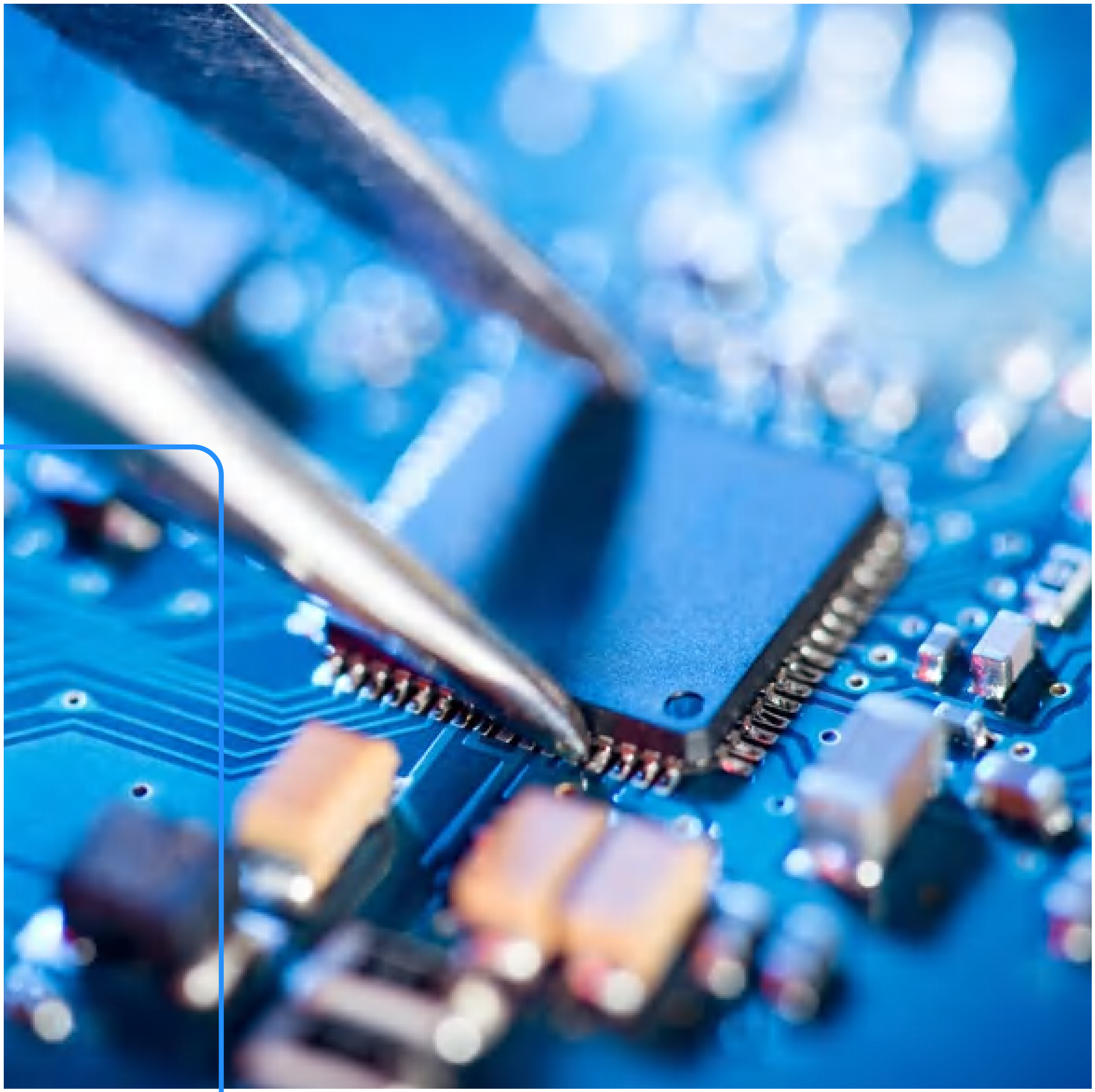
Elkem

Silicones

Electronics

Engineers' special tips to protect electronic components



Delivering your potential

Protecting Electronic Components and Technologies

Secure and sustainable silicone solutions

1 Summary at a glance

What information we'd like to share

Our goal in this eBook is to provide relevant information on the use of silicones to people and companies who use electronic parts as critical components in their products and processes. From small handheld communication devices to immense ocean-going vessels, from smart appliances for the home to automated industrial plants, electronics are more than ever at the heart of the Fourth Industrial Revolution. Electronics are enabling us to improve people's lives globally and produce better products and services, and silicones are present in many varied applications, becoming the material of choice to protect electronic parts and connections.
The true mega change in paradigm today is that electronics have moved from being peripheral components, particularly in transport applications, to become the very core of our energy in mobility. This shift to electrically powered vehicles on land, sea and air will be one of the main elements to enable us to reduce pollution and our carbon imprint and lower our dependency on fossil fuels. In short, durable and properly protected electronics are the key to countering global warming and controlling climate change for a sustainable future.

Who is this paper intended for?

■ This study is primarily addressed to Electrical and Electronics Engineers in all industries involved in designing, producing and maintaining innovative solutions to improve performance and ensure safety and security for a great diversity of applications and markets.

■ This study also provides key information for non-specialist decision makers, including Executive Managers, Industrial and Procurement Managers, as well as Financial Officers or Marketing and Salespeople, to enable them to understand how Silicone Technology works and why it is essential to improve their competitiveness.

How can I find out what's most relevant for me?

