Critical Material – The Beryllium Perspective

Keith Smith    VP Technology Materion Brush Inc.
Capitalized with $500, Brush Beryllium Company was incorporated on January 9, 1931 in Cleveland, Ohio.
Materion Corporation
A Global Materials Platform

Corporate Office:
Mayfield Heights, Ohio, U.S.A.

2600 Employees
50 Countries served
34 Facilities
12 Countries with our operations

Materion Corporation is a Publicly Traded Company

materion.com
Beryllium

Beryllium

- Be is number 4 on Periodic Table
- DoD considers Beryllium a “Critical and Strategic” Material

Attributes

- Lightweight, Stiff, Low CTE, High TC, High Melting Point
- Transparent to X-Rays, Neutron Moderator, Dampens Vibration
- Provides enhanced performance when alloyed with Cu, Ni, and Al.

Key Markets

- Defense, Aerospace, Consumer Electronics, Automotive Electronics, Energy, Medical.
Beryllium—A Critical Mineral Commodity—Resources, Production, and Supply Chain

Beryllium is a lightweight and strong metal used in a variety of applications, including aerospace, defense, and industrial components. It is a member of the alkaline earth metals group and is known for its high strength-to-weight ratio. This makes it suitable for use in applications requiring both strength and lightweight, such as in rocket engines, aircraft components, and electronics.

Global Beryllium Production

Beryllium is primarily produced from two minerals: beryllium oxide (BeO) and beryllium nitride (BeN). Beryllium oxide is typically found in the form of beryl, which is a mineral composed of beryllium oxide and other elements. Beryllium nitride is produced through a chemical process involving the reaction of beryllium metal with nitrogen gas. The production of beryllium involves several steps, including mining, milling, smelting, and refining. The mined beryllium ore is processed to remove impurities and concentrate the beryllium content. The resulting beryllium oxide is then treated to produce the pure beryllium metal.

Import Sources (2015–19)

Beryllium is imported from various countries, including those in the United States, Canada, and Russia. These countries supply beryllium in the form of metal, oxide, and other forms for various applications.

How Do We Use Beryllium?

Beryllium is used in a variety of applications due to its unique properties. Some of the primary uses of beryllium include:

- Aircraft and aerospace components
- Electronic and optical devices
- Nuclear reactors
- Magnetic and magnetic structures
- Jewelry and decorative items

Beryllium is also used in alloys, where it enhances the strength and durability of the material.

Where Does Beryllium Come From?

Beryllium is primarily found in the form of beryl, a mineral that is typically found in the Earth's crust. Beryl is mined from deposits found in various parts of the world, including the United States, Canada, and Russia. The mining process involves the extraction of beryl ore from the ground, followed by processing to remove impurities and concentrate the beryllium content.

Beryllium is a critical mineral for the United States, and its production and supply chain are essential for various industries. The United States is a major producer of beryllium, and the country's production capacity is supported by a well-established infrastructure.

USGS Mineral Resources Program

Beryllium is a strategic mineral, and its production and supply chain are monitored by the USGS Mineral Resources Program. The program provides information on the extraction, processing, and distribution of beryllium, as well as its availability in the market.

Domestic Production and Use

The production and use of beryllium in the United States are monitored by the USGS Mineral Resources Program. The program provides information on the extraction, processing, and distribution of beryllium, as well as its availability in the market. The data on beryllium production and use is used to inform policy decisions and ensure the availability of this strategic mineral for various industries.
## Critical Minerals EO

### Table 1: Draft List of critical minerals

<table>
<thead>
<tr>
<th>Mineral commodity</th>
<th>Sectors</th>
<th>Top Producer</th>
<th>Top Supplier</th>
<th>Notable example application</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Defense</td>
<td>China</td>
<td>United States</td>
<td>Oil and gas drilling fluid</td>
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<tr>
<td></td>
<td>Energy</td>
<td>United States</td>
<td>Kazakhstan</td>
<td>Satellite communications, beryllium metal for aerospace</td>
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<td></td>
<td>Communications &amp; electronics</td>
<td>China</td>
<td>China</td>
<td>Pharmaceuticals, lead-free solders</td>
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<tr>
<td></td>
<td>Other</td>
<td>China</td>
<td>China</td>
<td>Medical applications, global positioning satellites, night-vision devices</td>
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<tr>
<td></td>
<td></td>
<td>Brazil</td>
<td>South Africa</td>
<td>Jet engines (superalloys), stainless steels</td>
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<tr>
<td></td>
<td></td>
<td>Congo</td>
<td>Norway</td>
<td>Jet engines (superalloys), rechargeable batteries</td>
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<tr>
<td></td>
<td></td>
<td>China</td>
<td>Mexico</td>
<td>Aluminum and steel production, uranium processing</td>
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<td></td>
<td></td>
<td>China</td>
<td>China</td>
<td>Radar, light-emitting diodes (LEDs), cellular phones</td>
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<td></td>
<td></td>
<td>China</td>
<td>China</td>
<td>Infrared devices, fiber optics</td>
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<td>China</td>
<td>China</td>
<td>Rechargeable batteries, body armor</td>
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<td></td>
<td></td>
<td>Qatar</td>
<td>China</td>
<td>Cryogenic [magnetic resonance imaging (MRI)]</td>
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<td></td>
<td></td>
<td>China</td>
<td>Canada</td>
<td>Flat-panel displays (indium-tin-oxide), specialty alloys</td>
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<tr>
<td></td>
<td></td>
<td>Australia</td>
<td>Chile</td>
<td>Rechargeable batteries, aluminium-lithium alloys for aerospace</td>
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<td></td>
<td></td>
<td>China</td>
<td>China</td>
<td>Incendiary countermeasures for aerospace</td>
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<tr>
<td></td>
<td></td>
<td>China</td>
<td>South Africa</td>
<td>Aluminum and steel production, lightweight alloys</td>
</tr>
</tbody>
</table>
Topaz-Spor Mountain area in western Utah has been a commercial source of uranium and fluorspar.

