metal combination used.

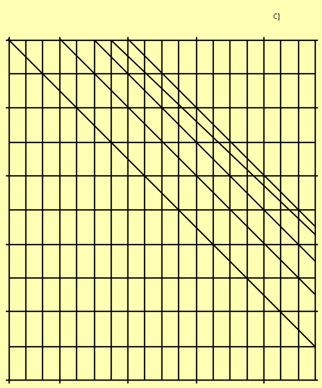


Fig. 8: Radial tensile stresses in a matched hard-glass seal. Glass 8250 - NiCo 2818 with partial heating of the metal ring.

The parameter is the pre-heating temperature of the entire seal.

When mounting glass-to-metal seals, tensile stresses should be avoided if possible or kept below the critical limit of 20 to 30 MPa. If the admissible tensile stress is exceeded, either the metal will detach itself from the glass in the junction area, thus impairing vacuum tightness, or cracks and fissures will develop in the glass.

Matched Glass-to-Metal Seals

Figures 8 and 9 show the radial tensile stresses occurring in matched ring-shaped seals (D_a/D_i = 1.15) when the ring is partially heated with and without different homogeneous pre-heating temperatures.

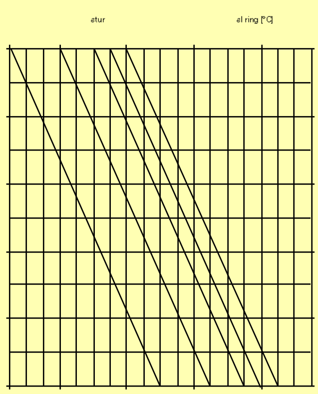


Fig. 9: Radial tensile stresses in a matched soft-glass seal. Glass 8422 - NiFe 47 with partial heating of the metal ring.

The parameter is the pre-heating temperature of the entire seal.

Figures 8 and 9 also show that, at increasing temperatures, the stresses clearly build up faster in soft-glass seals, which expand at a greater rate, than in hard-glass seals, whose expansion is reduced. Hard-glass seals should therefore be given preference for any application that requires strong partial heating of the metal part. When matched soft-glass seals are used, the entire seal should be given a uniform preheating treatment.

Compression Glass-to-Metal Seals

Figure 10 illustrates the pressure reduction and the build-up of tensile stress in standard compression glass-to-metal seals for different diameter ratios and with partial heating of the compression ring.

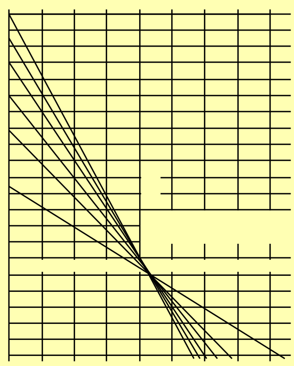


Fig. 10: Variation of radial stress p during partial heating of the steel compression ring of a seal with glass 8422.

Parameter: diameter ratio D_a : D_i
T_i: inversion temperature

The intersection of the stress lines indicates the inversion temperature T_i.

Different glass/metal combinations result in stress lines with different gradients and different intersections T_i.

When compression glass seals are preheated homogeneously, both the stress lines and the inversion temperatures are pushed to higher temperatures.

Figure 11 shows the T_i increase resulting from preheating 8422 compression seals.

Temperature Resistance

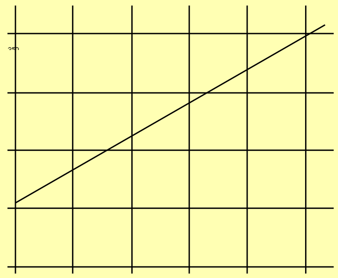


Fig. 11: Inversion temperature T_i of a standard 8422 compression glass seal as a function of the pre-heating temperature T_W.

SCHOTT glass-to-metal seals can be used without restrictions at temperatures ranging from -65°C to +250°C.

They can be used at much lower temperatures if no iron-nickel-cobalt alloys or certain alloyed special steels are used for the metal parts.

Because of an irreversible martensitic transformation, the thermal expansion coefficient of iron-nickel-cobalt alloys is likely to shift abruptly at temperatures below -65°C. Special designs using selected metals have been successfully used in the temperature range from -270°C to + 450°C.