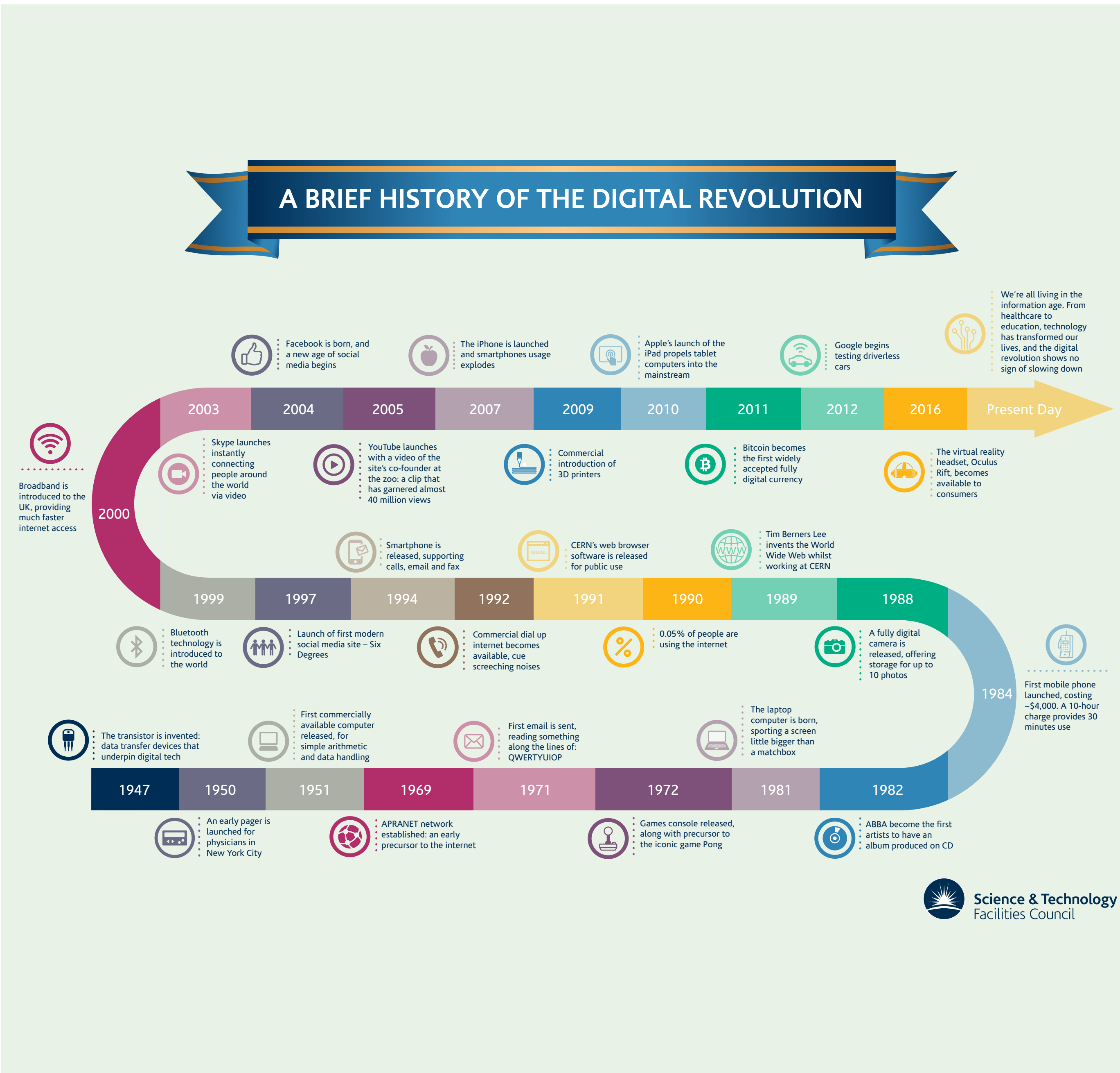
■ This paper has been organized in a user-friendly manner, **allowing readers to study each section in the way that suits them best and at the level of detail they require.**
This has been done by organizing the information at four levels:

- A one-line summary at the head of each section
- The key facts and figures in the right-hand margin of each page for a quick read-through
- Detailed technical or applications facts to substantiate the information needed for people in their specific field or area of responsibility
- Direct links to our Elkem Silicone Web pages and to the sources used.

Why Elkem Silicones?

■ Elkem Silicones is a fully-integrated global silicone manufacturer, providing customized solutions to a wide range of industries for multiple applications
■ Elkem Silicones has been active in the development and protection of electrical and electronic components from their very emergence and has deep-seated knowledge and experience in materials science & engineering, as well as the people and expertise you can talk to about innovation
■ Elkem Silicones is particularly aware of the need to address a complex set of issues to provide performance and protection of the most critical electronics components and is monitoring and participating in with the latest innovative initiatives.

2 Reliable electronics for economic development and societal change



Electronics: the heart of the Fourth Industrial Revolution and a sustainable future

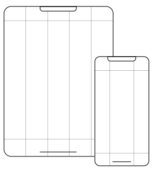
Electronics is the branch of science and technology which designs and uses printed circuits, transistors and microchips to amplify and rectify electrons moving through semiconductors, conductors, vacuums or gasses to produce a wide range of signals and functions in purpose-built devices. Most historians date the beginning of modern electronics as 1947, when printed circuits and transistors were first invented, quickly generating a new generation of sound devices and computers, to be followed by the development of communication and control devices[1].

The last two decades of the 20th Century saw the rapid introduction of electronics and IT into businesses and our personal lives, with the advent of most of the devices we take for granted today: computers, mobile phones, digitized sound, the internet, social media, etc. In the first two decades of the 21st Century, digital technology, widespread development and adoption of mobile devices and smart phones, the development of AI, the beginnings of IoT and the advent of hybrid transport vehicles moved electronics even further into every aspect of our lives. The decades to come (from now to 2050) will see digital technology and electronics take center stage in all our lives and become the main source, among other things, of our energy needs, for example in electrically-powered cars, but also in all our transport systems on land, sea and in the air[2].

Electronics will not only be at the very heart of our individual lives, including our health and wellbeing, but will be a key for our societies in lessening our dependence on fossil fuels, reducing pollution and our carbon imprints, thereby enabling us to face the challenge of global heating and climate change. To achieve these life-changing and societal goals, electronics will have to be more efficient than ever, more miniaturized, more reliable, safer, smarter and cost-effective.
This can only occur if electronic parts, components and connections are properly protected, avoiding breakdowns that could potentially hamper productivity, cause stoppages and, above all, endanger human life[3].

