

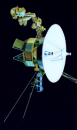
MEDSTERN CANADA LLP



RELIABLE. AUTHENTIC.

EDITION
SUMMER 2025





Voyager 1 utilizes Germanium (Ge) in thermocouples within its Radioisotope Thermoelectric Generators (RTGs), the spacecraft's primary power source, operating for more than 40 years in interstellar space.

RELIABLE GERMANIUM

**Optoelectronics, Telescopes,
Datacenters, Autonomous Vehicles**

OPTICAL FIBRES

Fibre optic cables often incorporate Germanium Dioxide (GeO_2) in the Silica glass core of the fiber to increase its refractive index. Better light confinement within the fiber and improved transmission quality over long distances in broadband networks are benefits. This makes Germanium an essential component in fiber optic cables used for high-speed internet, telecommunications, computing and data centers.

SI-GE ALLOYS

Silicon-Germanium alloys offer improved performance at high frequencies in Semiconductor Technology when compared to pure Silicon. Advanced applications, such as high-speed integrated circuits in consumer electronics, e.g. mobile phones, have become possible.

AUTONOMOUS VEHICLES

Lidars, Infrared Optics, Sensors



Germanium-based solutions are embedded in lidars, infrared optics, thermal imaging cameras, photographic lenses, smart windows and prisms, enabling autonomous vehicle sensing and Advanced Driver-Assistance Systems. ADAS improves safety and will eventually allow travel time to be used for work, or other activities, rather than focusing on driving.

ORNAMENTS, RINGS

Silverware, Silver-Copper Alloys



Silver benefits from Ge by enhancing its tarnish resistance, durability, and resistance to scratching and denting. Ge also improves the castability of silver-copper alloys, making it easier for the craftsman to create complex shapes and designs. Higher corrosion resistance is another factor. Such jewelry will require less maintenance and retain its bright finish longer.

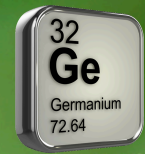
INVESTMENT OPPORTUNITIES

Sustainable Mining, Metals, and Galvanic Industries

Canada boasts a diverse range of minerals, including traditional commodities like base metals, as well as critical minerals. The country is home to a large number of mining companies and is a leading destination for international mining finance. Foreign direct investment (FDI) in the Canadian mining sector was \$65.1 billion in 2022.

Status 2024/2025

ACCESS RESOURCES, GROW SUPPLY BASE



**MINES, MINERAL
DEPOSITS**

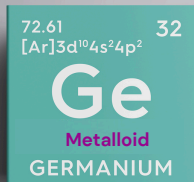
**METAL, GALVANIC
INDUSTRIES**

**LOGISTIC
INFRASTRUCTURE**

Including extraction, services, primary and downstream manufacturing, the Canadian Mining and Metals Sector contributed a total of \$108.5 billion to GDP in 2022. Canada has a well-established mining sector with a supportive regulatory framework, including established stock exchanges. Investors who can guarantee offtake agreements contribute significantly to the economy. Reliable and robust technologies are the key to leaving behind only clean water, healthy landscapes, and achieving greater competitive strength through value-added mining and metal commodities.

AUTHENTIC GERMANIUM

Physical and Chemical Properties



Atomic Structure, Germanium, Ge

Electron Affinity	119 kJ/mol	Electronegativity (Pauling)	2.01
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Periodic Table of the Elements

Germanium, Ge

Period 4

Group 14

Physical Properties, Germanium, Ge

Density at 20 °C	5323 kg/ m ³
Spec. Heat Capacity	308.3 J/ (kg * K)
Melting point	1211.40 K, 938.25 °C
Boiling point	3106.15 K, 2833.00 °C

Isotopes, Germanium, Ge

⁷⁰ Ge	⁷² Ge	⁷³ Ge	⁷⁴ Ge	⁷⁶ Ge
69.9242 u	71.9221 u	72.9235 u	73.9212 u	75.9214 u

PHYSICAL



Appearance: hard, brittle, grayish-white metalloid
Crystal Structure: face-centered cubic (FCC)
Hardness: 6.0 Mohs Scale, depending on purity
Malleability: not malleable
Conductivity: higher conductivity than Silicon
Young's Modulus: 102.7 GPa

CHEMICAL



Corrosion Resistance: good corrosion resistance in air and water, stable vs. many acids and alkalis.
Thermal Expansion (25°C): 6.0 μm (m⁻¹ · K⁻¹)
Common Oxidation States: from -4, +2, +4
Germanium Compounds: e.g., Germanium Dioxide (GeO₂), Germanium Tetrachloride (GeCl₄)...

