Mineral Metal Energy Oil Gas and Aggregate, *2(2): 171-175; 2025. DOI: 10.18311/2MEOGA/2025/v2i2/49629* *FEATURE ARTICLE*

INFORMATICS JOURNALS

Online ISSN : 3049-3455

Mineral Metal Energy Oil Gas and Aggregate

Contents available at: *www.informaticsjournals.co.in/index.php/2MEOGA*

2MEOGA

Adopt or Miss

What and How Different Countries and Companies Are Pursuing For Dominance in the Metal Matrix-Composite Market

Jayanta Bhattacharya

Former Professor, The Department of Mining Engineering and Former Founding Professor, The School of Environmental Science and Engineering, Indian Institute of Technology, Kharagpur—721302, West Bengal, India; jayantaism@gmail.com

1.0 Basics

Metal Matrix Composites (MMCs) are synthesized by combining a metal or alloy matrix with reinforcing materials such as ceramics, fibers, or particles to enhance properties like strength, stiffness, wear resistance, and thermal stability. The basic principle of synthesis involves embedding these reinforcements into the metal matrix to form a composite material with superior mechanical and physical characteristics compared to the base metal alone. Common synthesis techniques include powder metallurgy, stir casting, diffusion bonding, and infiltration methods. Each process is selected based on the desired properties, compatibility of materials, and application requirements. Uniform distribution of the reinforcement and strong interfacial bonding are critical to ensuring the effectiveness and durability of the final MMC product.

2.0 The Global Market

The global metal-composite market is experiencing significant growth, driven by advancements in aerospace, automotive, and defense sectors. Countries and companies worldwide are actively pursuing dominance in this market through strategic investments and innovations.Over the past decade, the global Metal Matrix

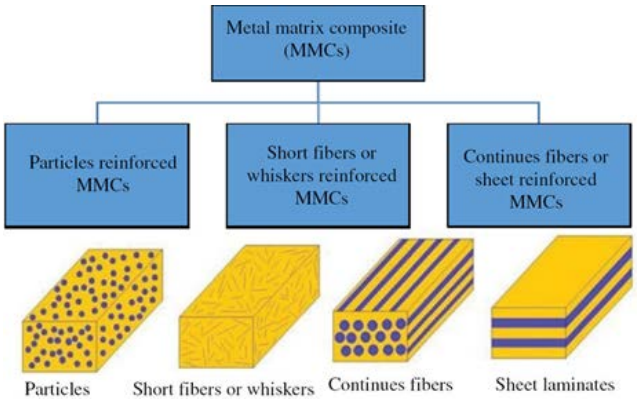


Figure. Metal Matrix Composite.

Composite (MMC) market has experienced significant growth, driven by increasing demand for lightweight, high-performance materials across various industries. In 2015, the market was valued at approximately USD 329 million. By 2020, it had grown to USD 467 million, reflecting a Compound Annual Growth Rate (CAGR) of about 7.2% during that period. This growth was primarily fueled by the automotive and aerospace sectors' pursuit of materials that offer superior strength-to-weight ratios and enhanced thermal properties. From 2020 to 2025, the market is projected to expand further, reaching USD 787 million, with an anticipated CAGR of 11.0%. Key factors contributing to this acceleration include advancements in

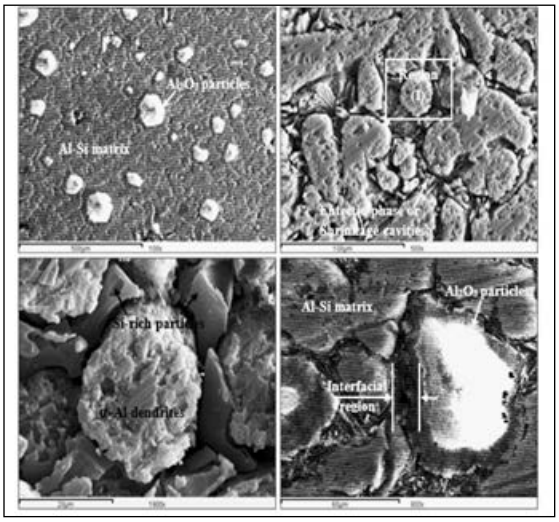


Figure. SEM Image of an example MMC.

manufacturing technologies such as powder metallurgy and additive manufacturing, as well as the rising adoption of MMCs in electric vehicles and electronic devices. Looking ahead, the market is expected to continue its upward trajectory, with forecasts estimating a value of USD 915.8 million by 2033, growing at a CAGR of 5.7% from 2025 onwards. This sustained growth underscores the increasing importance of MMCs in modern engineering applications, particularly in sectors prioritizing efficiency, durability, and performance.