[1] Electronics: the great transformation from the mid 20th Century to the 21st Century
[2] Electronics: the key to a sustainable future
[3] Protection of electronics: the key to success

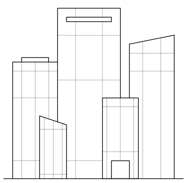
The main areas of electronics applications today and in the future



Personal mobile, computing, communication and entertainment applications

Most of us think first and foremost about electronics as devices which we carry with us everywhere, such as smart phones, tablets and other mobile tools. Indoors, we use our computers, modems, scanners and printers for work at home or in the office[4]. For entertainment, the applications are growing all the time, with innovative streaming to enjoy our favorite music images and video games. The list of priorities in this area includes:

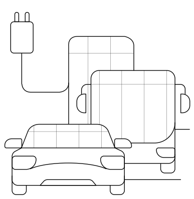
- Greater miniaturization, storage and performance features
- Higher resolution for both sound and images, as well as greater interactivity
- Resistance to shocks, water and extreme weather conditions to achieve longer hardware life.



Sustainable home applications

Electronics play an increasingly important role in improving comfort and reducing the cost of how we cook, clean and control the temperature in our homes. As homes become more electronic, people are also looking for smart systems to obtain crucial information, including the use of cost-efficient and sustainable energy, with smart meters and grids in networked electricity supply systems[5]. As home electronics become almost as sophisticated as industrial applications, with smart homes and domotics (home automation) going mainstream, people expect the following advantages:

- Ease of use and automated and/or smart functions
- Lower energy and water consumption, as well as cost-efficient and sustainable supply alternatives
- Durable, reliable, safe and reparable devices and systems.

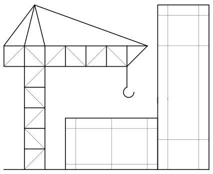


Transport applications on land, sea and in the air

Electronics are the main source today for improving mobility, comfort and reducing the cost of transportation, for both personal electrical and hybrid vehicles, as well as public urban and intercity transport. Electronics in these vehicles (and in the foreseeable future, for air and sea transport for both civil and military applications) are making the jump from being a support system for traditional fossil-fuel combustion engines to being the main source of energy. These electronic applications are especially demanding and must:

- Ensure thermal management systems (TMS) are as efficient as possible, in terms of energy and heat control in current technologies and new power sources
- Provide the right balance between insulation, conductivity and conduction for all climates
- Preserve the long-term capacities of lithium-ion batteries and, in the future, other storage systems, including hydrogen-based batteries
- Protect against failure due to vibrations, extreme environmental conditions, chemical or corrosive aggression, etc.

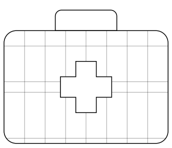
[4] Personal electronic devices: our primary link to the world
[5] Smarter and better homes



Industrial applications

Industrial automation, in what is referred to as the Fourth Industrial Revolution or Industry 4.0, is essentially geared to making manufacturing smarter through greater connectivity between machines and systems on the assembly line[6]. Electronics are at the heart of the innovative technologies being developed and deployed in such areas as the Internet of Things (IoT), which enable real-time tracking of operations, supply-chain coordination, predictive maintenance and a whole series of other interrelated functions to achieve greater productivity, longer machine life and ultimately better and safer working conditions. In this world of continuous innovation and improvement, electronics must obviously be as reliable and foolproof as possible to avoid downtime or errors due to data processing. They must ensure:

- High-performance and flexible solutions that can be constantly adapted to changing industrial needs and customer demand
- Components and connections (both cable-based and wireless) that can withstand the aggressions of industrial production: heat management, resistance to vibrations, protection against toxic or corrosive agents, etc.
- Lower energy and water consumption, as well as cost-efficient and sustainable utility supply alternatives
- Long-lasting, well-maintained and reparable parts and systems to keep production flowing and ensure human safety.



Medical and health applications

There are many fields where electronics are enabling disruptive changes, but medical applications are among the fastest and most spectacular areas of progress, impacting all our lives and daily health. Electronic systems enable remote diagnosis and surgery, ultra-precise scanning and imaging devices, to name but a few. And, of course, in the development of medicines and treatments (with the record rollout of Covid-19 tests, tracking, sequencing systems and vaccines being the most recent visible example), electronics and medicine are more than ever linked. Given the accuracy and the totally clean environments required, medically related electronics must be:

- Protected from any form of interference to avoid errors or false analyses, including not only physical shielding from external materials, but also electromagnetic interference
- Able to self-analyze crucial functions, if and when they occur and transparently transmit the data preventively and in real time
- As responsive as possible to inform medical practitioners and patients of problems that need to be resolved rapidly.

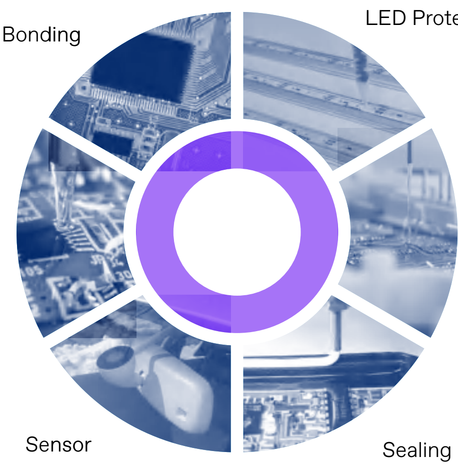
[6] Electronics: the heart of the Fourth Industrial Revolution

3 Protecting electronics: the key to success

Electronics must be as foolproof as possible in all applications.