GERMANIUM MINERALS AND PROCESSING

Mining, Metal, and Galvanic Industries, Raw Materials

Argyrodite



Sulfide minerals

Strunz:
2.BA.35

Germanite



Sulfide minerals

Strunz:
2.CB.30

Sphalerite



Sulfide minerals

Strunz:
2.CB.05a

Bornite



Sulfide minerals

Strunz:
2.BA.10

Ore Preparation Phase: From Sphalerite Gangue Material to ZnS ore concentrate

Crushing

Grinding

Classification

Beneficiation

- ☐ Jaw-, cone-, impact crushers
- ☐ Ball mills, rotating cylinder
- ☐ Hydrocyclones, centrifugal force, magnetic fields, water flow
- ☐ Froth flotation
- ☐ 3-10% Zn content, head grade Sphalerite ore
- ☐ Smaller sized rocks, fragments, particles, -325 mesh
- ☐ ZnS slurry preparation

Froth Flotation Process

- ☐ Conditioning in Flotation Cell
- ☐ Making ZnS particles hydrophobic
- ☐ Mechanical agitation, air injection
- ☐ Foam layer skimming, dewatering
- ☐ Addition of water, collectors, e.g. xanthates, dithiophosphates, frothers, e.g. methyl isobutyl carbinol
- ☐ 30-60% Zn content in ZnS ore concentrate

From ZnS to Germanium Dioxide, (GeO_2)

Roasting

Precipitation

- ☐ Zinc sulfide concentrate (ZnS)
- ☐ Temp: 900-1100°C
- ☐ SO_2 removal
- ☐ Volatile GeO_2 compounds in flue dust, fly ash
- ☐ $2\text{ZnS} + 3\text{O}_2 \rightarrow 2\text{ZnO} + 2\text{SO}_2$
- ☐ Fluidized-bed furnace
- ☐ $2\text{Ge} + 2\text{O}_2 \rightarrow 2\text{GeO}_2$
- ☐ E.g., Electrostatic precipitator (ESP), GeO_2 recovery

From Germanium Dioxide, (GeO_2) to Germanium Tetrachloride, (GeCl_4)

Dissolution

Distillation

- ☐ Germanium dioxide (GeO_2)
- ☐ Leaching with hydrochloric acid
- ☐ Fractional distillation, reboiler, GeCl_4 vapor, condensation to liquid
- ☐ $\text{GeO}_2 + 4\text{HCl} \rightarrow \text{GeCl}_4 + 2\text{H}_2\text{O}$
- ☐ Germanium tetrachloride, GeCl_4 liquid, impurities
- ☐ GeCl_4 trade categories: grade 99.99%, 99.999%, 99.9999%

TRANSPORTATION SUPPORT SERVICES

Supply Chain Integration



Tailored logistics support services are available to B2B Partners, outsourcing their supply chain needs, including secure storage in warehouses, freight rail transportation, and specialized service providers for cargo handling and management, to ensure products get to market on time and within budget.

MODES OF TRANSPORTATION

- Trucks: for short distance hauls and last-mile delivery
- Trains: for long-distance transport of products, goods
- Ships: for large volumes of commodities via ocean freight

TRANSLOADING FACILITIES

- Access to distribution centers, warehouses, and storage space
- Secure transfer of commodities between modes of transportation, e.g., rail-to-ship

LOGISTICS SUPPORT SERVICES

- Optimized shipping processes, analysis, including route planning, cost calculation, carrier identification, shipment tracking, and tracing for precision, real-time product movement

GERMANIUM PRODUCT FORMATS

Industrial Formats for Germanium, Ge

Tailored product formats can be made accessible to B2B Partners, based on achieved off-take agreements. The highlighted products on this page are a selection of possible product alternatives available for trade.