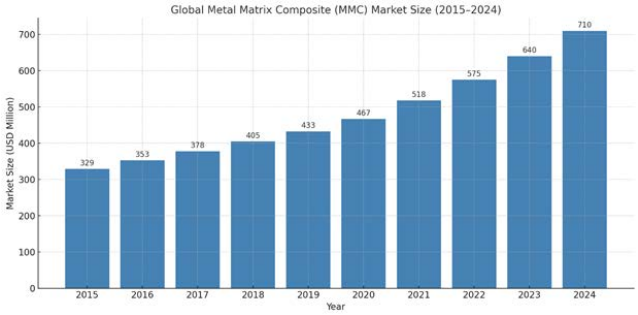


Figure. Global Metal Matrix Composite (MMC) Market growth in last 10 years.

Over the next decade, the global Metal Matrix Composite (MMC) market is poised for continued expansion, driven by technological advancements and the growing demand for high-performance, lightweight materials in key industries such as aerospace, automotive, defense, and electronics. The market, which is expected to reach around USD 787 million by 2025, is projected to surpass USD 1.3 billion by 2035, reflecting a steady Compound Annual Growth Rate

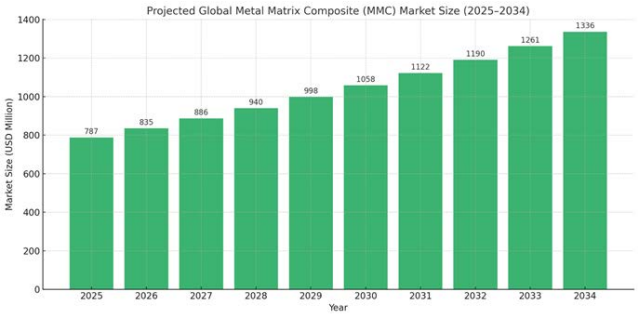


Figure. Projected Global Metal Matrix Composite (MMC) Market growth in the next 10 years.

(CAGR) of approximately 5.7%–6.5%. This growth will be underpinned by increased adoption of MMCs in Electric Vehicles (EVs), additive manufacturing, and space exploration technologies, where their superior strength-to-weight ratio, heat resistance, and durability offer significant advantages. Furthermore, emerging markets in Asia-Pacific and the Middle East are likely to play a pivotal role in accelerating market growth, as they invest heavily in advanced manufacturing infrastructure and lightweight material technologies. As environmental regulations tighten and industries push for greater fuel efficiency and performance, MMCs are set to become a critical material choice across multiple high-growth sectors.

3.0 Leading Countries in the Metal-Composite Market

United States

The U.S. maintains a dominant position in the metal-composite market, particularly in aerospace and defense applications. The presence of leading manufacturers and substantial R&D investments contribute to its strong market share.

China

China's status as the largest automotive producer globally has led to significant incorporation of metal matrix composites (MMCs) in manufacturing lightweight and fuel-efficient vehicles. The expanding aerospace sector, supported by government initiatives and increasing air travel demand, further propels China's MMC market.

Germany

Germany holds a significant share in the European MMC market, driven by its leading automotive

manufacturers and aerospace companies. The country's focus on advanced manufacturing technologies and lightweight materials aligns with the European Union's stringent environmental regulations aimed at reducing carbon emissions.

India

India's MMC market is growing, with key players like Tata Steel, Mahindra CIE Automotive Ltd., and Hindalco Industries specializing in manufacturing composites for various industries. Despite challenges during the COVID-19 pandemic, the market has shown resilience, with opportunities emerging in industries demanding lightweight, high-performance materials.

4.0 Prominent Companies in the Metal-Composite Market

Toray Industries (Japan)

Toray Industries is a global leader in carbon fiber composite materials, extensively used in aerospace applications, including components for the Boeing 787 airliner.

SGL Carbon (Germany)

SGL Carbon SE is one of the world's leading manufacturers of carbon-based products, including carbon fibers and composites, serving various industries worldwide.

Morgan Advanced Materials (UK)

Morgan Advanced Materials plc manufactures specialist products using carbon, advanced ceramics, and composites, catering to sectors like aerospace, automotive, and energy.

VSMPO-AVISMA (Russia)

VSMPO-AVISMA Corporation is the world's largest titanium producer, supplying titanium products to aerospace companies globally.

Höganäs AB (Sweden)

Höganäs AB is the world's largest producer of powdered metals, developing and marketing powders for customers in metallurgical industries, including automotive and aerospace.

Plansee SE (Austria)

Plansee SE manufactures products made from refractory metals like molybdenum and tungsten, serving industries such as electronics, automotive, and energy.

Strategic Trends and Developments

- Middle East Expansion: Gulf states like Oman, Abu Dhabi, and Saudi Arabia are establishing metal trading companies to capitalize on the growing demand for metals and diversify their economies beyond oil and gas.
- Trade Policies Impact: U.S. tariffs on steel and aluminum imports have affected global trade flows, prompting countries like India to seek alternative markets in Europe and Southeast Asia.

