



SINGLE CRYSTAL MULLITE FIBRE TECHNOLOGY TARGETING AEROSPACE, MILITARY AND WATER INDUSTRIES

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- GCM has a strong opportunity to develop on its mine to market strategy with its Torrington Minerals project.
 - Following the recent **addition of Professor Andrew Ruys**, a world renowned expert in oxide and non-oxide ceramics, GCM is now well equipped to continue research into developing single-crystal mullite fibres from Torrington topaz, providing a mine to market opportunity.
 - Single-crystal mullite fibres are **highly sought after for their exceptional properties**, including high-temperature stability, low thermal expansion and excellent mechanical strength.
 - Previous mullite fibre research primarily focused on fabricating mullite fibres for **reinforcing metal and ceramic matrix composites**, with potential applications across various industries such as:
 - **Defense applications ideal for body, vehicular, and possibly aircraft armour;**
 - **Aerospace;**
 - Impact and Wear Pads for the mining industry;
 - Chemicals;
 - Brake Pads for the Automotive industry; and
 - Catalytic Convertors and Filters.
 - GCM believes its mullite fibre research may lead to a potentially **disruptive beneficiation technology** which will transform low value topaz feedstock into high value single-crystal mullite fibres for use in Metal Matrix Composites (MMCs) and Ceramic Matrix Composites (CMCs).



- GCM management will review previous assessments of industry and assess the potential for the sale of Topaz concentrate to underpin the mining activities, opening the door to produce the **very high value mullite fibre, high-end non-oxide ceramic fibres which can sell for around US\$11,000 per kilogram¹**.
- The global metal matrix composites (MMC) market has been experiencing steady growth, driven **by increasing demand across various industries such as automotive, aerospace, and defense. In 2023, the market was valued at approximately USD 810 million and is projected to reach over USD 2.29 billion by 2032**, exhibiting a compound annual growth rate (CAGR) of around 12.4% during the forecast period².
- With the recently announced pilot plant location (NSW) to advance our VHD Block Technology, GCM will also focus efforts to continue to grow mullite whiskers into coarser fibres, potentially enhancing the reinforcement properties.
- For commercialisation, further study is recommended on factors like aluminium alloy types, mixing techniques, porosity, pore size distribution, calcining temperature, and infiltration parameters.
- As with the VHD Block Technology, GCM believes its single-crystal mullite fibre process will **garner significant market interest in the United States of America** (especially given its Defense and Aerospace applications) and has commenced mapping out its path to advancing these market and access potential government funding.

Green Critical Minerals Ltd (ASX:GCM) ('GCM' or 'the Company') which holds the 100% rights to the Torrington Topaz-Tungsten Project via its 100% owned subsidiary Torrington Minerals Pty Ltd is pleased to provide an update regarding its topaz single crystal mullite fibre technology.

Previous Research and Development

GCM's wholly owned subsidiary, TopFibre Pty Ltd, in collaboration with the University of New South Wales (UNSW), previously conducted extensive research on producing single-crystal mullite fibres from topaz (see ASX announcements 9 April 2019 and 3 July 2020). This research demonstrated the potential of mullite fibres in various applications, including:

- **Mining:** High-durability impact and wear pads.
- **Automotive:** Advanced brake pads and catalytic converters offering cost and performance advantages.

¹ <https://pubs.rsc.org/en/content/articlehtml/2015/ra/c5ra17300k>

² <https://www.gminsights.com/industry-analysis/metal-matrix-composite-market>



- **Defense:** Lightweight, high-performance military armour for body, vehicles, and aircraft.
- **Chemical Industry:** High-temperature filtration systems.

A secondary commodity, which will utilise all of the fluorine by-product, is sodium silicofluoride, which is used widely in water fluoridation and can be used to develop a high-value niche product (fibres) and a large-volume, low-value product (fluoride).

The research highlighted the superior thermal stability, mechanical strength, and lightweight properties of mullite fibre-reinforced composites. However, further development was paused due to resource constraints and COVID-19 disruptions.

Enhanced Research and Development Capability

With its recently acquired VHD Block Technology and the recent appointment of Professor Andrew Ruys, a globally renowned expert in oxide and non-oxide ceramics (see ASX announcement 5 November 2024), GCM has the capability to progress advanced material technologies. With this new capability, GCM will review its previous research with an intention to define a pathway to commercialisation for its single-crystal mullite fibre technology.

