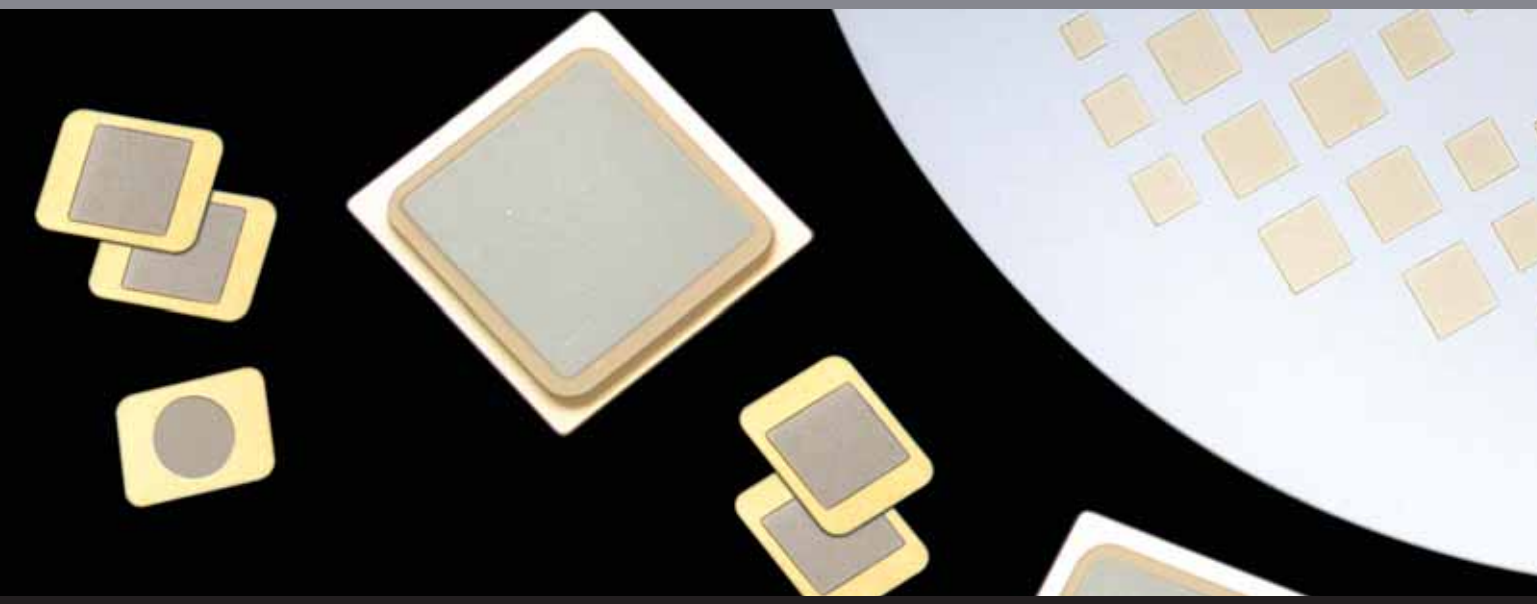

Page® Films

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saes getters

Page® Films

SAES® Thin Film Technology: the Evolution of the Getter Integration

Pioneering the development of getter technology, the SAES® Getters Group is the world leader in a variety of scientific and industrial applications where stringent vacuum conditions, ultra-high purity gases or moisture-free environments are required. For nearly sixty years our getter solutions have been fostering and supporting technological innovation in the display and lamp industries, in ultra-high vacuum systems, in vacuum tube devices, in vacuum thermal insulation and in hermetic packages. Continuous leading-edge R&D activities, advanced mass production at high quality standards, worldwide presence in sales and customer technical support have been key factors in the Group's success.
In order to specifically support the technology trend of increased miniaturization of electronic devices, such as in Micro Electro Mechanical Systems (MEMS), SAES Getters has developed the Page® film product line, consisting of getter films, a few-microns thick, that can be deposited and patterned on different substrates in a variety of shapes. SAES film getter solutions maintain suitable operational conditions of the device, either vacuum or inert gas, by keeping pressure or impurity level, respectively, under control, thus increasing reliability and lifetime of the final device. Tailor-made getter film composition and deposition patterns can be developed to meet the customer's technical requirements.
For the manufacturing of its Page films, the SAES Getters Group is ISO 9001:2000 certified and is committed to implementing a Quality Management System conforming to the ISO TS 16949:2002 automotive standard.