Return on Investment (ROI) figures for prominent companies

Based on the latest available data, here are the Return on Investment (ROI) figures for prominent companies in the metal matrix composites (MMC) market:

1. **Materion Corporation (Ticker: MTRN)**

- **Recent ROI Performance:**
  - As of September 30, 2024: 8.39%
  - Peak ROI in recent years: 11.73% (Q3 2023)
  - Lowest ROI in recent years: 1.24% (Q4 2020)

- **Financial Highlights:**
  - 2023 Net Income: $95.7 million
  - 2023 Revenue: $1.67 billion
  - 2023 Operating Cash Flow: $144.4 million
  - 2023 Free Cash Flow: $24.5 million

- **Outlook:**
  - Despite a 13% year-over-year decline in Q1 2024 sales, Materion maintained EBITDA margins at 17.5% of value-added sales.
  - The company anticipates record results in 2024, with adjusted earnings per share projected between $5.60 and $6.20, representing a 5% increase from the prior year.

2. **CPS Technologies Corporation**

- **Strategic Developments:**
  - In 2024, CPS acquired a 5-axis CNC machine, enhancing in-house manufacturing capabilities and reducing costs and delivery times.

- The company secured exclusive rights to manufacture and sell Fiber-Reinforced Aluminum (FRA)®, a material offering superior wear resistance and high-

temperature performance, suitable for military and commercial applications. Market Position:

- CPS focuses on advanced MMC solutions for sectors like aviation, defense, and oil & gas, aiming to improve performance and reliability across various applications.

3. 3M Company (Ticker: MMM)

- **Recent ROI Performance:**
  - As of September 30, 2024: 8.39%
- **Company Overview:**
  - 3M operates as a diversified technology firm with four business segments: Safety & Industrial, Transportation & Electronics, Health Care, and Consumer.
  - The company serves a global customer base, with operations across the United States, Europe, Middle East and Africa, Latin America/Canada, and the Asia Pacific regions.

4. Denka Company Limited

- **Financial Snapshot:**
  - FY 2017 Revenue: JPY 395.6 billion (~USD 3.56 billion)
  - FY 2017 Net Income: JPY 23 billion (~USD 207 million)
- **Company Profile:**
  - Denka is a Japanese chemical company established in 1915, manufacturing a range of products including organic and inorganic chemicals, cement, electronic component transfer materials, and food packaging materials.
  - The company is listed on the Tokyo Stock Exchange and is a constituent of the Nikkei 225 stock index.

5.0 Metal matrix composites, their structures, varieties, and applications

Metal composites—more specifically, Metal Matrix Composites (MMCs)—are advanced materials made by combining a metal or metal alloy (matrix) with a secondary material (reinforcement) to improve its mechanical, thermal, or other functional properties. They are part of a broader category of composite materials (which also includes polymer and ceramic matrix composites).

Based on the latest available data, here is a time series bar chart illustrating the Return on Investment (ROI) for prominent companies in the Metal Matrix Composites (MMC) market from 2020 to 2024. The chart represents the ROI percentages for each company over the specified years.

ROI Data Summary

Year	Materion Corporation	CPS Technologies Corporation	3M Company
2020	1.24%	13.94%	23.68%
2021	9.03%	23.48%	19.26%
2022	9.70%	13.08%	18.72%
2023	10.72%	7.82%	-12.56%
2024	8.39%	Data Not Available	26.67%

Structure of Metal Composites

◆ Matrix Phase

- The continuous phase that holds everything together.
- Usually a metal such as aluminum, titanium, magnesium, or copper.
- Provides ductility and toughness.

◆ Reinforcement Phase

- Discontinuous phase added to strengthen or enhance specific properties.
- Can be in the form of particles, fibers, or whiskers.
- Made from ceramics (e.g., SiC, Al_2O_3), carbides, borides, or even carbon fibers.

Varieties of Metal Composites

1. Particle-Reinforced MMCs

- Reinforcements: Small particles like silicon carbide (SiC) or alumina (Al_2O_3).
- Improves: Strength, stiffness, wear resistance.
- Example: Aluminum-SiC composites used in brake rotors.

2. Fiber-Reinforced MMCs

- Reinforcements: Continuous or short fibers like carbon fibers or boron fibers.
- Improves: Load-bearing capability, fatigue resistance.
- Example: Titanium-carbon fiber composites in aerospace structures.

3. Whisker-Reinforced MMCs

- Whiskers: Tiny, single-crystal fibers with high strength (e.g., SiC whiskers).
- High strength but processing and health risks due to inhalable fine whiskers.

6.0 Applications of Metal Composites

Industry	Application
Aerospace	Aircraft structures, turbine blades, satellite frames
Automotive	Brake discs, drive shafts, cylinder liners, pistons
Defense	Lightweight armor, missile components
Industrial	Cutting tools, extrusion dies, wear-resistant coatings
Electronics	Heat sinks, electrical contacts
Space	Lightweight, high-strength structures for satellites and space probes
Biomedical	Implants, prosthetics (e.g., titanium matrix with biocompatible ceramics)

Advantages

- High strength-to-weight ratio
- Better wear and creep resistance
- Superior thermal and dimensional stability
- Tunable properties by altering reinforcement

Challenges

- Expensive manufacturing (e.g., powder metallurgy, stir casting, diffusion bonding)
- Machining difficulties due to hard reinforcements
- Limited recyclability