As we have seen above, electronics systems are so crucial in our lives that to function properly and safely, circuits and components must be protected to counter everything from extreme environmental conditions, contaminants, shocks and vibrations, as well challenges that are specific to each application.
One of our internal electronics experts sums up the wide number of considerations that must be integrated in each application:
"The main challenge for manufacturers of electronic products is to ensure that their electrical and sensitive electronic parts work in a safe and reliable way, adjusting to components in very different applications. On the one hand, personal devices are becoming ever smaller and parts are lodged in increasingly confined spaces, generating more heat and stress.
At the same time, larger electronic applications, in particular engines and power sources, are becoming bigger and generating unprecedented levels of energy, often in very harsh environments. Also, industry and medicine are making giant leaps thanks to electronic breakthroughs and will determine our global wellbeing in the future.[7]
For all these applications, users are demanding higher performance, greater reliability and durability, as well as more cost-effectiveness. Proper productivity and durability can therefore only be achieved through an understanding of the various protection techniques available, using the appropriate materials. Silicones are today increasingly one of the materials of choice due to their intrinsic qualities and versatility, but they must be carefully selected, installed and tested."

Product selection guide



Key benefits for Electronic Silicone Solutions

- Excellent ageing stability long term thermal & chemical stability
- Thermal management from thermal insulation to conduction performance
- Low ionic Low volatile
- Low density for weight reduction when using silicone foams
- Flexible rheological properties for easy processing

[7] Understanding protection techniques and materials

An overview of technical solutions

To achieve protection in the great diversity of electronic applications, electrical and electronic engineers have access to several different and complementary techniques, summarized in this chapter.

Potting and encapsulation

Potting and encapsulation are two main and basic techniques used to protect sensitive and critical electronic components from diverse threats, including harsh environmental and climatic conditions, corrosive chemical aggression and exposure to heat and fire.

How do they differ and how are they complementary?

Potting is the process of partially or completely filling or embedding the electronic component or assembly in an enclosure with a resinous material such as silicone for the purpose of providing resistance to shock and vibration, as well as creating a seal against moisture, dust, solvents, and corrosive agents. Potting materials are also used to aid with electrical insulation, flame retardancy and heat dissipation[8].

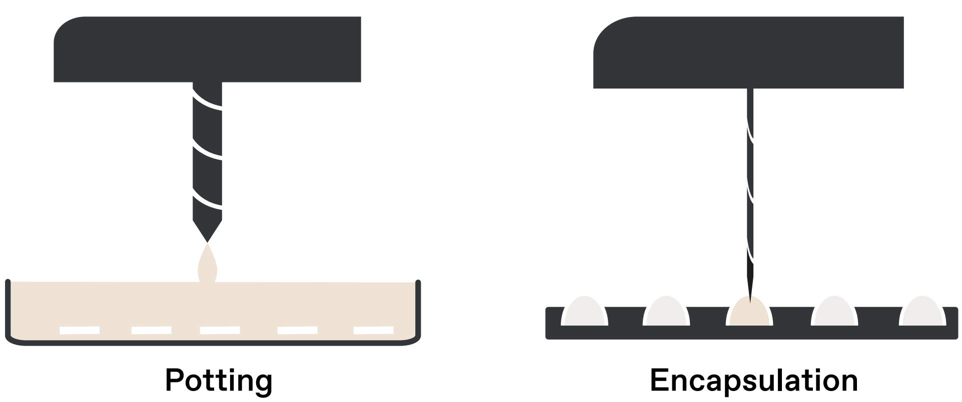
Encapsulation is a similar process to potting but uses a process whereby the component is generally dipped into a mold and then placed in a space, without necessarily filling the entire cavity. The purpose of encapsulation is therefore to create a protective "shell" around the component, without embedding it. Encapsulation, like potting, provides resistance to shock and vibration, as well as creating a seal against moisture, dust, solvents, and corrosive agents[9]. Encapsulation is also used to aid with electrical insulation, flame retardancy and heat dissipation. The advantage of encapsulation, when this is required and possible, is that the encapsulated part, since it is not permanently integrated into the final part, can be accessed and/or more easily replaced.

Making the right choice for each application

The key to determining whether potting or encapsulation is best for any application is based on several factors, including the operating and environmental conditions of the final product, the physical properties required for the materials being used and the processing requirements and capacities of the manufacturer.

Silicones are increasingly the materials of choice for potting or encapsulating sensitive electronics such as sensors, actuators, central processing units (CPUs), printed circuit boards (PCB) and other assemblies because of their excellent wetting capabilities, which minimize air pockets and other imperfections, thus making electronic devices fully resistant to external aggression[10].

[8] Potting: a complete sealing and bonding technique
[9] Encapsulation: an efficient and flexible solution
[10] Silicones are increasingly the material of choice



Sealing and bonding

The assembly of sophisticated electronic systems requires the use of different and very precise adhesives, which replace soldered or welded joints, to both bond and shield different component arrays. This is especially useful for complex assemblies of materials that cannot be submitted to high-temperature processing[11]. The keys for efficient sealing and bonding are, first and foremost, that the material used provides proper and durable adhesion that is resistant to such factors as temperature changes, vibrations and corrosive substances. Sealing and bonding materials must also enable accurate positioning at high production rates, thus improving quality and productivity.

Adhesives, at different levels of viscosity, can be applied manually or automatically, to provide a bond with variable flexibility according to need, absorbing differential movement and dilation of components or adapting to changes in temperature[12]. The liquid product is applied to one of the assembled parts and then cured to achieve the required physical and mechanical properties.

This process protects sensitive components from dust, moisture, corrosive substances or extreme temperature changes.

In industrial manufacturing, wet seals are frequently used as FIPGs («formed in-place gaskets») an uncured wet seal is set into the parts and then further processed. The CIPG procedure («cured in-place gasket»), enables processing only after the sealant has cured.

Silicones are commonly used to seal and bond substrates in the assembly of printed circuit boards (PCBs) and modules and are the only type of adhesive that will adhere to a silicone substrate.

