

Matrix Composites: Polymeric & Ceramic

Fabrication, Structure, Properties, Interface Characteristics & Applications



Presented By:

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Polymeric Matrix Composites (PMC)

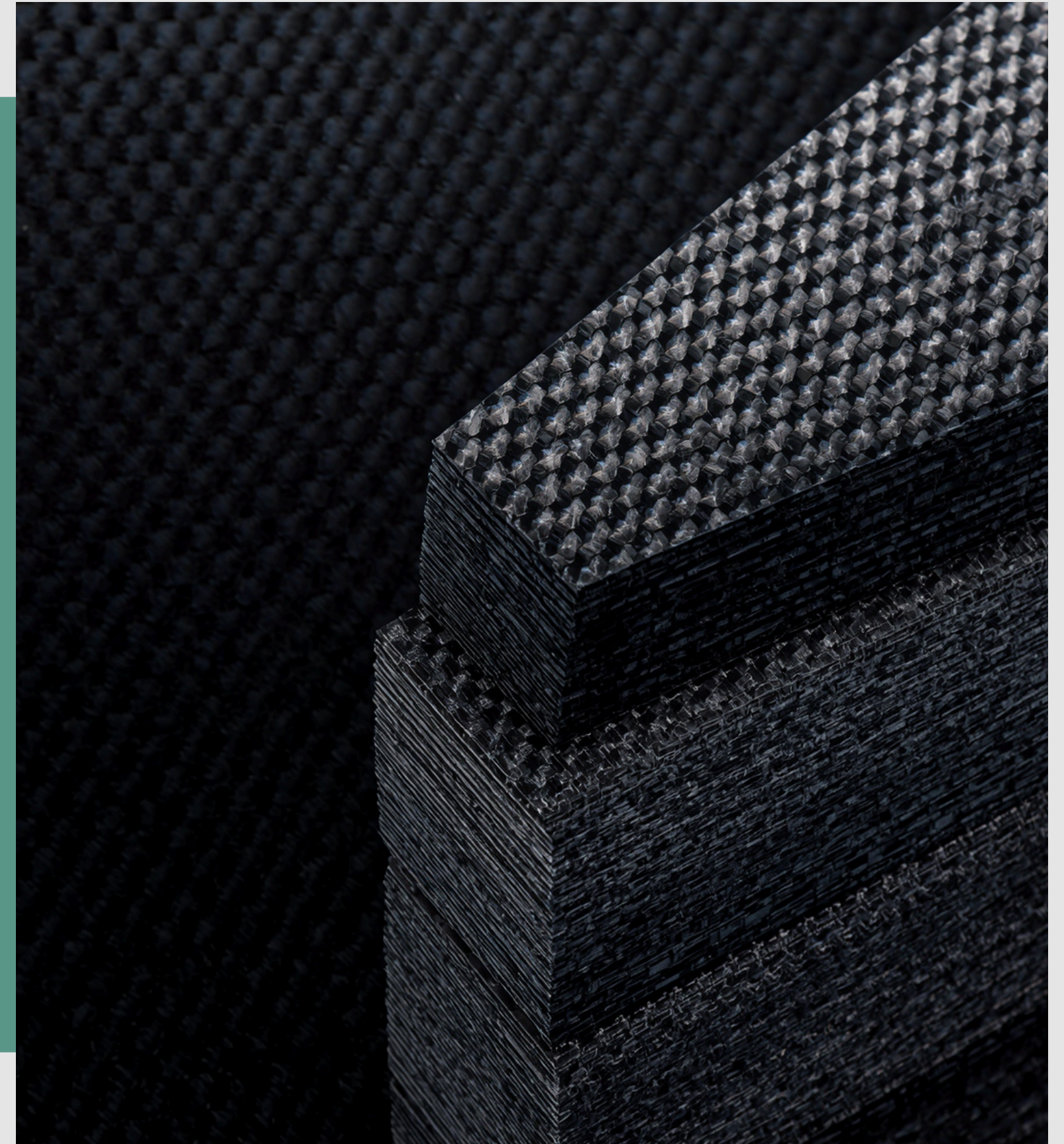
Polymeric Matrix Composites (PMCs) are advanced materials consisting of a polymer resin as the matrix reinforced with fibers such as glass, carbon, or aramid.

They are widely used due to their lightweight nature, high strength-to-weight ratio, corrosion resistance, and ease of fabrication into complex shapes.

PMCs are foundational in aerospace, automotive, marine, and civil engineering applications, offering tailored mechanical and thermal properties.

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1. Hand Lay-up

1. Spray-up Process

1. Filament Winding

1. Pultrusion

1. Resin Transfer Molding

PMC Fabrication Methods

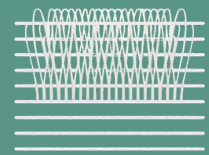
Polymeric Matrix Composites (PMCs) are manufactured using a variety of fabrication techniques, each suited to specific applications, geometries, and production volumes. The choice of method significantly influences the final mechanical properties and microstructure of the composite. The fabrication process determines fiber orientation, void content, resin distribution, and overall structural integrity. Selecting the appropriate method is critical to achieving desired performance characteristics in the final composite component.

