

Key Mineral Products

To achieve a regional leadership position aligned with our vision of the future, our strategy is built around six main core mineral groups that can be generally described as follows:

High Purity Silica



Silica is the term used to describe a group of minerals composed of oxygen and silicon (SiO_2). Whilst it is the world's second most abundant mineral, products containing at least 98% purity are needed for industrial use.

We'll produce the crystalline form of silica – quartz – as both sands and flours at the StGeorge location. As a hard, chemically inert mineral with a high melting point, silica delivers a range of benefits across multiple applications.

Float and container glass customers use high purity silica as the major mineral component in their manufacturing process, providing the glass with transparency, strength and durability. High purity silica products ($>99.5\% \text{SiO}_2$) are also used in the manufacture of PV solar panels and crucibles, in the manufacture of semiconductors and electronics, in fiberglass components such as wind turbine blades and automotive parts and in display glass for smartphones and tablet devices. Lower purity silica products ($<98\% \text{SiO}_2$) are used in other applications like for the manufacturing of ceramics, metallurgy, construction and sport surfaces.

Our high purity quartz sand (HPQS), mined and processed from the Neaua quarry, can potentially be used to produce fused quartz, a material with unique optical, mechanical and thermal properties which makes it indispensable in the manufacture of a wide range of high-tech products including semiconductors, photovoltaic cells from silicon ingots, optical fiber and quartz lightning.

Quartz sands are an essential molding material base for sand casting, shell casting, investment casting, and for production of sand and masking cores. By adding the relevant binder during sand conditioning in the foundry, molding and coresand mixtures are created. These are called molding materials.

Construction Sand



Construction sand is an important building resource but must be processed and selected with great care and attention to detail. It is a fine aggregate that has several applications, including but not limited to: concrete, backfill, gardening, surface treatments, and preventing the accumulation of snow and ice. It is important to know what kind of sand is best for building because it comes in different forms, making it good for different kinds of buildings.

Concrete sand, also known as sharp sand or coarse sand, is a type of sand that is commonly used in the construction industry for making concrete. It is designed to have certain characteristics that make it suitable for mixing with cement, gravel, and water to create concrete. Concrete sand is typically composed of grains with a relatively large particle size compared to other types of sand. It has a rough texture and angular shape, which helps provide good interlocking and bonding properties when mixed with cement. The angularity of the grains allows for better cohesion, resulting in a stronger and more durable concrete mixture.

Concrete sand fills the spaces between coarse aggregates like gravel or crushed stone in a mix. It increases concrete workability and ensures water, cement, and additive dispersion. Concrete sand increases the strength, density, and performance of cured concrete. Concrete sand differs from play sand and masonry sand, which are unsuitable for building concrete. Concrete sand is graded and treated for concrete manufacturing.

Fine sand is a type of sand with particles that aren't too big. It has a fine texture and is smooth to the touch. Most fine sand grains are smaller than coarse sand grains, and you can find fine sand in riverbeds, beaches, and mountains. The exact particle size of fine sand can vary, but it generally falls within the range of 0.0625 to 2 millimeters in diameter. These small particles make fine sand ideal for various applications, including construction, landscaping, and creating smooth surfaces.

Fine sand is utilized in mortar and concrete mixtures since it's compact. Filling gaps between larger particles strengthens and stabilizes the structure. Fine sand makes glass, sandblast, and other industrial items. Because of its softness, fine sand is chosen for beach resorts and leisure places. It's easier to walk on than coarser sands, making beachgoers more comfortable.



Plastic clay is an extremely rare mineral, found in localized deposits at a handful of locations around the world. It's a sedimentary material, made from kaolinite, or decomposed granite that has been mixed through river action with other clays, sands, gravel and vegetation. It is a type of fine-grained natural soil material containing clay minerals (hydrous aluminium phyllosilicates, e.g. kaolinite - $\text{Al}_2\text{Si}_2\text{O}_5(\text{OH})_4$). Clays develop plasticity when wet but can be hardened through firing.

The plasticity of this mineral ensures that the main use of plastic clay is as a base material in the manufacture of ceramics. Plastic clays have a wide range of colours, but when fired, selected clays give results that are pure white.

As the streams flowed from upland areas the kaolinite mixed with other clay minerals, sands, gravels and vegetation before settling in low-lying basins to form overlaying seams of plastic clay. Plastic clays usually contain three dominant minerals: kaolinite, mica and quartz. In addition, there are other 'accessory' minerals and some carbonaceous material (derived from ancient plants) present. The wide variation both in mineral composition and in the size of the clay particles results in different characteristics for individual clay seams within a deposit. Internationally, deposits of high quality plastic clay are much rarer than those of kaolin.