Silicone solutions are particularly useful for assembly applications on or near sensitive electrical and electronic components since they do not release any corrosive by-products. Some silicones like silicone foam are also low-density materials and therefore lightweight, useful for handheld devices, for example, but also in transportation applications, contributing to lower energy consumption.[13]

Conformal coating

A conformal coating is a protective (and usually very thin) chemical barrier or polymer film applied to sensitive electronic components such as printed circuit boards (PCBs). Its main function is to prevent water, moisture or other invasive substances from damaging the equipment. These coatings must be made with the right materials according to exacting specifications to enable vacuum sealing of complex-shaped or miniature parts that cannot be subjected to thicker encapsulation or potting processes[14].

Its intrinsic characteristics, in particular its thinness (sometimes down to a few microns), makes conformal coating a particularly environmentally friendly solution, without sacrificing protection or dielectric strength. It must nevertheless be used in applications where thin coating is sufficient as a protective barrier.

Silicones are particularly well adapted to conformal coating because they can be tailor-made to provide the coverage needed (in one or several layers) and can be adapted to a great variety of manufacturing processes and application techniques, including state-of-the-art automated and robotized systems. This results in greater precision, faster processing times and ultimately improvement of productivity and cost effectiveness[15].

[11] Ensuring protection and adhesion
[12] Manual or automated processing
[13] Safe sealing and bonding solutions in sensitive environments
[14] Conformal coating: for ultra-thin sustainable protection
[15] Processing and productivity gains

4 Principles of material sciences to ensure electronic protection

Understanding and selecting the right materials for each application

In previous chapters, we have described and analyzed the various applications and techniques available for protecting critical electronic parts in a wide range of industries. In this chapter, we take a close look at the various materials available to get the job done properly, safely and durably.

For several years now, conventional materials such as glass, metals and ceramics have been replaced by polymers (homopolymers, copolymers, composites, complexes, blends of small molecules, and alloys) to protect electronic, microelectronic, and nanoelectronic systems. This shift has come about quite naturally because these new materials offer highly diversified molecular characteristics and specific electrical, electronic, mechanical, physical, chemical, and optical features. [16]

These advantages enhance the performance of the final product or end use, but also contribute to improving processing since they speed up production, reduce weight and volume, propose greater versatility for potting, encapsulating or coating complex shapes and miniaturized parts and ultimately result in better quality, longer product life and greater cost-effectiveness.
However, the growing complexity of electronic systems and the wide range of applications means that the materials chosen must meet multiple criteria, which can only be covered through in-depth knowledge of the materials used. [17]

Silicones, which are available in a wide variety of chemical combinations and in different forms, including elastomers and fluids (which we describe in a section below in this eBook) can be adapted or tailor-made to fulfill a host of requirements. Nevertheless, and to be objective, there are some trade-offs when considering other materials. Elkem experts work closely with their customers to analyze different needs, to propose silicones when these are optimal, but also to consider complementarity with other polymers.

For example, let's compare the intrinsic properties of epoxies versus silicones. [18]

- First, silicones offer better heat resistance (up to 200°C) and yellowing resistance than epoxies (limited to 120°C)
- Second, epoxies are generally harder than silicones after curing, which can be a drawback or an advantage depending on the application
- Epoxies generally stronger bonding strength than silicone glues, but silicone adhesion can be modified and optimized to stick to various substrates and offer more flexibility once they have been cured.

Furthermore, both epoxy resins and polyurethanes present higher shear modulus than silicones, which are important features in hard and resistant systems but can be a drawback when re-workability and ease of processing are the awaited benefits.

[16] Key criteria of material sciences for protecting electronics
[17] Silicones: a material of choice
[18] Epoxies versus silicones

Comparative chart of each material

On this table, we summarize the basic features of silicone materials and compare these to the performance of polyurethanes and epoxy resins.

		Silicones	Epoxy Resins	Polyurethanes
Temperature range and elasticity	Heat resistance	Good	Poor	Poor
	Temperature range, °C	-50 to 200	-50 to 150	-30 to 120
	Elasticity	Elastomer - Gel	Rigid resin	Rigid resin - Elastomer
Strength, adhesion and resistance features	Modulus	Low	High	High
	Mecanical strength	Medium	Strong	Strong
	Adhesion strength	Medium - High	High	Medium
	UV Resistance	Excellent	Poor	Poor
	Ozone stability	Good	Poor	Poor
	Ionic impurities	Minimal	Medium	Medium
Flame retardancy and dielectric behavior	Flame retardancy*	Self-extinguishing	Non-Self-extinguishing	Self-extinguishing
	Dielectric stability	High	Medium	Low
	Coeff. Therman Exp.	High	Low	Medium

*As a base material, silicone demonstrates flame retardant properties comparable to UL94-V0.

One of our internal experts sums up the fast pace of change in electronics and how important it is to work collaboratively:

“When one considers how quickly electronics are evolving and how, every day, new applications are being developed in dozens of industries and thousands of specific products or systems, it is important to examine options with experts and take no possibility for granted. Silicones are indeed increasingly a material of choice because of the huge range of possible formulations and features, but they must be carefully considered and tested, both in terms of processing and end user benefits. Silicone R&D specialists, process engineers and product developers must therefore work hand-in-hand to align their needs and implement efficient future-proof solutions. The key words to achieve this are: **collaboration and agility.”** [19]

[19] The need for expert analysis

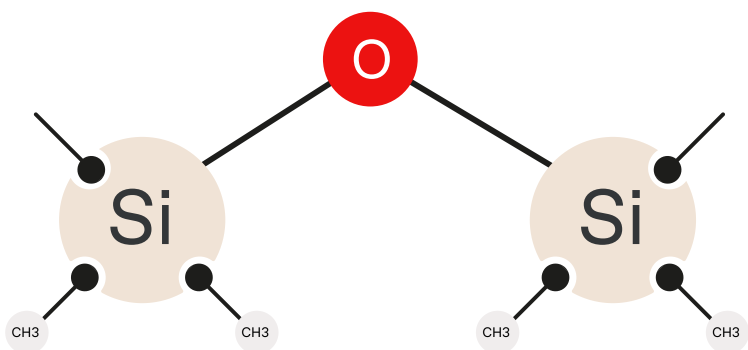
The underlying chemistry of silicone materials

As we have said above, silicones are used in a wide range of applications to protect electronics, from hand-held communication devices to large transport vehicles, via household appliances and medical applications. Their intrinsic versatility originates in the fact they are polymers that contain silicon, a naturally occurring nonmetallic chemical element of the carbon family, which is extremely sustainable because it makes up almost 28% of the Earth's crust, surpassed only by oxygen. [20]

This quartz is combined with carbon, hydrogen and oxygen and, in some cases, other elements to produce semiconductors and silicones.