Customized Solutions for Device Miniaturization

The most common and technically accepted way to maintain a controlled ambient environment in a hermetically sealed device like MEMS and MOEMS (Micro Opto Electro Mechanical Systems) is to use a getter capable of chemically absorbing active gases. The technical solution to these requirements is SAES Non-Evaporable Getters (NEG), chemical pumps that absorb active gases, such as H_2O, CO, CO_2, O_2, N_2 and H_2.
To support the continuous technology efforts in miniaturizing the packaging dimensions, the SAES Getters Group has developed a film technology fully compatible with MEMS and MOEMS devices: PageWafer® and PageLid® are film getter materials that can be patterned on silicon, glass, metallic or ceramic substrates.

For consumer industrial and automotive applications

Increase MEMS performance stability

PageLid is the way to integrate a Page film inside a discrete hermetic vacuum package. Page film can be patterned with different shapes on a variety of commercially available lid materials, eliminating the need of any handling and welding of discrete getters. PageWafer is the suitable technical solution to integrate Page getter film into wafer-to-wafer bonded MEMS devices, acting as the cap wafer of the MEMS package. In PageWafer, the getter film is selectively placed inside cavities with depths ranging from a few to hundreds of microns.
The patented SAES technology allows the customization of the pattern of Page film, assuring no loose particles and optimal adhesion. Lateral dimensions of a typical pattern vary from few hundreds of microns to some millimeters. Contamination-free environments are a key parameter in the manufacturing process to keep defects under control. A state-of-the-art set up of optical and interferometer inspection systems is available in SAES Getters' class 100 cleanroom, allowing the on-line monitoring of the manufacturing quality standards for all Page materials.

In addition to material analysis and characterization of its own products, SAES Getters applies in-house analytical skills to customers' materials and devices to determine outgassing rates and residual gas compositions. A dedicated lab equipped with state-of-the-art instrumentation offers Residual Gas Analysis (RGA) and outgassing services.

Class 100 cleanroom

Extended MEMS lifetime

Page Film Competitive Advantages

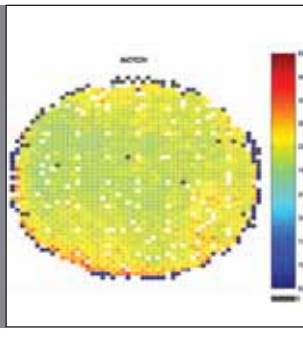
- ☐ Performance and stability throughout the device life time
- ☐ Reduced power consumption in portable devices
- ☐ Device thermal and mechanical stability
- ☐ Particle-free
- ☐ Full customization of the film pattern geometry
- ☐ Class 100 cleanroom manufacturing