Modelling clay is used in art and handicraft for sculpting. Clays are used for making pottery, both utilitarian and decorative, and construction products, such as bricks, walls, and floor tiles. Different types of clay, when used with different minerals and firing conditions, are used to produce earthenware, stoneware, and porcelain.

Clay, relatively impermeable to water, is also used where natural seals are needed, such as in pond linings, the cores of dams, or as a barrier in landfills against toxic seepage (lining the landfill, preferably in combination with geotextiles). Studies in the early 21st century have investigated clay's absorption capacities in various applications, such as the removal of heavy metals from waste water and air purification.

It is used also as an additive to some paints to extend the titanium dioxide (TiO_2) white pigment and modify gloss levels.

Calcium Carbonate



Calcium carbonate is a chemical compound with the chemical formula CaCO_3 . The vast majority of calcium carbonate used in industry is extracted by mining or quarrying.

The main use of calcium carbonate is in the construction industry, either as a building material, or limestone aggregate for road building, as an ingredient of cement, or as the starting material for the preparation of builders' lime by burning in a kiln.

In the oil industry, calcium carbonate is added to drilling fluids as a formation-bridging and filtercake-sealing agent; it is also a weighting material which increases the density of drilling fluids to control the downhole pressure. Calcium carbonate is added to swimming pools, as a pH corrector for maintaining alkalinity and offsetting the acidic properties of the disinfectant agent.

It is also used as a raw material in the refining of sugar from sugar beet; it is calcined in a kiln with anthracite to produce calcium oxide and carbon dioxide.

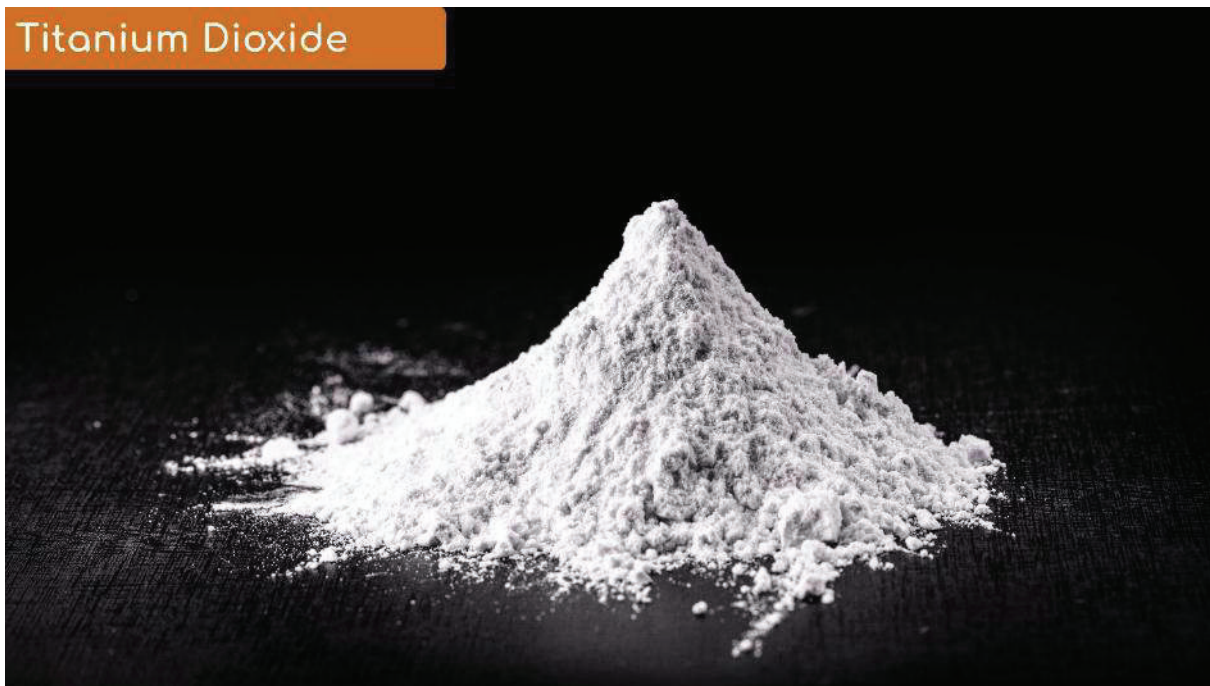
Fine ground calcium carbonate (GCC) is an essential ingredient in the microporous film used in diapers and some building films, as the pores are nucleated around the calcium carbonate particles during the manufacture of the film by biaxial stretching. GCC and PCC are used as a filler in paper because they are cheaper than wood fiber. Printing and writing paper can contain 10–20% calcium carbonate.

Calcium carbonate is widely used as an extender in paints, in particular matte emulsion paint where typically 30% by weight of the paint is either chalk or marble. It is also a popular filler in plastics.