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PMC Structure & Properties

Polymeric Matrix Composites (PMCs) consist of a polymer resin reinforced with fibers such as carbon, glass, or aramid. Their unique microstructure delivers an exceptional combination of lightweight design, high strength, and tailored mechanical performance across diverse engineering applications.



**Fiber Reinforcement
Types &
Arrangements**



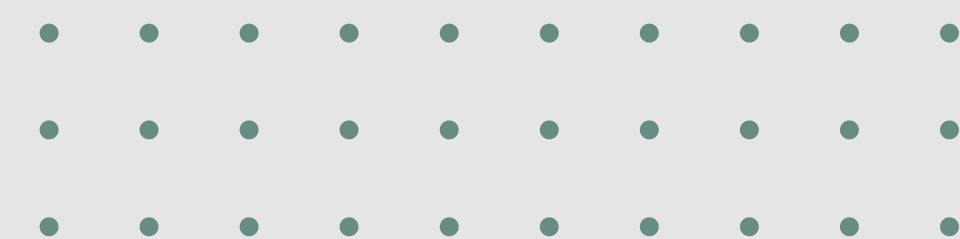
**Matrix Material &
Resin Systems**



**Mechanical
Properties & Strength**



**Thermal Behavior &
Stability**



Methods & Tools

1

PMC Interface Characteristics

Fiber-matrix bonding is critical to load transfer in polymeric matrix composites. The interface governs stress distribution, crack propagation, and overall mechanical performance.

Key interface mechanisms include chemical bonding, mechanical interlocking, and residual thermal stresses. Surface treatments such as sizing agents and coupling agents (e.g., silanes) enhance adhesion and wettability.

Weak interfaces allow debonding and fiber pull-out, improving toughness, while strong interfaces maximize stiffness and strength.

2

PMC Applications

PMC applications span high-performance industries due to their excellent strength-to-weight ratio and tailorable properties.

Aerospace: Aircraft fuselage panels, wing structures, rotor blades – carbon/epoxy composites reduce weight by 20–30%.

Automotive: Body panels, drive shafts, leaf springs – glass/polyester and carbon/epoxy reduce vehicle weight and improve fuel efficiency.

Sports Equipment: Tennis rackets, bicycle frames, golf clubs, and helmets benefit from high stiffness and fatigue resistance.

Ceramic Matrix Composites (CMC)

Ceramic Matrix Composites (CMCs) are advanced engineering materials consisting of ceramic fibers embedded within a ceramic matrix. They are designed to overcome the inherent brittleness of monolithic ceramics while retaining their high-temperature stability and low density. CMCs offer exceptional performance in extreme environments, making them ideal for aerospace, defense, and industrial applications. Their unique combination of high strength, thermal resistance, and lightweight properties positions them as next-generation structural materials.

Sweshareefa Mahakul

Assistant Professor, Dept. of Mechanical Engineering



1. Chemical Vapor Infiltration

1. Polymer Infiltration & Pyrolysis

1. Melt Infiltration

1. Hot Pressing

1. Sintering

CMC Fabrication Methods

Ceramic Matrix Composites are manufactured using specialized high-temperature processing techniques that ensure proper fiber-matrix bonding and microstructural integrity.

Each fabrication method offers distinct advantages in terms of density, porosity control, and compatibility with reinforcement fibers, making the choice of process critical to final composite performance.

Sweshareefa Mahakul, Assistant Prof. ME

CMC Properties & Interface Characteristics

Ceramic Matrix Composites exhibit exceptional high-temperature performance and unique fiber-matrix interface characteristics.

These properties make CMCs ideal for extreme environment applications in aerospace, energy, and defense sectors.