To determine the resistance to temperatures and temperature shifts, type tests are performed on request. These tests are conducted on non-mounted glass-to-metal seals. When tests are performed on mounted seals one must take into account the fact that the different thermal expansion of a given package may transmit considerable mechanical forces to the glass-to-metal seal. To avoid damage to the glass-to-metal seal, these forces can be kept to a minimum by selecting appropriate designs and materials. We will be pleased to assist you in making these choices.

4. Package Sealing Techniques

Hermetic packages for electronic components generally consist of a seal-header (base plate) and a cap that houses the actual component. Both Cap and header are hermetic and their interconnection must also be vacuum tight.

For the assembly of glass-to-metal seals with caps to create hermetically sealed housings, various processes are used:

- Resistance welding
- Laser welding
- Press-fit welding
- Cold welding.

The most common technique is resistance welding, which is used in two variants:

- Phase controlled welding
- Capacitor discharge welding.

These techniques require a suitable design for the outer metal part of the glass-to-metal seal. Since this part is generally produced by stamping and given welding ridges in the process, the conditions for a hermetic seal of the housing are met (fig. 12).

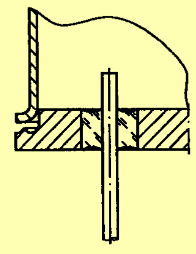


Fig. 12

Other designs include a welding ridge on the cap or the so-called slanted-edge cap, which are combined with a plane flange or a plane surface of the header (fig. 13).

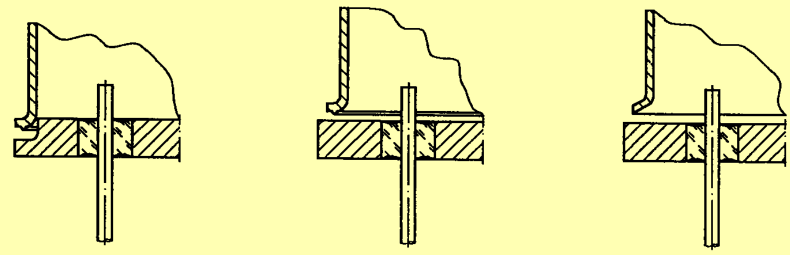


Fig. 13

Miniaturized components or components drawn from thin sheet metal can be designed without welding ridges because of the reduced contact area (fig. 14).

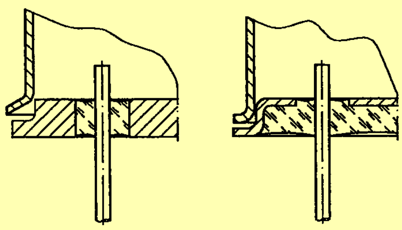


Fig. 14

Another variant of the sealing technique is used for hybrid packages. These are sealed by a rolled seam, using resistance welding (fig. 15).

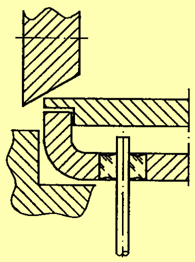


Fig. 15

To minimize the thermal and mechanical stresses to which glass-to-metal seals are exposed in all sealing processes, pressure and energy must be carefully matched.

5. Electric and Dielectric Characteristics

Insulation Resistance

The insulation resistance of technical glasses is set by the volume resistivity and the surface resistivity. At room temperature, SCHOTT sealing glasses have an electric volume resistivity ranging from 10^{13} to 10^{20} Ω cm, which makes them good insulators. But under normal conditions (T = 20°C, 50% relative humidity), this high electric volume resistivity is rendered meaningless by the surface resistivity, which is considerably lower.

The surface resistance is essentially determined by the absorption of water on the free glass surface and thus depends on the chemical resistance of the sealing glasses used. For this reason, SCHOTT uses sealing glasses with high chemical resistance.

Under normal conditions, the insulation resistance of current glass-to-metal seals ranges from 10^{10} to 10^{12} Ω, depending on the type of glass used. It is largely independent of the electric creep distance.

For even higher insulation resistance (10^{12} to 10^{13} Ω) and for use in very humid climates, special surface treatment processes can be applied by SCHOTT.

At temperatures above 100°C, the effect of the water film disappears almost completely and the insulation resistance is determined by the volume resistance alone. Since the sealing glasses are ion conductors, their electrical conductivity increases with the temperature; i.e. the temperature characteristic of the electric resistivity is negative. The temperature dependence of the electric resistivity for certain sealing glasses is shown in fig. 16.