Calcium carbonate is added to a wide range of trade and do it yourself adhesives, sealants, and decorating fillers. Ceramic tile adhesives typically contain 70% to 80% limestone. Decorating crack fillers contain similar levels of marble or dolomite. It is also mixed with putty in setting stained glass windows, and as a resist to prevent glass from sticking to kiln shelves when firing glazes and paints at high temperature.

In ceramic glaze applications, calcium carbonate is known as whiting, and is a common ingredient for many glazes in its white powdered form.

Titanium Dioxide



Titanium dioxide, also known as titanium(IV) oxide or titania, is the inorganic compound with the chemical formula TiO_2 . When used as a pigment, it is called titanium white, Pigment White 6 (PW6), or CI 77891. It is a white solid that is insoluble in water, although mineral forms can appear black. As a pigment, it has a wide range of applications, including paint, sunscreen, and food coloring. When used as a food coloring, it has E number E171.

World production in 2022 exceeded 19 million tons. It has been estimated that titanium dioxide is used in two-thirds of all pigments, and pigments based on the oxide have been valued at a price of \$23.2 billion.

First mass-produced in 1916, titanium dioxide is the most widely used white pigment because of its brightness and very high refractive index, in which it is surpassed only by a few other materials

When deposited as a thin film, its refractive index and colour make it an excellent reflective optical coating for dielectric mirrors; it is also used in generating decorative thin films such as found in "mystic fire topaz".

In cosmetic and skin care products, titanium dioxide is used as a pigment, sunscreen and a thickener. As a sunscreen, ultrafine TiO_2 is used, which is notable in that combined with ultrafine zinc oxide, it is considered to be an effective sunscreen that lowers the incidence of sun burns and minimizes the premature photoaging, photocarcinogenesis and immunosuppression associated with long term excess sun exposure.

In ceramic glazes, titanium dioxide acts as an opacifier and seeds crystal formation.

It is used as a tattoo pigment and in styptic pencils. Titanium dioxide is produced in varying particle sizes which are both oil and water dispersible, and in certain grades for the cosmetic industry. It is also a common ingredient in toothpaste.

The exterior of the Saturn V rocket was painted with titanium dioxide; this later allowed astronomers to determine that J002E3 was likely the S-IVB stage from Apollo 12 and not an asteroid.

Zircon



Zircon, scientifically known as zirconium silicate ($ZrSiO_4$), is a naturally occurring mineral found in ancient mineral sand deposits. It crystallized from magma when igneous rocks formed and belongs to the tetragonal crystal system. Zircon is recognized as the most abundant and widely distributed zirconium-bearing mineral, often appearing in cone-shaped or granular forms. Its natural color can vary from brown to colorless, yellow, pink, red, blue, and green, depending on its origin and the type and quantity of impurities. Zircon forms part of ancient coastal mineral sand deposits, where heavy minerals like zircon, ilmenite, rutile, and monazite were concentrated by wave and wind action.

Zircon's versatility is due to its specific physical properties: Low Magnetic Susceptibility and Electrical Conductivity: Makes it easily separable from other minerals like ilmenite and rutile; High Purity Levels: After processing, zircon achieves a high level of $ZrO_2 + HfO_2$ purity, suitable for advanced applications.

Zircon remains indispensable for industries requiring high-quality refractory materials, advanced ceramics, and zirconium compounds. Its utility spans metallurgy, casting, precision tools, and high-tech material production. Additionally, zircon's role in enhancing other materials broadens its scope of application, ensuring its relevance in both current and emerging technologies.

With advancements in processing techniques and sustainable mining practices, zircon is poised to meet the growing demand for high-performance materials in industries such as aerospace, electronics, and energy.

Processing: Wet Concentration - ore is washed and processed in spiral separators to remove lighter quartz and clay impurities, yielding a heavy mineral concentrate. Exploiting zircon's low magnetic susceptibility and electrical conductivity, heavy mineral concentrate is separated into its components (ilmenite, rutile, leucoxene, zircon, and monazite). Zircon is further cleaned and refined to achieve a concentrate of 65% $ZrO_2 + HfO_2$, with SiO_2 as the other principal component.

Key High-Tech Crystalline Products

Silicium Ingots



Monocrystalline Silicon Ingots are large, solid blocks of crystalline silicon, typically shaped as cylinders or rectangular bars, that serve as the foundational material for various high-tech industries. Silicon, symbolized as Si on the periodic table, is derived from quartz or silica sand (SiO_2) and is one of the most abundant elements on Earth. Due to silicon's unique electrical properties, silicon ingots are crucial in the production of semiconductors and photovoltaic (solar) cells. The process of producing silicon ingots involves purifying raw silicon and crystallizing it into a uniform structure, either as single-crystal or multicrystalline silicon, depending on the end-use.