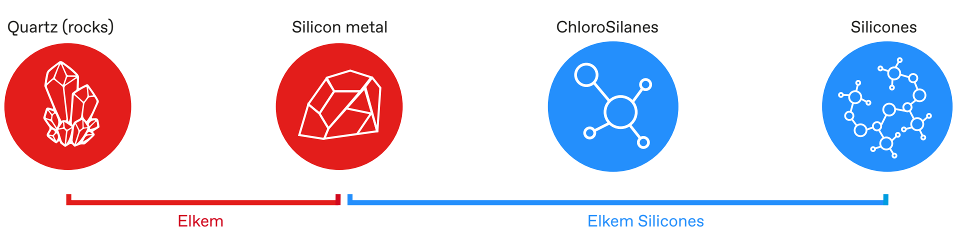
Silicones are made up of polyorganosiloxanes, where silicon atoms are linked to oxygen to create the siloxane bond. The remaining valences of silicon are linked to organic groups, mainly methyl (CH3):

- PolyDiMethylSiloxane
- Phenyl, vinyl, hydrogen



The basic structure of silicone materials

How do we get silicon raw materials to silicone products?



Transforming silicon raw materials to silicone products

[20] Silicon: an abundant and sustainable resource

What sets silicones apart?

The molecular structure of silicones is very different from that of epoxies and other organic polymers. The nature of the siloxane bonds (-Si-O-Si-) that form the backbone of silicone compounds gives silicones properties that are not found in other organic polymers. The geometry, stability, and high binding energy of these siloxane bonds make silicones highly flexible and much more resistant to high temperatures than other polymers. It is this rare combination of flexibility and high temperature resistance that sets silicones apart. [21]

The main features of silicones include:

■ Thermal stability (from -80°C to 250°C, even 300°C on specific composition), ensuring proper viscosity in a wide temperature range, which means good upstream process uniformity (excellent spread and coating capabilities) and reliable downstream operating performance in demanding conditions

■ Very good bonding features to a variety of substrates

■ Strong resistance to natural ageing (oxidation, UV), extreme weather conditions, corrosive chemicals and radiation

■ Excellent dielectric properties that remain sufficiently constant over a wide temperature and frequency range and thermal conductivity properties in specifically formulated grades

■ Excellent environmental compatibility and no known harmful effects

■ Water-repellent surface (beading effect), low moisture uptake and complete sealing to avoid all forms of outside invasions

■ Low hardness compared to the other polymers, enabling the production highly flexible materials with a linear thermal expansion coefficient approx. 3 × 10-4 m/(m K)

■ High fire resistance capabilities, including low emission of smoke and toxic fumes, as well as self-extinguishing

■ High chemical purity in terms of ionic content, featuring low volatile content

■ Low surface energy

■ Good wetting and bonding on many substrates

■ Easy re-workability or strong adhesion to meet specification needs

■ Extremely low inner stress on potted components, preventing delamination from the housing substrate.

[21] Silicones offer a multitude of versatile features

The versatility of silicone materials and technologies

Silicones are increasingly the material of choice in electronic protection and, of course, in other applications because they are available in a great variety of forms that can be formulated into different products. In this section, we provide a non-exhaustive overview of the main silicone ingredients and formulations, as well as some key applications and processing characteristics.