Flashover Voltage

Glass has a high dielectric breakdown strength of approx. 20 kV/mm. But for glass-to-metal seals, the characteristic flashover resistance is that of the creep distance between the live metal elements, which is much lower.

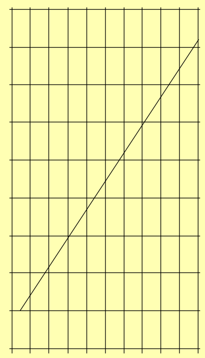


Fig. 17: Admissible alternating test voltage U_{eff} (50 Hz) as a function of the creep distance KW between two live electrodes.

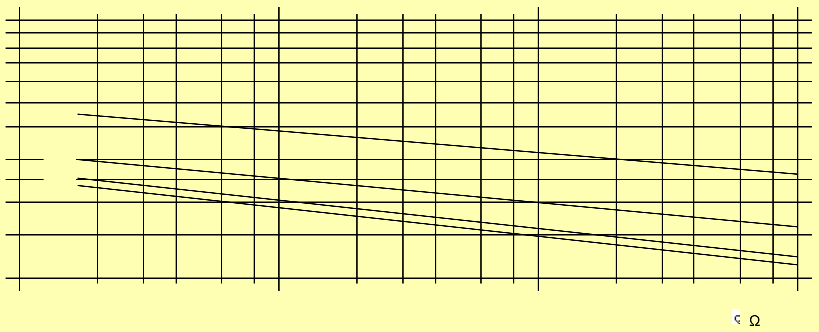


Fig. 16: Electrical resistivity ϱ of SCHOTT sealing glasses as a function of the glass temperature.

Fig. 17 shows the admissible alternating test voltage (50 Hz) as a function of the creep distance.

Dielectric Characteristics

Standard glass-to-metal seals have intrinsic capacities of 0.5 to 3 pF with dissipation factors of tan δ = 25 to 250 x 10^{-4}. The intrinsic capacity (C_E) and the dissipation factor (tan δ) of glass-to-metal seals are determined in a type test with 1 MHz at room temperature. To a great extent, these values depend on the dielectric properties of the sealing glass used and on the geometrical characteristics of the glass-to-metal seal.

Upon request, the intrinsic capacity tolerance of glass-to-metal seals can be limited to approximately ± 10%.

Current-Carrying Capacity of Conductors in Glass-to-Metal Seals

Fig. 18 shows the current-carrying capacity of wires of different sealing alloys and of copper conductors as a function of the wire diameter. The current load used in this example causes the temperature of the conductor to rise by 30 K under normal ambient conditions.

The sealed-in conductors can be exposed to higher current loads if shock loads (extremely short high-current impulses) are avoided and efficient heat dissipation is provided for. Special seal types capable of withstanding extremely high current loads (up to several thousand amps) use tubes of a sealing alloy with brazed-in solid copper pins.

When the conductors are exposed to very high current loads with steep edge pulses (power-up condition), the electrodynamic forces on the sealings (Pintsch effect) should not be neglected. Sealings for these special applications can be current-shock type-tested on request.

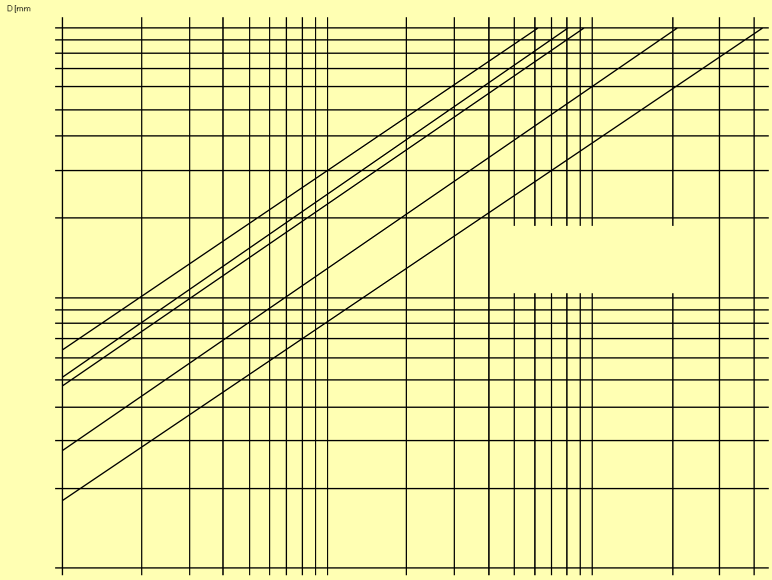


Fig. 18: Current-carrying capacity I of various sealing alloys and of copper for a temperature increase of the metal of 30 K, as a function of the diameter D of the conductor.