Structure: Composed of a single, continuous crystal structure. Atoms in monocrystalline silicon are perfectly aligned, resulting in minimal defects and impurities.

Production Method: Typically produced using the Czochralski (CZ) process or the Float Zone (FZ) method.

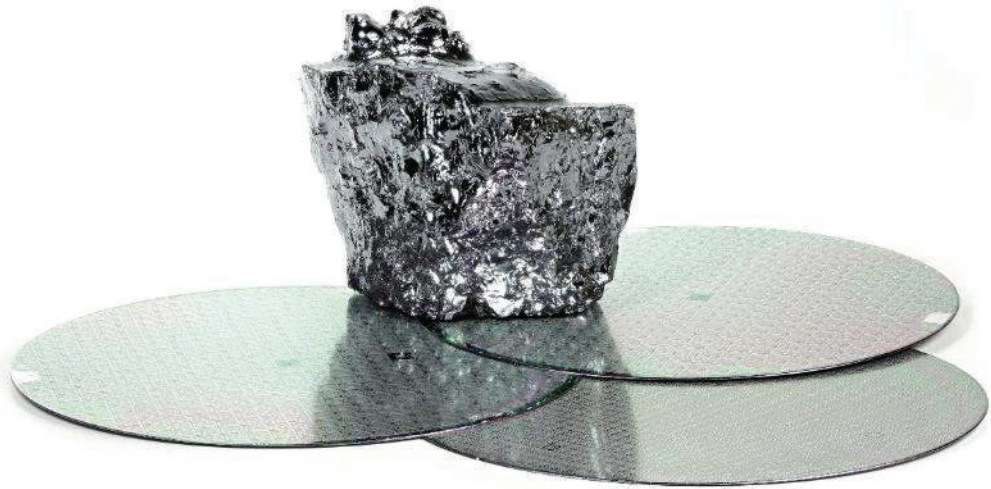
Applications: Primarily used in the semiconductor industry for integrated circuits (ICs) and in high-efficiency photovoltaic cells for solar panels.

Color: Typically grayish with a metallic sheen, though it can appear darker due to impurities.

Size: Silicon ingots can vary in size, with typical monocrystalline ingots being up to 300 mm in diameter and several meters in length. Multicrystalline ingots are usually rectangular blocks.

Purity: The purity of silicon ingots ranges from solar-grade silicon (5N = 99.999% purity) to electronic-grade silicon (>9N = 99.9999999% purity). The purity level is vital as even trace impurities can affect the performance of semiconductor devices and solar cells.

The CZ process is the primary method for growing large, single-crystal silicon ingots used in semiconductor manufacturing. In this process, highly purified silicon is melted in a quartz crucible, and a seed crystal is slowly pulled upwards while rotating. This results in a cylindrical ingot composed of a single crystal.



Silicon wafers are thin slices of silicon, typically circular, that serve as the fundamental substrate for manufacturing electronic and photovoltaic devices. Silicon, one of the most abundant elements on Earth, is processed and purified to form silicon wafers, which are the building blocks for a wide range of high-tech applications. The silicon wafer industry is central to the semiconductor and solar energy sectors, as nearly all modern electronics and solar cells begin with a silicon wafer.

These wafers are used as a substrate for fabricating semiconductor devices, including microchips, transistors, and photovoltaic cells. The wafers typically range in diameter from 100 mm to 300 mm (4 to 12 inches), though there are ongoing efforts to develop larger wafers to increase production efficiency.

The purity of silicon wafers is critical, particularly in semiconductor applications. Semiconductor-grade silicon wafers are typically 99.9999999% pure (9N or 10N purity), as even trace impurities can interfere with the electrical properties required for high-performance devices.

The semiconductor industry is the largest consumer of silicon wafers, with wafers forming the foundation of nearly all modern electronic devices. Silicon wafers are processed to create integrated circuits (ICs) or chips, which power everything from computers and smartphones to automotive electronics and data centers.

Silicon wafers are also critical in the solar energy industry, where they are used to produce photovoltaic (PV) cells. These cells convert sunlight into electricity, making silicon wafers the heart of modern solar panels.

Silicon wafers are also used in the optoelectronics industry, which includes the production of devices that convert electrical signals into light and vice versa.

Silicon wafers are the cornerstone of nearly all modern consumer electronics. The integrated circuits fabricated on silicon wafers power the processors, memory, and sensors.

Silicon wafers are increasingly vital to the automotive industry as vehicles become more computerized and electric.

Industrial Uses of Silica Sand, Silicon and Silicon Ingots & Wafers

Silica (industrial) sands contain a high proportion of silica (*having, normally, but not exclusively, more than 95% SiO₂ content in its processed form*) and are used for applications other than as construction aggregates.