Beryllium was discovered in 1959.

Materion has been actively mining at that site since 1969.

The mineral is identified as bertrandite, a hydrous beryllium silicate ($\text{Be}_4\text{Si}_2\text{O}_7\text{(OH)}_2$).
Beryllium Supply Chain

- Materion is the only fully integrated beryllium supplier in the world.
- Materion holds estimated ore reserves for 75 years of production.
- Supplies over 70% of the world’s mined beryllium.

- Be production facilities in the US:
  - Delta, UT  Mining
  - Elmore, OH  Extraction, casting, metal fabrication, machining
  - Tucson, AZ  BeO
  - Fremont, CA  Be foil and fabrication
  - Lincoln, RI  Clad products
  - Reading, PA  CuBe strip and wire
  - Warren, MI  CuBe
  - Chicago, IL  CuBe
Challenges

► Foreign Competition:
  ► Materion produces Beryllium domestically, yet competes internationally.
  ► Domestic mining and manufacturing costs much higher.

► How do we build a domestic capability for Critical Minerals which is viable and competitive?
Government Involvement - Materion

- DLA – Strategic Materials Stockpile

- Cooperative Research and Development:
  - LIFT – Manufacturing USA Institute
  - Metals Affordability Initiative

- DoD Manufacturing and Industrial Base Policy Office
  - Defense Production Act Title-III Investment
Be Production at Elmore, Ohio Plant
The Be Pebble Plant in Ohio is the world’s most modern beryllium refining production facility.

- Cost: $110,000,000
- Public-Private partnership with DoD DPA Title-III.
- First production: April 2011.
Challenges

► Can we obtain sufficient volume to be viable?

► Ability to generate acceptable financial returns.

► Will the stock market reward the effort?

► Skilled Workforce – ability to attract and retain.

► Is there a role for the Government?
Aluminum beryllium casting, mag. 200x, viewed with Differential Interference Contrast.
- Daniel Slates; Materion Brush Performance Alloys; Elmore, Ohio USA
Consumer Electronics

- Advanced chemicals for OLED applications
- Multiple product offerings for smartphones, including connector material and voice coil motor (auto focus lens stabilizer)
- Phosphor wheel and opto-ceramic coatings for laser projectors
- Wafer level optical coatings for electronic devices
- 3D/gesture control optical filter capability
- Semiconductor targets for Tier 1 suppliers
Medical

- Precious metal blood glucose test strips for diabetes testing
- Be material for x-ray equipment applications
- Narrow-band optical filters for spectroscopy
- Continuous glucose monitoring (CGM) electrodes for type 2 diabetes
Defense

- Infrared sensors for fighter jet, unmanned aerial vehicle optical targeting
- Optical filters for precision-guided munitions
- Structural components for combat vehicles and aircraft
- Optical, structural, and electronic components for satellites
Automotive Electronics

- Connector material for battery and high temperature applications
- High-performance alloys (i.e., CuBe, ToughMet®) for the powertrain
- Metal matrix composites (i.e., SupremEx®) for chassis, suspension, and braking component applications
- Optical filters: night vision, speed control, sensors, camera applications
Energy

- ToughMet couplings for oil production
- ToughMet components for oil drilling applications
- Connector materials (i.e., Dovetail®) for fuel cell batteries
- Precious metal targets for coatings on construction glass
Materion Business Groups

**Advanced Materials Group**
Specialty materials for thin film deposition, microelectronic packaging products and inorganic chemicals.

**Aerospace Metal Composites**
Manufacturer of High Performance Metal Matrix Composites and Alloys.

**Precision Optics & Thin Film Coatings**
Largest manufacturers of precision thin film coatings and optical filters.

**Beryllium & Composites**
Global producer of beryllium-based metals and metal matrix composites.

**Performance Alloys**
One of the world’s leading suppliers of high-performance alloys.

**Ceramics**
Global leader in high-performance engineered ceramics.

**Electrofusion**
Focused on beryllium x-ray windows, ultra high vacuum (UHV) components and Truextent acoustic solutions.

**Large Area Coatings**
Specializing in the physical vapor deposition (PVD) of inorganic materials onto flexible polymeric films.

**Technical Materials**
The world’s leading resource for customized, high-performance specialty strip metal products.