6. Surface of Metal Parts

The basis material of the housing consists mainly of steel or iron-nickel alloys. In addition to corrosion resistance, our customers require these components to have other functional characteristics, such as suitability for bonding and soldering. To ensure these characteristics, electroless plating or electroplating is required after sealing the glass.

Pre-Treatment

The pre-treatment for subsequent surface finishing is essentially determined by the type of metalworking used to shape glass-to-metal seals. Any trace of cooling lubricants, drawing compounds, corrosion protection agents, metal dust and metal oxides affects the adherence of metal platings and must be completely removed.

Metal platings with good adhesion and defined surface quality can be obtained with the following pre-treatment processes:

- Mechanical grinding
- Degreasing with organic solvents or aqueous solutions
- Electrolytic cleaning in aqueous alkaline solutions
- Pickling with inorganic acids to remove metal oxides.

Optimally matched pre-treatment processes are an essential prerequisite for the deposition of strongly adhering metallic coatings on the basis material.

Metal Purification Processes

Various metals can be deposited from aqueous solutions (plating solutions) under the influence of an electric current or through chemical reduction. The properties of the deposited metallic coating are essentially determined by the chemical composition of the plating solution and the conditions under which the metal is deposited. Platings can be brittle or ductile, dull or bright. Processes for depositing nickel, gold, silver, copper and tin ensure the required functional characteristics of glass-to-metal seals.

Nickel Electroplating

Fig. 19 shows the basic principle of the electroplating process, illustrated by the deposition of nickel. When nickel salts are dissolved in water, nickel ions are formed. The nickel is deposited by applying an external current to the cathode. At the same time, metallic nickel is dissolved at the anode.

To make sure that the reactions always take the same direction, direct current must be used. The individual processes at the anode and the cathode always occur simultaneously. Parameters such as the type of metal salt, concentration of the plating solution, temperature, current density and pH value influence the ongoing processes at the anode and the cathode and thus determine the properties of the plating.

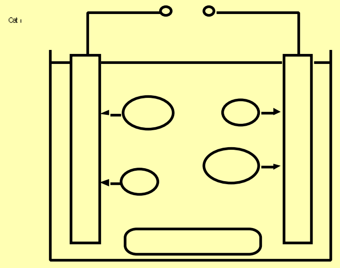


Figure 19

Chemical or Electroless Nickel Plating

Chemical or electroless plating involves the exchange of charges between the basis metal and the metal salt solution without an outside source of electricity. Electroless plating means that the electrons needed for the reduction of metal ions are supplied by a reduction agent that is present in the plating solution. This agent sets free electrons while being oxidized. The deposition process and the functional properties of the nickel plating, for example the phosphorus content of the nickel plating, are controlled by the reduction agent as well as the other components in the chemical nickel bath.

The characteristics of electroless nickel plating are:

- Uniform deposit of nickel on geometrically complex parts
- Low coating thickness tolerance
- Good suitability for soldering, bonding and welding
- Corrosion resistance.

Gold Plating

Uniform metal deposits are obtained from plating solutions in which the gold ion is present as a complex. Today, gold-plating solutions generally contain a potassium gold cyanide K[Au(CN)$_2$] complex. To improve adhesion, thin pre-gold layers have been used with good results. The pre-gold plating solutions must be compatible with the main gold plating solution. Hard gold platings for plug connections are obtained by codepositing cobalt or nickel.

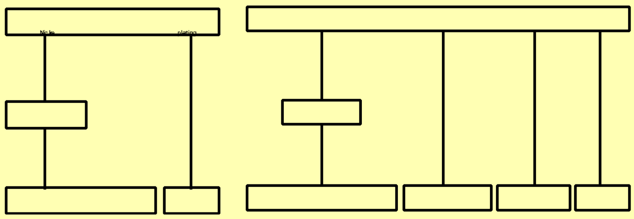


Fig. 20: Combined platings

Combined Platings

Well matched plating combinations can be used to alter the functional properties of the metal surface. Thus it is possible to reduce unwanted diffusion processes and to improve adhesion and corrosion resistance. The following figure shows typical combined platings applied by SCHOTT.