They are produced both from loosely consolidated sand deposits and by crushing weakly cemented sandstones. Unlike construction sand, which are used for their physical properties alone, silica sands are valued for a combination of chemical and physical properties.

These include a high silica content in the form of quartz and, more importantly, very low levels of deleterious impurities, particularly clay, iron oxides and refractory minerals, such as chromite.

They typically have a narrow grainsize distribution (*generally in the range 0.1 to 1 mm*). For most applications, silica sands have to conform to very closely defined specifications and consistency in quality is of critical importance.

Particular uses routinely require different combinations of properties and attributes. Consequently, different grades of silica sand are usually not interchangeable in use.

Silica sands command much higher prices than construction sands and serve a wider geographical market, including exports.



How silica sand is used depends on physical, chemical, and mechanical characteristics such as grain size, shape, color, structure, and distribution, as well as refractoriness, strength and stability. These characteristics can differ depending on how the mineral is processed after it is mined.

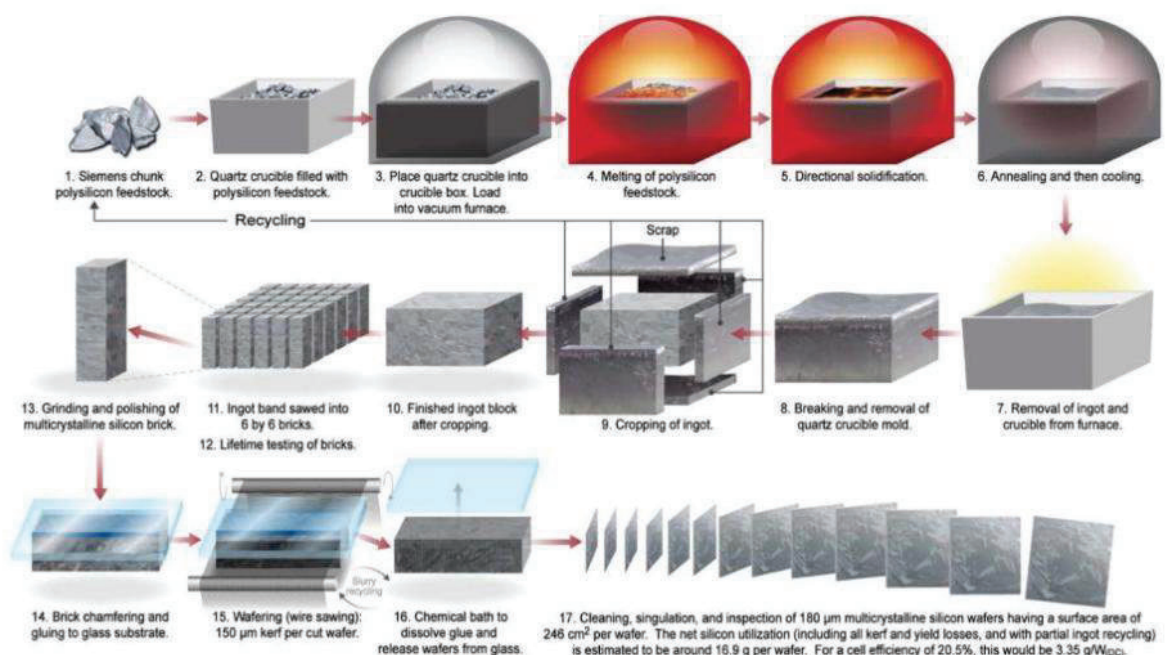
Silica sand is one of the most common varieties of sand found in the world. It is used for a wide range of applications, and can be purchased from various suppliers throughout the world.

Silica sand is used in industrial processing, to make glass, as fill, and to create molds and castings. At industrial scales, silica sand can cost less than \$0.50 US Dollars (USD) per pound, while the consumer rate is around \$1.50 USD per pound.

Silica sand (SiO_2) is a versatile material with a wide range of applications due to its unique properties, including high purity, hardness, and resistance to chemical and physical weathering. Some of the primary uses of silica sand include:

- **Glass Manufacturing** - Silica sand is a key ingredient in the production of various types of glass, including float glass (*used in windows and mirrors*), container glass (*bottles and jars*), and specialty glass (*such as optical glass and fiberglass*). High-purity silica sand is crucial for producing clear and high-quality glass products.
- **Solar Panels Industry (crucibles and ingots)** - The silicon ingot that eventually becomes the solar cell is cast in a quartz crucible. Quartz crucibles are made by melting high-purity quartz sand. The quartz crucibles used to make the ingots are then discarded after just a few uses due to cracks and impurities. As a result, vast quantities of raw materials are lost and needs replacement. This is not good, considering the solar cell market is about to really take off and the number of mines extracting and processing high-purity quartz sand worldwide is very limited. High-purity quartz sells for EUR 5 – 25 per kg because of the scarcity of this high-end product in this industry.