SAES Competitive Advantages

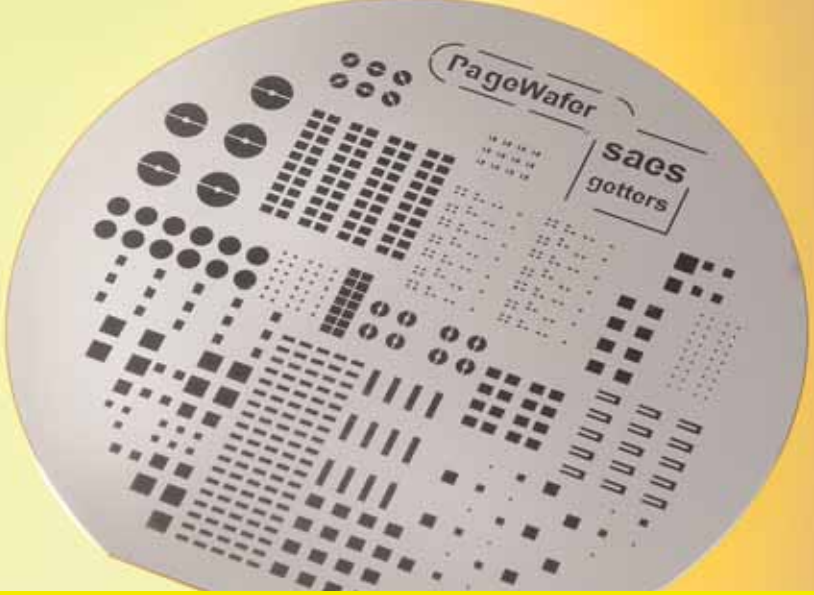
- ☐ Full control of every process step, from in-house manufacturing of raw getter materials to final wafers testing.
- ☐ Residual gas analysis lab equipped for direct measurement in sealed hermetic MEMS packages (detection limit to 10^{-6} ccmbar).
- ☐ Analytical capabilities for the measurements of materials outgassing.
- ☐ In-house modeling capabilities to support any hermetic package design (ANSYS).
- ☐ Sorption test capability according to the ASTM F 798-97 standard.
- ☐ A global sales & service network, offering dedicated resources and expertise around the world, to best support customers at any product development and manufacturing stage.

→ RGA vacuum bench at SAES corporate labs

→ Pressure distribution uniformity after bonding process using Page Film.



PageWafer®



HIGHLIGHTS

General Features

- ☐ Easiest getter integration into wafer-level MEMS
- ☐ Compatible with silicon and glass substrates up to 8" diameter
- ☐ Composition and thickness tailored to process and performance requirements
- ☐ Highest gas sorption performance
- ☐ Homogeneous vacuum pressure all over the wafer surface
- ☐ No loose particles
- ☐ Compatibility with all MEMS vacuum bonding processes
- ☐ Allows high Q-value in resonators and gyroscopes

Applications

- ☐ Gyroscopes and accelerometers
- ☐ Infrared sensors
- ☐ RF devices
- ☐ Pressure sensors
- ☐ Resonators
- ☐ Optical devices
- ☐ Biomedical devices
- ☐ Time management crystal devices

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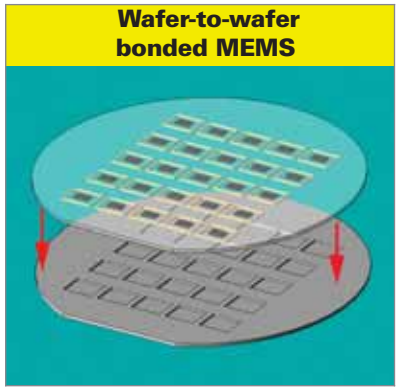
A Key Technology

Low cost and reliability are the main driving forces for the successful commercialization of Micro Electro Mechanical Systems (MEMS) devices. One possible way to decrease the cost of MEMS devices is shifting from ceramic packages down to wafer-to-wafer bonded MEMS, in which the silicon wafer becomes itself part of the package. PageWafer® is SAES® Getters' technical solution to integrate the Page® getter film into wafer-to-wafer bonded MEMS devices that need vacuum or a moisture-free gas-filled environment to operate. Page films, with thicknesses down to a few microns, are the viable and proven way to ensure long term stability of hermetically sealed devices, because they remove by chemical sorption all active gases, including H_2O, O_2, CO, CO_2, N_2 and H_2. PageWafer is a silicon, glass or ceramic cap wafer with a diameter up to 8", which acts as the cap wafer of the wafer-level MEMS package. PageWafer's Page film is patterned to fit MEMS designers' specific requirements. PageWafer does not include any MEMS moving part. PageWafer has been proven able to increase the Q-factor of a vibrating MEMS structure, by enhancing the vacuum level and its reliability in the wafer-to-wafer bonded MEMS, at the same time reduce its power consumption.