Functional Properties of Metal Platings

The following table gives an overview of the various metal platings and the resulting functional surface properties. The thickness of the plating layer is of decisive importance and an essential criterion for subsequent application.

Surface	Thickness	Functional properties
Electroless nickel plating	2-8 µm	Good corrosion protection Good wire bonding Good solderability with flux Uniform thickness distribution Good weldability Au/substrate depletion layer Solder/gold layer depletion layer
Nickel electroplating	3-12 µm	Good corrosion protection Good solderability with flux Au/substrate depletion layer Solder/gold layer depletion layer
Purest-grade gold flash	0,05-0,3 µm	Improved solderability Protection layer against tarnish/oxidation
Purest-grade gold	0,5-2,5 µm	Good alloying of semiconductors Flawless bonding of connector leads (boding wire Au or Al) Very good solderability without aggressive flux
Hard gold	0,1-2,0 µm	Wear protection: contacts, plug connectors
Silver	4-12 µm	Very good solderability without aggressive flux High electrical conductivity
Tin, tin/lead	6-18 µm	Improved corrosion protection, very good solderability without aggressive flux

7. Hermeticity

One of the foremost quality characteristics of SCHOTT glass-to-metal seals is their hermeticity.

Because of its importance to the functionality of components, the vacuum tightness of our glass-to-metal seals is constantly monitored through random sample inspections.

Tightness tests are performed with helium leakage detectors that work according to the mass-spectrometer principle.

Using helium as a test medium, modern leakage detectors are capable of tracing minute leaks of 10^{-12} mbar l/s. However, this is only possible under laboratory conditions and requires long pumping and measurement cycles.

In tough everyday usage, leakage rates of up to 10^{-8} mbar l/s can realistically be measured.

That is why SCHOTT glass-to-metal seals are generally guaranteed to a leakage rate of 10^{-8} mbar l/s; in this case, the pressure differential between the interior and the exterior is 1 bar.

In special cases and upon agreement, leakage rates down to 10^{-11} mbar l/s can be confirmed and guaranteed, because, as a rule, SCHOTT glass-to-metal seals also meet these lower leakage requirements.

The leakage rate of SCHOTT glass-to-metal seals can also be tested under non-static conditions. For example, it is possible to conduct cap welding tests with increased welding stresses and then to determine the remaining leakage rate.

8. Glass Colors

To differentiate similar products and to identify certain connections, for example polarity identification for customer processing, variously colored glasses can be sealed into the glass-to-metal seal.

The coloring does not alter the properties of the glass, except for filter glasses sealed into caps. In this case, the coloring determines the optical characteristics of the glass.

Another exception are glass seals for applications in opto-electronics. In this case, the light transmission of the glass can be considerably reduced by coloring.

Available colors for glass-to-metal seals include: green, blue, brown and black, as well as neutral glasses.

9. Glass Preforms for Glass-to-Metal Seals

9.1 Introduction / Overview

Sintered glass preforms for glass-to-metal seals are produced in a multi-stage process.

In the first stage, glass powder is produced in conventional ball mills, blended with an organic binder and spray-granulated.

The glass press-granulate is dry-pressed into the desired shape (glass moldings, green compact) in modern unaxial high-performance presses. The binder is then burned off and the glass part is sintered to create a mechanically stable glass preform.

Glass preforms can be produced in multiple configurations and a wide range of dimensions with narrow tolerances to meet the requirements of any given application.

With few exceptions, all technical glasses are suitable base materials for glass press-granulates and thus the production of glass preforms. The characteristics of the glasses are not altered. This results in a multitude of uses in practically all fields of electrical engineering and electronics.

SCHOTT also uses this process for the production of sintered glass parts from special low-melting glasses, so-called solder glasses (melting temperature approx. 400 - 700°C), whose processing is not possible or economically feasible with other techniques.

In addition to the glasses listed in this brochure, other glasses for special applications are available on request.

9.2 Glass Press-Granulate

The glass powder obtained from grinding is not directly useable for dry pressing. Therefore, the non-plastic glass powder has to be given appropriate free-flow and die-forming characteristics by adding organic binders and spray drying.