(market prices source: <https://www.metal.com/price/Photovoltaic/High%20Purity%20Quartz%20Sand>)



- **Foundry Casting** - Silica sand is used in the foundry industry to create molds and cores for casting metal parts and components. It provides the necessary refractoriness and moldability to withstand the high temperatures and pressures involved in metal casting.
- **Hydraulic Fracturing (Fracking)** - Frac sand, a specific type of high-purity silica sand, is used in the oil and gas industry during hydraulic fracturing operations. It is injected into underground rock formations to prop open fractures, allowing the extraction of oil and natural gas.
- **Water Filtration** - Silica sand is commonly used as a filtration medium in water treatment plants and swimming pool filtration systems. It effectively removes

suspended solids, impurities, and particles from water, making it suitable for drinking water and industrial processes.

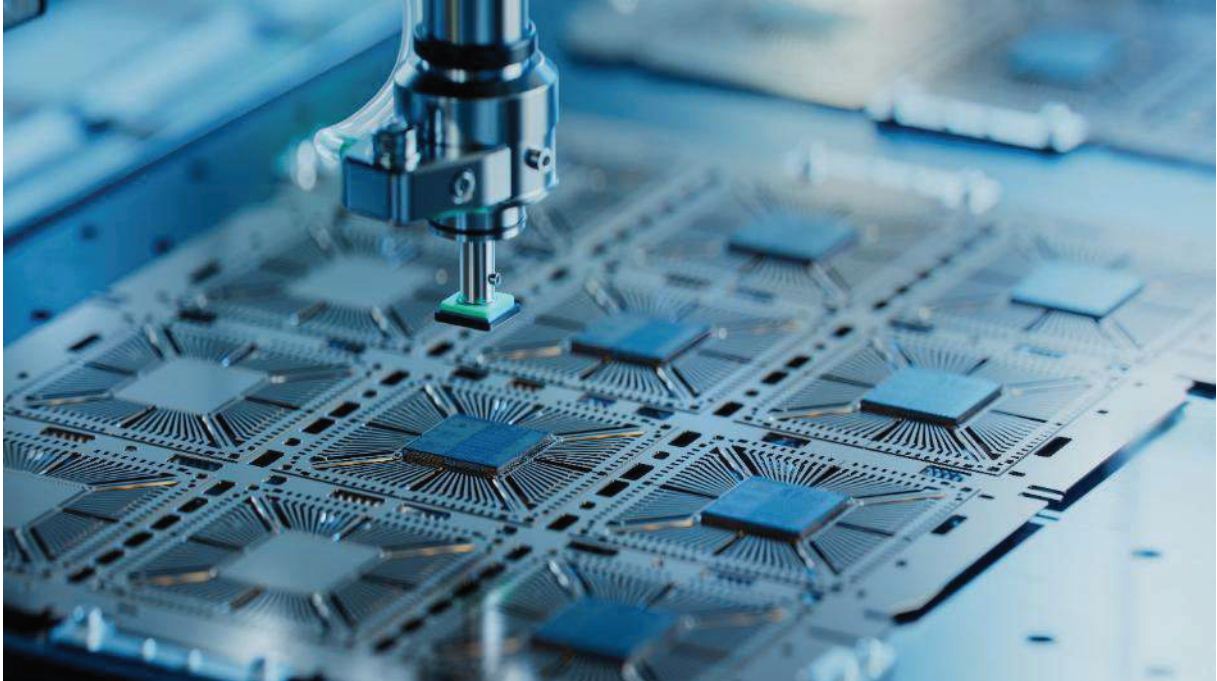
- **Construction** - Coarse-grain silica sand is used in construction applications such as concrete and mortar mixtures, as well as in the production of bricks and blocks. It provides strength and stability to building materials.
- **Ceramics and Refractories** - Silica sand is a component in the production of ceramics, including porcelain, earthenware, and stoneware. It is also used in refractory materials that can withstand high temperatures and are used in kilns, furnaces, and other high-heat applications.
- **Sports and Recreation** - Fine-grain silica sand is often used in sandboxes, golf course bunkers, and beach volleyball courts due to its soft texture and good drainage properties.
- **Metal Production** - Silica sand is used as a flux in the production of ferrous and non-ferrous metals, such as iron, steel, aluminum, and copper. It helps lower the melting point of the raw materials and facilitates slag formation.
- **Paints and Coatings** - In the manufacturing of paints and coatings, silica sand is used as a filler to enhance texture and consistency. It can also improve the durability and scratch resistance of coatings.
- **Chemical Production** - Silica sand is employed in various chemical processes, such as the production of silicon compounds, silicon wafers for the electronics industry, and the manufacturing of chemicals like sodium silicate.
- **Abrasives** - Fine-grain silica sand is used as an abrasive material in sandblasting and abrasive cleaning processes to remove rust, paint, and coatings from surfaces.