The basic ingredients of silicone commodity products

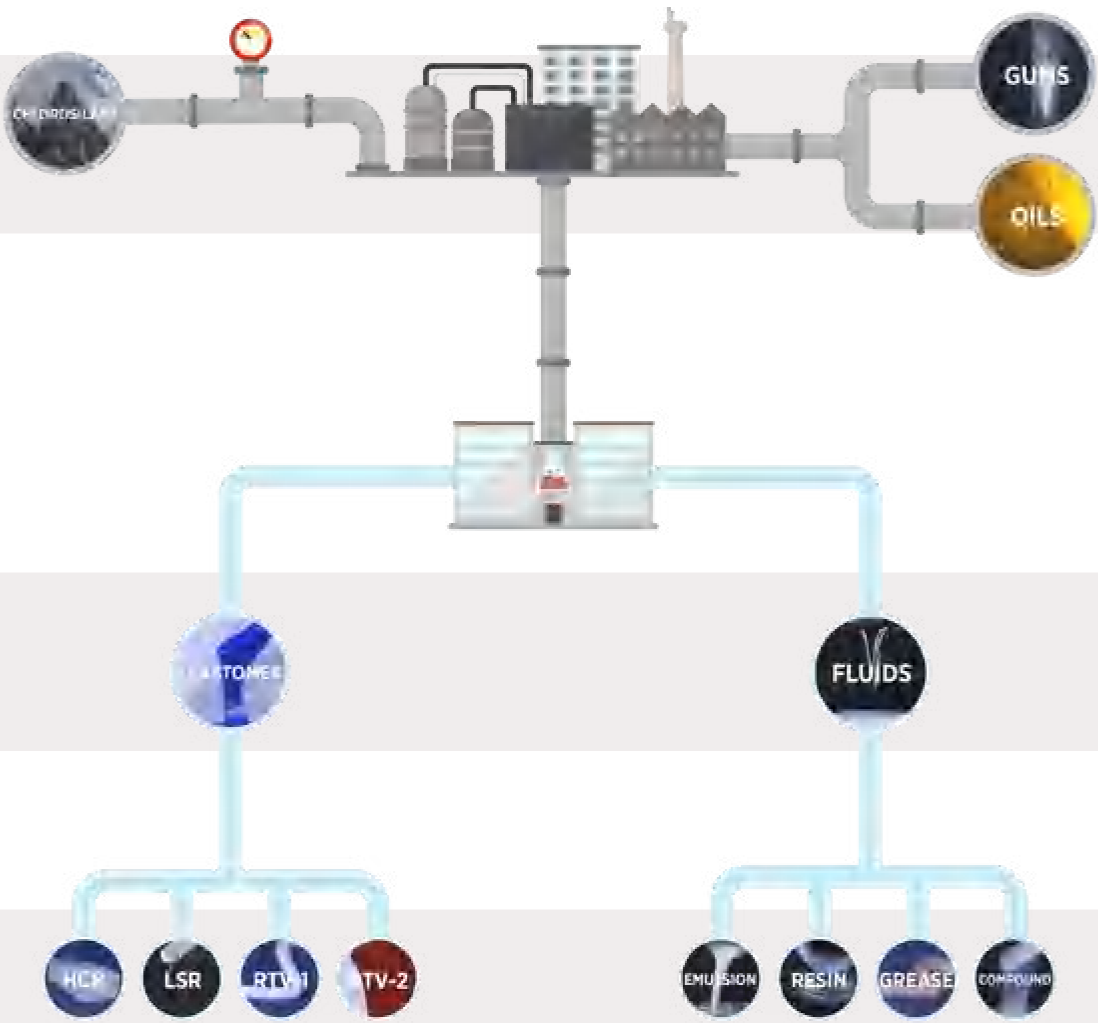
As we have seen above, the basic building blocks of silicones are chlorosilanes, which are first processed industrially using hydrolysis and polycondensation, to produce two basic silicone commodity products: gums and oils. Those commodity ingredients are used by some of our customers to formulate their own advanced specialty silicones, essentially for two product families: Elastomers and Fluids. Both these product families produce a wide range of technologies, which feature specific qualities and are processed in a variety of ways to produce specialized properties. [22]

Fluids

Silicone fluids are silicone oils (polydimethylsiloxane) which are processed to different degrees of polymerization, resulting in variable viscosity. Silicone oils glide and slip over one another because of high methyl density and thus low intermolecular association of its polymeric chains, providing great fluidity. Additives can modify the oils to give them specific characteristics so they can be used as is, in dispersion or in emulsions. [23]

Silicone fluids are used in a wide array of special applications, particularly those requiring resistance to extreme weather conditions, from -60°C to 300°C. Their high stability also enables them to resist all types of radiation, in particular UVs. The extremely low volatility of silicone fluids and resistance to weathering means that their waterproofing capacities are highly durable, and they are often a perfect complement to elastomers in electrical protection. Silicon resins, for example, are useful as PSAs (Pressure Sensitive Adhesives) used as tackifiers to help stabilize components and, in sealing and bonding, as adhesion promoters. After drying and crosslinking, resins can form films that are flexible or rigid, thermoset or thermoplastic films that confer specific properties to the treated surfaces and facilitate sealing and bonding. Resins offer high resistance to heat, at sustained temperatures of up to 250°C (and peaks of up to 500°C). They also resist oxidation and have good dielectric properties, making them an ideal formulation in high-performance electrical insulation products.

[22] Silicone raw materials and commodity products
[23] Silicone fluids: adaptability to meet extreme specifications



Core Product (oils, gums, resins...) are obtained by having **Chlorosilanes undergo hydrolysis and polycondensation**

We identify 2 families of silicones: **elastomers and fluids**, regrouping a large variety of technologies with various properties

Specialty product are obtained after a formulation phase.

Elastomers

Silicone elastomers are made with a combination of linear polymers, reinforcing agents, a crosslinker and a catalyst. The viscosity and type of the basic straight-chain molecule combined with the processing temperature determine the type of elastomer produced: Heat Cured Rubber (HCR), Liquid Silicone Rubber (LSR), and Room Temperature Vulcanization (RTV). These elastomers can also be reinforced with mineral fillers to meet precise processing requirements. A wide variety of additives can also be added to the elastomer in its final composition to ensure specific characteristics or performance standards for such applications as electrical and electronic insulation or conduction, heat transfer, fire retardancy, adhesion, etc. [24]

Silicone elastomers are especially appreciated in high-performance applications, such as in harsh environments where other polymeric materials will fail. Elastomers feature long durability and reliability, even when exposed to a wide range of temperatures (from -50°C to 250°C) or to extreme outdoor exposure (humidity, UV, Ozone). Their dielectric properties and thermal resistance are especially well suited to insulate and protect electronic equipment.

RTV elastomers, for example, are formulated as one-component (RTV-1) or two-component (RTV-2) elastomers and are available in different media, including gels. Since they cure at room temperature, they are simple to use and apply and are ideal in critical applications where the heat generated by other bonding or sealing processes such as soldering are impossible or dangerous. Beyond their processing advantages, they offer good adhesion, as well as weather and heat resistance, making them ideal for electronic protection. Both RTV-1 and RTV-2 formulations offer variable viscosity and good flowability, customizable hardness, low shrinkage, resistance to deformation and resistance to high and low temperatures, acid and alkali.

Silicone elastomers: A versatile range of customizable solutions for critical and demanding applications.

Silicone elastomers are compounded using reactive, straight-chained molecules together with a cross-linking agent and reinforcement to produce good mechanical properties (elasticity, absorption, tear strength).

RTV-1 is a one-component, Room Temperature Vulcanization silicone rubbers that, as the name implies, cure at room temperature. They are simple to use and apply and require no special preparation. RTV-1 silicones are ideal in critical applications where convenience and speed are prime requirements

RTV-1 can be divided into several types, based on by-products generated during the curing process, such as alkoxy, oxime, acetic, acetone, amine products, etc.