Glass press-granulate is produced by adding organic binders (and plasticizers) to the finely ground glass powder (average grain size approx. 10-20 µm) in a spray-dryer.

SCHOTT glass press-granulate offers the following benefits:

- constant bulk density
- excellent free flow
- minimized punch wear
- excellent die lubrication, easy ejection.

9.3 Sintered Glass Parts

For the manufacture of geometrically stable sintered glass parts, green compacts or glass moldings are sintered in special (mostly continuous) furnaces after the organic binder has been evaporated without residue.

Sintered glass parts offer the following benefits:

- diversity of shapes
- complex shapes
- precise dimensions and narrow tolerances
- mechanical stability
- constant weight
- no binder residues
- smooth surface, free of pores.

9.4 Dry Pressing

The hot working processes generally used in glass manufacturing are very difficult to apply to the production of small parts with complex geometries, and the tolerances obtained are generally unsatisfactory. The press and sinter technology is much better suited for such parts, and allows for comparably high geometric precision (typically < 3-5%).

The most commonly used technology for the production of sintered glass parts is dry pressing glass press-granulate. The multitude of possible press geometries is determined by two factors:

- The pressing tool is one-dimensional in the sense that the punch moves in only one direction (up or down). This excludes holes, grooves or necks perpendicular to the pressing direction

- To ensure uniform compression and, as a result, homogeneous sintering contraction, the ratio of height (dimension in the press direction) to diameter of the pressed part should not be too great. The usual limit is approximately 3:1 for solid parts or parts with more than minimal wall thickness.

9.5 Quality Inspection of Sintered Glass Parts

For sintered glass parts, the SPC control parameter that is generally inspected is not the height but the weight. Constant weight of sintered glass parts can generally be guaranteed to < 5%, provided the parts are not too small.

9.6 Applications

In addition to sintered glass parts for hermetically sealed packages (glass-to-metal seals), which are produced in large quantities, sintered glass parts are also used as insulating positioning pins, spacers, precision form parts and in many other applications.

10. Quality Assurance

SCHOTT Electronics International Holding GmbH Landshut uses a quality management system according to DIN EN ISO 9001.This quality management system, which has been certified since 1992, is continually monitored by the quality management service department and adjusted to changing conditions whenever required.

Throughout the entire manufacturing process, our products are inspected to high SCHOTT quality standards to ensure that they meet the quality criteria specified. For this purpose, SCHOTT mainly uses statistical random-test methods. Quality results are recorded by a modern Computer Aided Quality (CAQ) system, evaluated and used as the basis for constant further quality improvement. The quality of the products we ship corresponds to the high quality requirements agreed upon with our customers. In close cooperation with our customers we jointly determine the quality parameters to be inspected and the tests to be performed. The agreed quality characteristics and tests are stated in a technical product specification.

The standard quality features for glass-to-metal seals monitored by SCHOTT include the following characteristics which are of vital importance to the product:

- Dimensional and visual inspection
- Electrical insulation resistance
- Hermeticity
- Thickness of electroplated layers
- Surface adhesion tests

In addition to these standard tests, SCHOTT is equipped for a wide range of special tests and climate/temperature environment tests. These include:

- Tensile and compression tests
- Bend tests
- Solderability tests
- Thermal shock tests
- Corrosion tests, for example salt-spray tests
- Welding tests as capping tests, etc.

In keeping with our standing as a leading supplier of glass-to-metal seals for microelectronics, these tests are generally based on US Military Standards. In addition, the relevant IEC and EN Standards are applied.

Environmental testing is essentially based on MIL-STD-883 “Test Methods and Procedures for Microelectronics“. By special agreement, our products can also be tested to E 60068 environmental standards.

If in special cases a given testing procedure exists neither in our Landshut plant nor in the accredited testing labs at our Mainz headquarters, such tests can, if required, be performed by external testing labs. This applies in particular to shock, vibration and acceleration tests agreed on for special applications.