The Significance of Single-Crystal Mullite Fibre

Single-crystal mullite fibre is often regarded as the "holy grail" in composite reinforcement materials due to its exceptional properties:

- **High-Temperature Stability:** Maintains structural integrity at elevated temperatures, making it ideal for aerospace and industrial applications.
- **Superior Mechanical Strength:** Offers high tensile strength and fracture toughness, enhancing the durability of composite materials.
- **Low Density:** Contributes to lightweight composites, crucial for applications where weight reduction is essential.
- **Chemical Resistance:** Exhibits excellent resistance to corrosion and chemical degradation, extending the lifespan of components.

These attributes make single-crystal mullite fibre a highly sought-after material for reinforcing both metal matrix composites (MMCs) and ceramic matrix composites (CMCs), leading to improved performance in demanding environments.

Market Potential and Size

The global metal matrix composites (MMC) market has been experiencing steady growth, driven by increasing demand across various industries such as automotive, aerospace, and defense. In 2023, the market was valued at approximately USD 810 million and is projected to reach over

USD 2.29 billion by 2032³, exhibiting a compound annual growth rate (CAGR) of around 12.4% during the forecast period. These markets are driven by increasing demand from aerospace, automotive, defence, and industrial sectors seeking materials that offer performance advantages over traditional options.

Additionally, as single-crystal mullite fibres long have been considered the holy grail of fibre reinforcements, but they are not available commercially, there are literally hundreds, if not thousands, of industrial and research laboratories that are potential customers.

High-end non-oxide ceramic fibres, such as silicon carbide (SiC) fibres, are renowned for their exceptional properties, including high-temperature stability, strength, and oxidation resistance. These attributes make them ideal for reinforcing metal and ceramic matrix composites used in industries such as aerospace, automotive, and defence.

The pricing of these fibres varies based on factors like manufacturing processes, quality, and intended applications. For instance, chemical vapor deposited (CVD) SiC monofilaments are among the most expensive ceramic fibres, with prices reaching up to approximately €8,000 per kilogram (around USD 11,000 per kilogram)⁴.

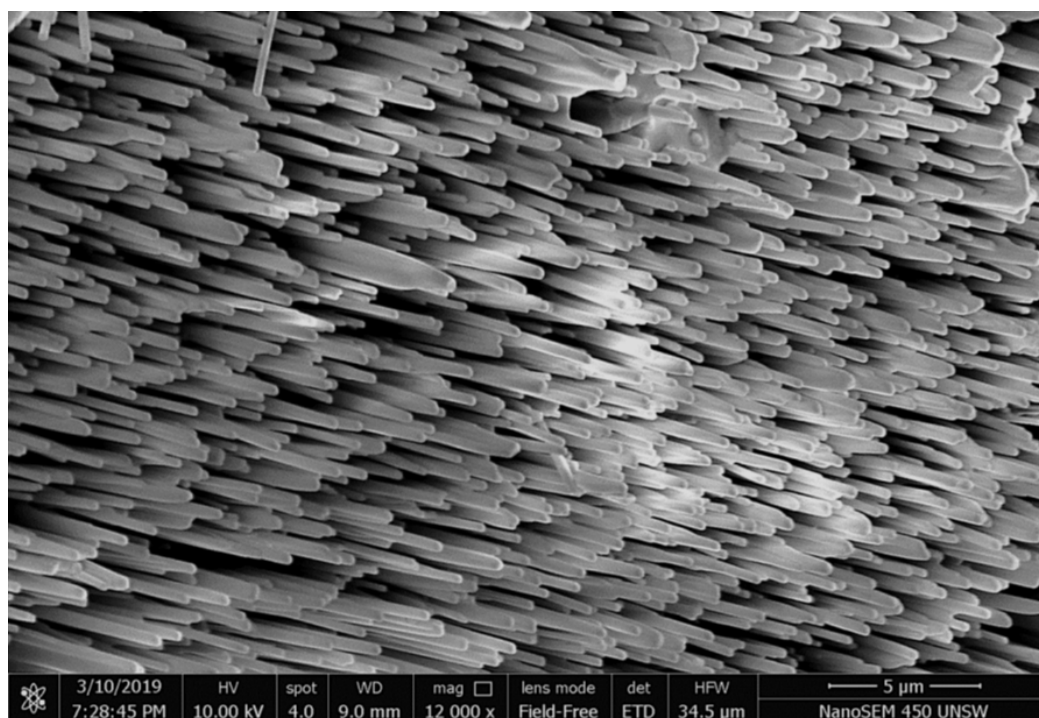


Figure 1 Proof-of-concept that parallel (and separable) fibres by growth on templates can be fabricated is demonstrated.