Germanium Dioxide, GeO_2 Powders, Crystals		Germanium Tetrachloride, GeCl_4 Cylinders, Containers	
			

Rods	Wires	Discs	Ingots
			

Silicon-Germanium Alloys, Si-Ge	Silica-Germanium dioxides, $\text{SiO}_2\text{-GeO}_2$	Germanium-Copper- Silver alloys, Ge-Cu-Ag	
			

GERMANIUM COMMODITIES

Classes and Standards

Chemical compounds, Intermediate materials

☐ High-Purity Germanium tetrachloride, GeCl_4

- ☐ CAS# 10038-98-9 | GeCl_4
- ☐ Liquid in cylinders, containers
- ☐ Metallic Germanium manufacturing
- ☐ Purity $\geq 99.9999\%$, 6N Semiconductors
- ☐ Purity $\geq 99.999\%$, 5N Fiber optics
- ☐ Purity $\geq 99.99\%$, 4N Intermediate

☐ High-Purity Germanium dioxide, GeO_2

- ☐ CAS# 1310-53-8 | GeO_2
- ☐ Powders, crystals
- ☐ Metallic Germanium manufacturing
- ☐ Purity $\geq 99.9999\%$, 6N Ultra High Purity
- ☐ Purity $\geq 99.999\%$, 5N Very High Purity
- ☐ Purity $\geq 99.99\%$, 4N High Purity

High-Purity Germanium, Alloys

☐ High-Purity Germanium, unalloyed

- ☐ CAS# 7440-56-4 | Ge
- ☐ Ingots, bars, discs, wires, rods
- ☐ Purity $\geq 99.9999\%$, 6N Semiconductors
- ☐ Purity $\geq 99.999\%$, 5N Fiber optics
- ☐ Purity $\geq 99.99\%$, 4N Alloys component

☐ Silicon-Germanium alloys, Si-Ge

- ☐ E.g., $\text{Si}_{16}\text{Ge}_4$, $\text{Si}_{12}\text{Ge}_8$, $\text{Si}_8\text{Ge}_{12}$, $\text{Si}_4\text{Ge}_{16}$
- ☐ ASTM F416, ISO/ASTM 52920
- ☐ Wafers, quantum wires, microchips
- ☐ Automotive, ADAS, advanced sensors

☐ Silica-Germanium dioxides, SiO_2 - GeO_2 system

- ☐ E.g., 0.75 SiO_2 - 0.25 GeO_2
- ☐ DIN EN 60793-2, DIN EN 60794
- ☐ Crystals, strands, thin film silica glass
- ☐ Communication, Internet, optical fibers

☐ Germanium-Copper-Silver alloys, Ge-Cu-Ag

- ☐ E.g., 0.925 Ag - 0.065 Cu - 0.010 Ge
- ☐ ASTM E378, ASTM E478
- ☐ Rings, sheets, wires, ingots
- ☐ Castings, silverware, jewelry

Other Standard Measurements

☐ Measurement Standards

- ☐ DIN 17034, ISO/IEC 17025: Laboratories
- ☐ DIN EN ISO 17294-2:2017-01: Environmental
- ☐ GHS, ECHA Classifications: Transportation
 - ☐ Germanium tetrachloride, GeCl_4
- ☐ ASTM B329, Metal Powders Density
 - ☐ Germanium dioxide, GeO_2

☐ GHS, ECHA Classifications: Transportation

- ☐ Germanium tetrachloride, GeCl_4
- ☐ ASTM B329, Metal Powders Density
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GLOSSARY

Abbreviations, Definitions

Froth Flotation	a mineral processing technique that separates valuable materials from tails based on differences in their surface properties, specifically their hydrophobicity (water-repelling) or hydrophilicity (water-attracting).
Surfactants	are surface-active substances that alter surface interactions of minerals in water. They act as collectors, selectively binding to specific mineral surfaces, making them hydrophobic. They also act as frothers, stabilizing air bubbles and creating a froth layer that carries the desired mineral.
Fluidized Bed Furnace	a fluidized bed furnace relies on the principle of suspending solid particles in a stream of air or gas, creating a 'fluidized bed' for efficient heat transfer and combustion. Key components include an air distributor, bed material, and a combustion chamber, often with an afterburner section to remove emissions.
Electrostatic Precipitator	an electrostatic precipitator (ESP) is a device used for the removal of fine, volatile particles like dust and smoke from a gas stream. Using electrostatic forces, it works by charging particles with an electrical charge.
Standardization Institutes	ISO: International Organization for Standardization EN European Norm/Standard ASTA: American Society for Testing Materials DIN: Deutsches Institut für Normung

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