— Sweshareefa Mahakul, Assistant Prof., ME



High-Temperature
Stability



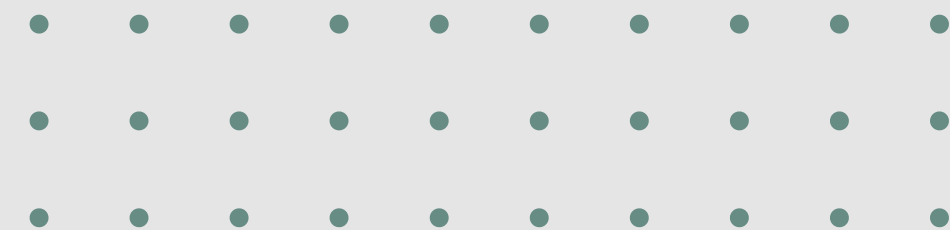
Oxidation Resistance



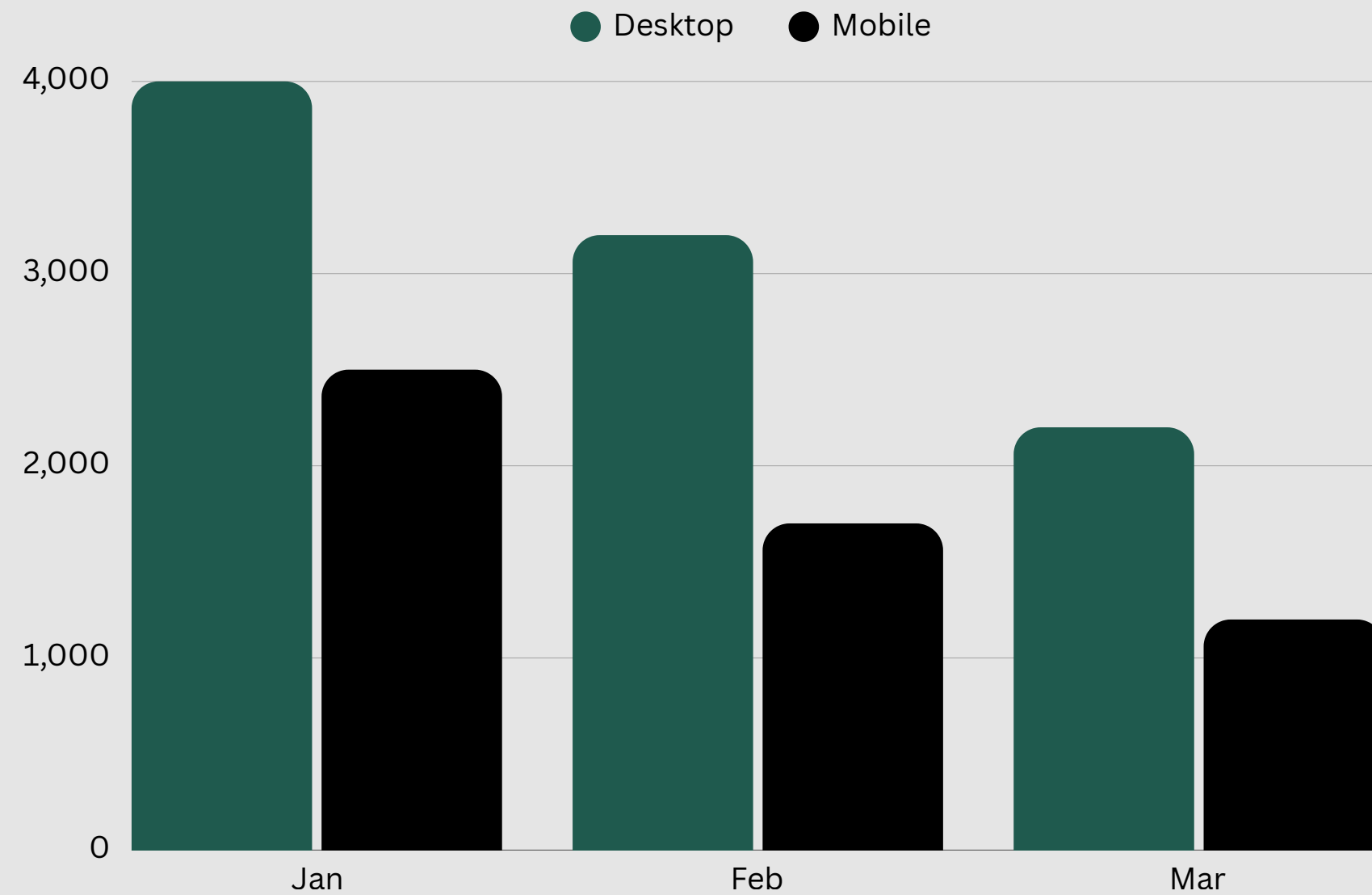
Thermal Shock
Resistance



Fiber-Matrix Interface
Bonding



CMC Toughness & Applications



Toughening Mechanisms in CMCs:

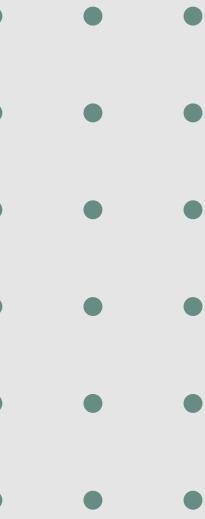
- Crack Deflection: Cracks redirect along weak fiber-matrix interfaces, absorbing energy and preventing catastrophic failure.
- Fiber Bridging: Intact fibers span crack faces, resisting opening and redistributing stress across the composite.
- Fiber Pull-Out: Fibers debond and slide out during fracture, dissipating significant energy and enhancing toughness.

Key Applications:

- Aerospace: Turbine blades, combustion liners, thermal protection systems for re-entry vehicles.
- Energy: Gas turbine components, nuclear reactor structures, heat exchangers.
- Defense: Missile nose cones, armor systems, hypersonic vehicle structures.

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Thank



You!

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