³ <https://www.gminsights.com/industry-analysis/metal-matrix-composite-market>

⁴ <https://pubs.rsc.org/en/content/articlehtml/2015/ra/c5ra17300k>

Recommendations for Future Work

GCM will now commence to develop a work program for the single crystal mullite fibre technology, considering the recommendations from previous research which may include:

1. **Optimisation of Fibre Production:** Refining parameters such as porosity control, calcining temperatures, and infiltration techniques to achieve consistent and scalable production.
2. **Exploration of Metal and Ceramic Matrix Composites:** Conducting live testing in MMCs and CMCs to validate mullite fibre performance under real-world conditions.
3. **Pilot Plant Design:** Developing a pilot production facility to bridge the gap between laboratory-scale research and commercial-scale manufacturing.
4. **Market Assessment:** Engaging with key industry players to identify priority applications and secure partnerships for product development and adoption.
5. **Environmental Impact Studies:** Ensuring sustainable practices in the extraction of topaz and production of mullite fibre, aligning with GCM's environmental and social governance objectives.

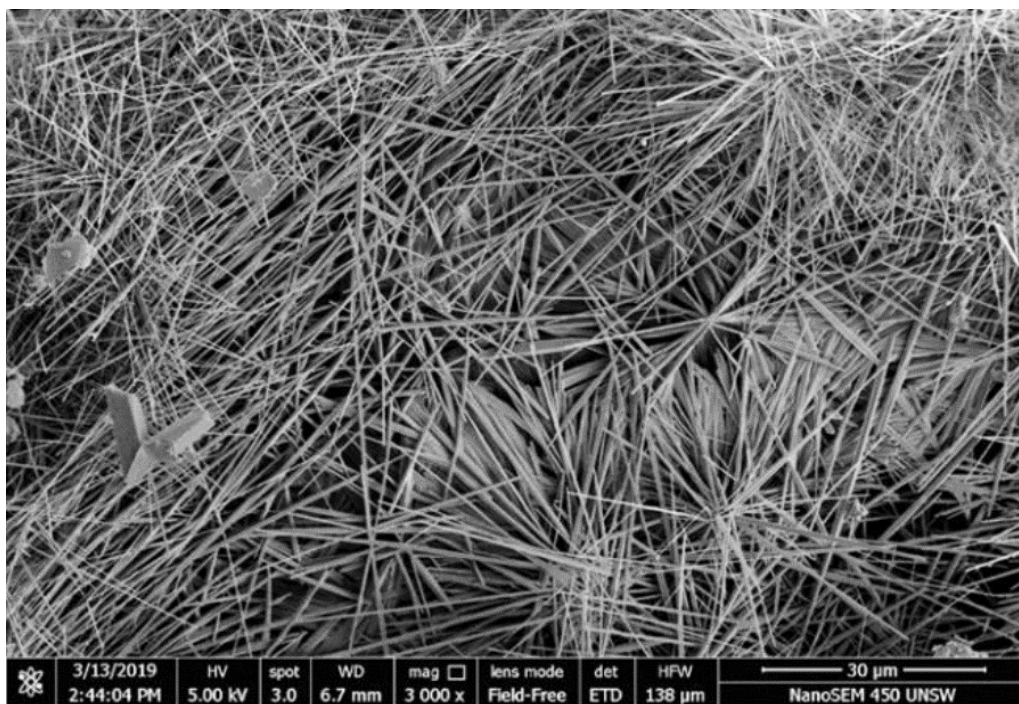


Figure 2 The maximal fibre length of $\leq 35 \mu\text{m}$ is readily achieved.

Commitment to Innovation

GCM remains committed to unlocking value from its portfolio of mineral and advanced material assets with a strong focus on mine to market whilst maximising the returns for shareholders. The Company will provide updates on the progress of this initiative as milestones are achieved.



The general aim of the program is to develop the means leading to the production of commercial quantities of such individual, single-crystal, mullite fibres from topaz of dimensions suitable for implementation as reinforcements for MMCs and CMCs.

Authorisation

The provision of this announcement to the ASX has been authorised by the Board of Directors of Green Critical Minerals Limited.

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