Tables of material data

Table 2

1	2	3	4	5		6	7	8		9		10		
Glassno	Main applications	α_{20-300}	Transformation temperature T_g	Glass temperatures in °C at viscosities dPas		Density	t_{k100}	log of the electric volume-resistivity in Ω cm at		Dielectric properties at 25 °C for 1 MHz		Chemical resistance classes		
		[10^{-6}·1/K]	[°C]	$10^{7.6}$	10^{4}	[g/cm³]	[°C]	250°C	350°C	DZ	tan δ [10^{-4}]	W	S	L
S-8061*	Reinforced compression seals with austenitic steels and Seals with NiFe alloys	9,3	467	677	1035	2,60	286	8,8	7,0	6,7	21	3	1/2	2
8242	Matched seals with NiCo 29 18 o. NiFe 42	4,8	470	720	1120	2,27	302	8,9	7,2	4,9	26	3	4	3
8250	Matched seals with NiCo 29 18 o. NiFe 42	5,0	492	715	1060	2,28	384	10,3	8,5	4,9	22	3	4	3
8350	Compression seals Seals with steels and NiFe alloys	9,0	520	708	1035	2,52	198	7,1	5,7	7,2	70	3	1	2
8421	Compression seals Seals with steels and NiFe alloys	9,6	525	721	1000	2,59	253	8,1	6,4	7,4	43	3	3	2
8422	Compression seals Seals with steels and NiFe alloys	8,6	540	722	1027	2,46	212	7,3	5,8	7,3	60	2	3	3
8537	Battery seals Seals with steels and NiFe alloys	9,1	480	595	745	2,75	395	10,7	8,7	7,1	10	5	4	3
8629	Compression seals Seals with steels and NiCo 29 18	7,6	529	720	1020	2,52	267	8,3	6,7	6,4	26	1	3	2
8630	Compression seals Seals with steels and NiFe alloys, increased requirements for electrolytic resistance and temperature stability.	9,1	440	660	975	2,53	317	9,3	7,6	6,5	21	3	1/2	2

*Manufactured by SCHOTT Technologies

Comments on Table 2

Column 2:

The sealing metals indicated are described in table 3.

Column 3:

$\alpha_{20\text{-}300}$: Mean linear coefficient of expansion in the temperature range from 20 to 300°C according to DIN 52 328.

Column 4:

T_g: Transformation temperature according to DIN 52 324

Column 5:

Viscosity
The indicated viscosity temperatures mark the following processing stages:
$10^{7.6}$ dPas (softening temperature). Noticeable deformation of glasses under their own weight, even after short heating periods (minutes).
10^4 (processing temperature). Central viscosity of the range from 10^3 to 10^5 dPas in which most processing techniques such as pressing, blowing, drawing are applied.

Column 7:

t_{k100} value: Temperature at which the electrical resistivity is 10^8 Ω cm according to DIN 52 326.

Column 9:

DZ: Dielectric constant
tan δ: Dissipation factor.

Column 10:

W: Resistance to water according to DIN ISO 719
S: Resistance to acid according to DIN 12 116
L: Resistance to alkaline solutions according to DIN ISO 695
W is subdivided into 5 resistance classes, S into 4 and L into 3. The higher the class number, the lower the resistance.

Table 3: Sealing Metals

Material	Designation according to DIN	Material no. DIN	Main components [%]	$\alpha_{20\text{-}300}$ [$10^{-6}K^{-1}$]	Electric resistivity at 20°C [$\Omega mm^2/m$]	Density [g/cm^3]	Curie temp. [°C]
NiFeCo,Kovar	NiCo 2918	1.3981	29Ni 18Co Rest Fe	5,4	0,48	8,3	approx. 425
NiFe,Alloy 52	NiFe 47	2.4475	51Ni Rest Fe	10,2	0,38	8,2	approx. 495
NiFe	NiFe 45	2.4472	54Ni Rest Fe	11,4	0,35	8,2	approx. 525
Construction steel (CRS)	St...... C....... Ck.....	1.02..–1.03.. 1.11..	Fe	ca. 13	ca. 0,10	7,8	–
Machining steel (CRS)	S Mn (Pb)	1.07..	Fe	ca. 13	ca. 0,10	7,8	–
Rust and acid proof steels - ferritic - (SS)	X..Cr..	1.40..–1.41..	Cr 12 – 19 Fe	ca. 11	0,55 – 0,70	7,7	–
Rust and acid-proof steels - austenitic - (SS)	X..CrNi..	1.43..–1.45	Cr 16 – 28 Ni 4 – 26 Fe	ca. 17	0,60 – 0,90	7,7– 8,0	–

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