A Customized Solution

PageWafer is the most advanced way to integrate a getter film in vacuum sealed MEMS. It guarantees that during MEMS device lifetime there will be no performance drift due to vacuum degradation, even in harsh environments, such as automotive applications. PageWafer contributes to a homogeneous pressure across the entire wafer area, especially in large diameter wafers where conductance problems limit the lowest achievable pressure at the center of the wafer during the MEMS vacuum sealing.



The Page film is SAES' patented zirconium alloy, whose composition and morphology are optimized to maximize sorption performance and reduce activation temperature. Thickness of the getter film is in the range of few microns, depending on the quantity of gas to be absorbed, while pattern dimensions can be fully customized from a few hundreds of microns up to millimeters. PageWafer getter film can be patterned inside cavities with depths varying from a few to hundreds of microns, as well as on flat wafer surface. A key characteristic of PageWafer is its capability to be activated during the sealing/bonding process without the need of dedicated activation steps.

PageWafer Characteristics

The PageWafer film is mechanically stable with respect to temperature cycles (tested up to 500 temperature cycles from -40 to 150 °C) and it complies with the semiconductor industry adhesion test (ASTM D 3359-02). PageWafer can be safely handled in air, as the Page film is supplied in a stable, passivated form.

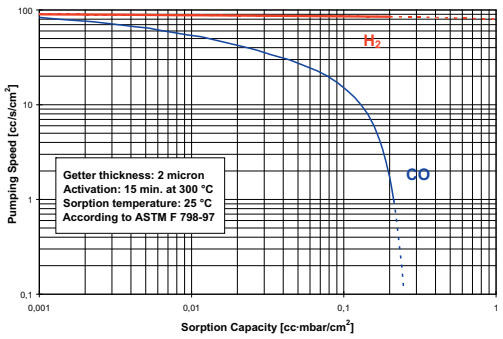
In terms of activation temperatures, PageWafer is compatible with the major wafer-to-wafer MEMS bonding techniques such as glass frit, anodic, direct fusion and eutectic paste bonding processes, as shown in the table below.

Bonding type	Bonding/ activation temperature	Typical bonding time	Page performance (a.u.)
Eutectic (AuSn)	300 °C	15'	1
Anodic	350 °C	30'	1.5
Eutectic (AuSi)	400 °C	30'	2
Glass frit	450-470 °C	30'	2.5
Low temperature direct	450-500 °C	30'	2.5

Typical pumping speed vs capacity plots for CO and H_2 (according to ASTM F 798-97) are reported in the chart on the right.

The other active gases, such as CO_2, O_2, H_2O and N_2, are pumped by the Page film with different sorption capacities, as summarized in the following table.

Page film sorption curves for H_2 and CO



Relative Sorption Capacity for Different Gases at Room Temperature (a.u.)						
CO	CO_2	O_2	H_2O	N_2	H_2	Noble gases
1	1	3	6	0.5	>50	N/A

When the Page film is operating in hot conditions, as it is during the bonding step, its sorption capacity for the various active gases is much higher than its capacity at room temperature (almost two orders of magnitude at 450 °C). This is because the higher temperature promotes the diffusion of the chemisorbed gases from the surface of the getter film into its bulk. This higher capacity allows the Page to also act as a "process getter" allowing the sorption of the larger quantity of gases desorbed during the high-temperature bonding process.

Depending on the bonding process, the Page film can be patterned inside bonding frames of glass frit or eutectic paste. PageWafer also fully withstands standard wafer chemical cleaning processes, such as megasonic DI water, RCA and HNO_3 cleaning.

PageWafer gas sorption capacity and speed can be customized to any wafer-level MEMS device, through the adequate sizing of the Page film thickness and of the coated area.