- **Horticulture and Agriculture** - Silica sand can be used in soil mixtures and as a soil amendment to improve drainage and aeration in gardening and agricultural applications.

Silicon (Si) is the cornerstone of modern industry, serving as the foundational material for numerous applications across diverse sectors. Their high purity, exceptional electronic properties, and structural versatility make them indispensable in fields ranging from electronics and renewable energy to aerospace and advanced materials science. Below is an in-depth exploration of the industrial uses of silicon:

Semiconductor Manufacturing



Silicon ingots are primarily used in the production of semiconductors, which are the backbone of modern electronics. The high-purity monocrystalline silicon ingots (typically above 99.9999% pure, or 6N purity) are sliced into wafers, which undergo extensive processing to create microchips. These microchips power an extensive array of electronic devices, including:

- *Consumer Electronics:* Smartphones, tablets, laptops, and televisions rely on silicon-based microprocessors and integrated circuits.
- *Automotive Electronics:* Advanced driver-assistance systems (ADAS), engine control units (ECUs), and infotainment systems use silicon chips for functionality.
- *Telecommunication:* Silicon semiconductors are critical for manufacturing transceivers, fiber optic systems, and wireless communication devices.
- *Industrial Automation:* Controllers, robotics, and industrial machinery depend on silicon-based chips for precise control and data processing.

Aerospace and Defense

The aerospace and defense industries utilize silicon for various high-performance applications:

- *Radiation-Resistant Semiconductors:* Monocrystalline silicon wafers are used in satellites and space exploration, as they can withstand high radiation levels.
- *Advanced Sensors:* Silicon-based sensors monitor pressure, temperature, and motion in aircraft and defense systems.
- *Laser Systems:* Silicon components are integral to targeting, range-finding, and guidance systems.

Photovoltaic Solar Cells



The renewable energy sector is a significant consumer of silicon ingots, particularly for the production of photovoltaic (PV) cells used in solar panels. Polycrystalline and monocrystalline silicon ingots are processed into wafers, which serve as the active layers in solar cells. Their high efficiency in converting sunlight into electricity has made silicon the dominant material in solar panel manufacturing. Applications include:

- *Residential Solar Systems:* Providing clean energy to homes.
- *Utility-Scale Solar Farms:* Generating large-scale renewable energy.
- *Space Exploration:* Powering satellites and space probes.

Power Electronics



Silicon is extensively utilized in power electronics, which manage and control the flow of electrical energy in systems. Silicon-based devices like diodes, transistors, and thyristors are critical in:

- *Electric Vehicles (EVs):* Silicon components regulate power in EV chargers, inverters, and battery management systems.
- *Renewable Energy Systems:* Wind turbines and solar power plants rely on silicon-based power converters.
- *Energy Transmission:* High-voltage direct current (HVDC) systems utilize silicon power electronics for efficient long-distance electricity transmission.

MEMS (Micro-Electro-Mechanical Systems)



Silicon is integral to the fabrication of MEMS devices, which combine mechanical and electrical components at the microscale. These devices are ubiquitous in modern technology:

- *Sensors:* Accelerometers, gyroscopes, and pressure sensors used in smartphones, automotive safety systems, and industrial equipment.
- *Medical Devices:* Silicon-based MEMS enable innovations in diagnostic devices, drug delivery systems, and implants.
- *Consumer Electronics:* Microphones, touch screens, and optical sensors.

Advanced Material Science and R&D

Silicon is crucial in materials science research and development due to their unique physical and chemical properties. Applications include:

- *Silicon Carbide (SiC) Production:* Silicon serves as the raw material for creating silicon carbide, a compound with superior thermal and electrical properties used in high-power and high-frequency applications.
- *Nanoelectronics:* Silicon nanowires and quantum dots, derived from ingots, are being explored for next-generation computing and data storage.
- *Additive Manufacturing:* Silicon-based materials are used in 3D printing applications for creating high-strength, lightweight components.

LED and Optoelectronics



Silicon is used in the manufacturing of light-emitting diodes (LEDs) and other optoelectronic devices. Silicon's high thermal conductivity and mechanical stability make it an ideal substrate for:

- *Display Technologies:* LEDs in televisions, smartphones, and large-scale displays.
- *Lighting:* Energy-efficient LED bulbs and industrial lighting solutions.
- *Fiber Optic Communication:* Silicon-based photonic devices are essential for high-speed data transmission.