RTV-1 features convenient characteristics such as easy application, soft curing conditions, good adhesion and weather and heat resistance.

Since some RTV-1 silicones have a chemically neutral curing system, guaranteeing no oxidation on contact with metals and are intensively used in the bonding and protection of electronic components. These neutral RTV-1 silicones are odorless, and are particularly well adapted to the creation of safe and non-toxic workstation environments. Their rapid skin-formation time is suited to industrial constraints, such as just-in-time scheduling, thus providing great flexibility in interdependent processes.

[24] Elastomers: high performance and versatility for critical protection

RTV-2 silicones are two-component, Room Temperature Vulcanization silicone rubbers, gels or foams. Each part of the system includes either a crosslinker or a catalyst that will react when the two parts are mixed to generate the intended properties. They can be customized to produce variable degrees of viscosity, adherence and mechanical, chemical or temperature resistance characteristics.

RTV2 is available in a viscosity/hardness range varying from soft to medium, usually from 15 to 60 Shore A. RTV2 features several advantageous characteristics, including ease of application and processing, light viscosity and good flowability, low shrinkage, no deformation, customizable hardness, resistance to high and low temperatures, acid and alkali, thus generating highly durable products.

Silicone Gels are silicone fluids, slightly crosslinked to form a cohesive three-dimensional network, but sufficiently loose to allow swelling by non-reactive silicone fluids. The cohesive masses thus obtained, provide great flexibility and have no defined shape or elasticity since the three-dimensional network is too loose for them to return to their original shape after deformation, even under low stress.

Gels: due to their low modulus, these materials can protect against external influences and transmission of mechanical stress, with easy reworkability Silicones RTV1 and Gels are the materials of choice for potting and encapsulating sensitive electronics like sensors, actuators, central processing units (CPUs) and printed circuit boards (PCB), as they are the first line of defense against outside aggression.

Silicone foam is a polyorganosiloxane composition that produces elastomeric foam after or during curing. They function with two simultaneous reactions – foaming and cross-linking – that enable the creation of a low-density elastomer with insulation properties and resistance to heat.

Silicone foam is a material that provides the performance benefits of standard silicones, plus improvement of flexibility and low density.

They are highly efficient in potting and encapsulating sensitive electronic parts and assemblies, such as sensors, CPUs, printed circuit boards (PCB), etc. [25]

Elkem Silicones offers protection to improve performance, safety and longevity for all components and can be easily integrated into different processing environments:

- Adhesives, which provide self-adhesion to many metals, ceramic, glass and plastics and are excellent candidates for assembly applications on or near sensitive electrical and electronic components, given that they do not release any corrosive by-products
- RT foams are ideal lightweight solutions for thermal insulation, fire resistance and sealing application
- High performance Gels are especially adapted for on-board electronics. They provide high heat resistance with high level of purity for power electronics applications.
- Adhesive and Gap Fillers (RTV-2 technology, thermally conductive) are solutions of choice for heat management
- Adapted viscosity RTV-2s are also great materials for potting and encapsulation for electronics protection in the most demanding environments.

[25] Optional curing systems to meet different needs

Elkem Silicone products: a wide choice of solutions for different applications

This table presents a sample of key Elkem Silicones products, in terms of their technical features and possible applications. It is not exhaustive but is intended as a guideline for considering silicone solutions for electronics protection. For more information on specific uses, we invite you to contact us.

BLUESIL™ and CAF™ product	Main properties	Potting & encapsulation	Sealing and bonding	Conformal coating	Thermal conductivity	Adhesion
BLUESIL™ ESA 6018 A/B	Gel with inherent tack, high damping, low volatiles	■		■		
BLUESIL™ ESA 6001HT	Gel with outstanding thermal resistance, low tack & low ionic content	■				
BLUESIL™ ESA 7252 A/B	2 K potting, encapsulant elastomer	■			■	
BLUESIL™ ESA 7244 A/B	2 K self-adhesive elastomer	■	■			■
CAF™ 530	1 K neutral alcoxy, curing thixotropic, primer less	■	■			■
CAF™ 33 AXAD	Activated 1 K, high performance assembly with high thermal resistance		■			■
BLUESIL™ ESA 8352 A/B	2 K room temperature cure, self-adhesive elastomer		■			■
BLUESIL™ RESIN 991	1 K, conformal coating			■		
BLUESIL™ ESA 67XX A/B	2 K, thermally conductive gap filler				■	
BLUESIL™ ESA 77XX A/B	2 K, thermally conductive adhesive				■	■
BLUESIL™ ESA 7263 A/B	2 K, thermally conductive potting	■			■	
BLUESIL™ RTF 3244 A/B	2 K foam, RT curing, equivalent V0 on 10 mm thick for FIPFG		■			

Elkem Silicones: committed to Delivering Your Potential

Working collaboratively to ensure full protection of electronics

At Elkem Silicones, we pride ourselves in being one of the world's leaders in fully integrated silicone manufacturing, with R&D laboratories, production sites and sales offices located in Europe, North America, Latin America, and Asia-Pacific. To transform our technical expertise and high-performance facilities into tangible advantages for our customers, we believe in the power of professionals working together, powered by passion, to produce agile and innovative solutions in a constantly changing environment.

At Elkem Silicones, we are convinced that our high-quality silicone products and associated services are only as good as the people behind them. Our team of professionals are always available to provide the products, services and support you deserve, with empathy and a personal touch. Increasingly, our focus is not only on improving performance, but also contributing to the development of a sustainable planet. This means that we do everything in our power to provide better, safer and more environmentally friendly products, and to ensure safer and healthier working environments for all operators. We are also especially involved in all industries that contribute to lowering pollution and reducing carbon imprint, such as renewable energy production and applications.

From technical support to customized formulations and regulatory support, Elkem Silicones will partner with you for all your needs in electronic protection and other fields to help you deliver your potential. Because we care!

For detailed commercial contacts please visit our website:
elkem.com