Typical Page Film Characteristics	
Getter activation	15 min. at 300 °C in vacuum or noble gas
Film density	~6·10³ kg/m³
CTE (bulk)	~6·10⁻⁶ m/m/°C
Young's modulus (bulk)	67 GPa
Stress value at rupture	120 MPa
Electrical conductivity	>20 kS/m
Storage temperature / Shelf life	25 °C / 1 year in dry N_2

PageWafer®

The SAES Getters Group manufacturing companies are ISO9001 certified, the Asian and Italian companies are ISO14001certified also. Full information about our certifications for each company of the Group is available on our website at: www.saesgetters.com

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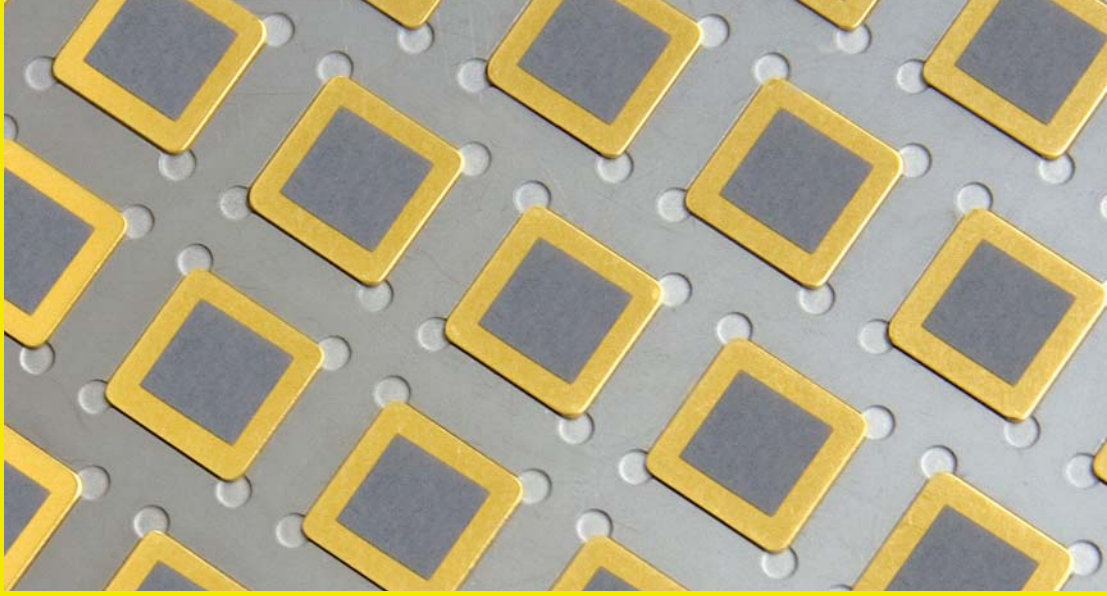
PageLid®



HIGHLIGHTS

General Features

- ☐ Easiest getter integration into discrete MEMS packages
- ☐ Custom patterning on glass, ceramic and metal lids
- ☐ Getter composition and thickness tailored to customer requirements
- ☐ Highest gas sorption performance
- ☐ No loose particles
- ☐ Compatible with all MEMS vacuum bonding processes
- ☐ Allows high Q-values in gyroscopes and resonators

Applications

- ☐ Gyroscopes and accelerometers
- ☐ Infrared sensors
- ☐ RF devices
- ☐ Pressure sensors
- ☐ Resonators
- ☐ Optical devices
- ☐ Biomedical devices
- ☐ Time management crystal devices

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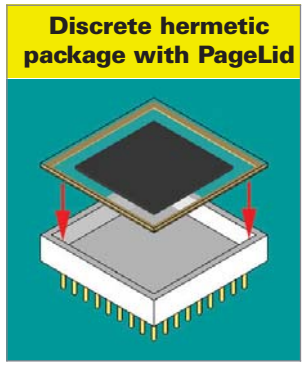
A Key Technology

PageLid® is SAES® Getters' advanced technological solution for the integration of the Page® thin film into discrete hermetic ceramic or metallic packages for vacuum or inert gas sealed devices, particularly MEMS. It delivers long-term vacuum stability, thus guaranteeing against any performance drift due to vacuum degradation throughout the MEMS device lifetime, even in harsh environments such as in automotive applications.