Industrial Machinery and Tools

Silicon ingots are used to produce components for high-precision industrial machinery:

- *Precision Optics:* Silicon substrates are polished and coated for use in high-performance optical systems.
- *Cutting Tools:* Silicon-carbide-based tools and abrasives are widely used in manufacturing.

Chemical Industry

Silicon is used as a precursor for producing various silicon-based chemicals:

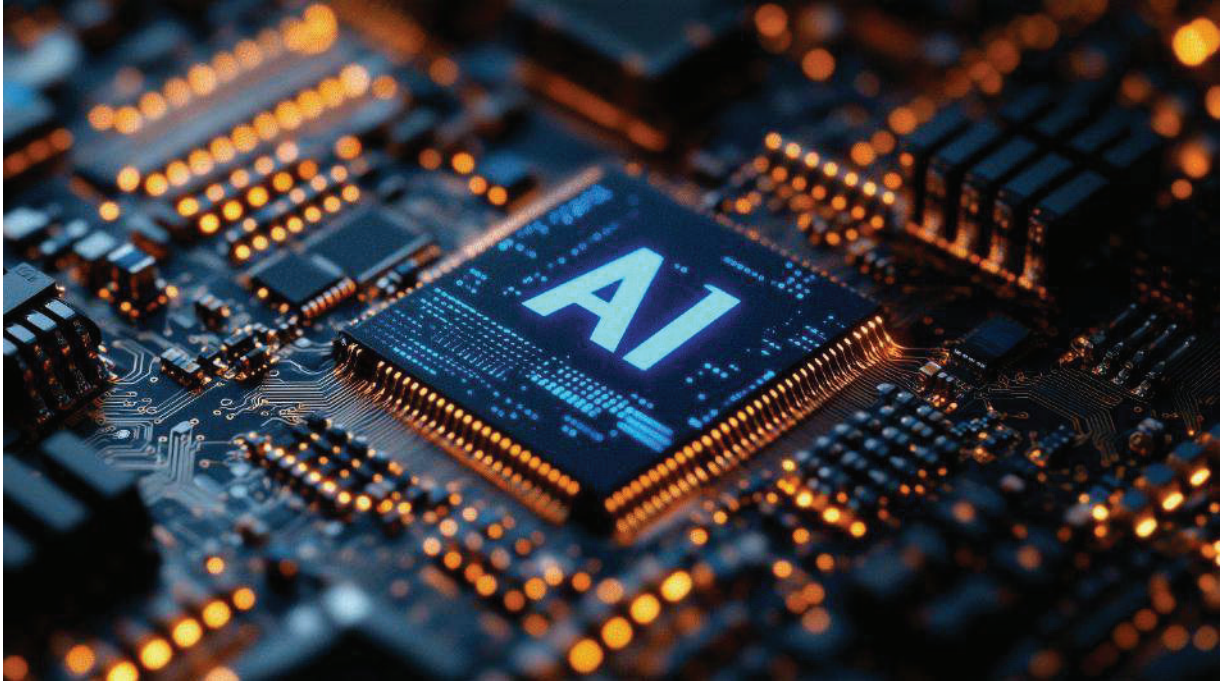
- *Polysilicon Production:* Silicon is further refined to produce polysilicon, used in electronics and PV industries.
- *Silicones and Silanes:* These compounds, derived from silicon, find use in sealants, adhesives, lubricants, and coatings.

Construction and Infrastructure

While less common, silicon contributes indirectly to construction through specialized applications:

- *Smart Glass:* Silicon-based coatings are used in architectural glass for energy efficiency and thermal control.
- *Structural Components:* Silicon-carbide composites are used in high-performance building materials.

Emerging Applications



Silicon ingots & wafers are paving the way for emerging technologies and industries:

- *Artificial Intelligence (AI):* High-performance computing chips used in AI applications are based on silicon wafers.
- *Quantum Computing:* Silicon-based qubits are being developed for quantum processors.
- *Internet of Things (IoT):* The proliferation of IoT devices relies on silicon chips for connectivity and processing.

Challenges and Future Prospects

The versatility of silicon underpins their extensive use; however, challenges remain. These include the energy-intensive nature of silicon purification and wafer fabrication processes, as well as the limitations of silicon in extreme environments (e.g., high temperatures, high voltages). Research into alternative materials like silicon carbide (SiC) and gallium nitride (GaN) continues to address these challenges.

Despite these hurdles, the demand for silicon ingots is expected to grow, driven by advancements in renewable energy, artificial intelligence, and nanotechnology. As industries push the boundaries of innovation, silicon will remain at the forefront, enabling technological progress across multiple domains.

In summary, silicon ingots & wafers are an indispensable material in modern industry, enabling applications that span electronics, energy, aerospace, and beyond. Their adaptability, efficiency, and abundance ensure their central role in the technological advancements of today and the future.