PageLid is SAES Page film applied to metallic, ceramic, glass or germanium lids in customer-defined patterns. Direct getter film patterning on the lid avoids welding of bulk getters into discrete miniaturized hermetic packages, reducing assembly time and final costs. Page film significantly reduces outgassing from the lid, through chemical sorption of active gases, including H_2O, O_2, CO, CO_2, N_2 and H_2.

A Customized Solution



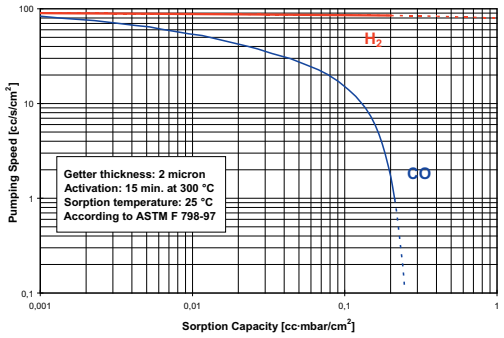
PageLid substrates can be any material currently used for manufacturing lids for hermetic packages, from glass, germanium, metal or ceramic. PageLid sizes and shapes can fit any package base, while the Page film can be patterned on the lid, even with a solder preform or glass frit present. When a transparent central window is required, the Page film can be deposited onto the frame without affecting the solder preform. Page film can also be patterned onto ceramic plates that are subsequently singulated into PageLid products. Dimensions of the Page film pattern cells can vary from hundreds of microns up to some centimeters, while various shapes can be patterned as well (circular, rectangular, ring-shaped).

PageLid Characteristics

Page film consists of SAES' patented zirconium alloy, whose composition and morphology are optimized to maximize sorption performance and reduce activation temperature. Page film complies with the semiconductor industry adhesion test (ASTM D 3359-02). Page film is also mechanically stable with respect to temperature cycles used in automotive applications (tested up to 500 temperature cycles from -40 °C up to 150 °C). PageLid can be safely handled in air, since its getter film is supplied in a stable, passivated form. It is clean room compatible, since it is particle free. PageLid is activated during the heating and bonding stage of the sealing process.

PageLid has been proven compatible with the solder preform hermetic bonding process and the projection welding process, sometimes requiring an additional activation step at high temperature under vacuum. PageLid absorption capacity for active gases coming from outgassing or from possible leaks can be properly sized to ensure the device design lifetime. The gas pumping speed can be tuned to contribute to evacuation time reduction when particular package geometries prevent a fast package evacuation. Typical pumping speed vs capacity plots for CO and H_2 (according to ASTM F 798-97) are reported in the chart on the right.

Page film sorption curves for H_2 and CO



The other active gases, such as CO_2, O_2, H_2O and N_2 are pumped by the Page film with different sorption capacities, as summarized in the following table.

Relative Sorption Capacity for Different Gases at Room Temperature (a.u.)						
CO	CO_2	O_2	H_2O	N_2	H_2	Noble gases
1	1	3	6	0.5	>50	N/A

A typical activation requires a minimum of 15 min. at 300 °C. If Page film is activated at higher temperatures or for longer time, its performance is improved as shown in the table below.

Typical activation temperature	Typical bonding time	Page performance (a.u.)
300 °C	15'	1
350 °C	30'	1.5
400 °C	30'	2
450-500 °C	30'	2.5

When the Page film is operating in hot conditions, as it is during the bonding step, its sorption capacity for the various active gases is much higher than its capacity at room temperature (almost two orders of magnitude at 450 °C). This is because the higher temperature promotes the diffusion of the chemisorbed gases from the surface of the getter film into its bulk. This higher capacity allows the Page to also act as a "process getter" allowing the sorption of the large quantity of gases desorbed during the high-temperature bonding process.

Typical Page Film Characteristics	
Getter activation	15 min. at 300 °C in vacuum or noble gas
Film density	~6·10³ kg/m³
CTE (bulk)	~6·10⁻⁶ m/m/°C
Young's modulus (bulk)	67 GPa
Stress value at rupture	120 MPa
Electrical conductivity	>20 kS/m
Storage temperature / Shelf life	25 °C / 1 year in dry N_2

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