23rd International Metallurgy and Materials Congress

23. Uluslararası Metalurji ve Malzeme Kongresi

22-24 October/Ekim 2026, ISTANBUL

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METEM

UCTEA Chamber of Metallurgical and Materials Engineers' Training Center

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immc2026

IMMC2026 PROGRAMME
IMMC2026 PROGRAMI

HALL-3 **10.00 - 11.00** **Opening Ceremony /** Açılış Töreni

	FUAYE RED HALL KIRMIZI SALON		HALL-6 BLUE HALL MAVİ SALON		HALL-5 PURPLE HALL MOR SALON
13.00 - 14.10 Session **1** Oturum	**CRMS** **Critical Raw Materials and Rare Earth Elements Symposium** Kritik Hammaddeler ve Nadir Toprak Elementleri Sempozyumu	**13.30 - 14.00**	**NMS** **Nanomaterials Symposium** Nanomalzemeler Sempozyumu	**13.00 - 14.20**	**NFMS** **Non-Ferrous Metals Symposium** Demir Dışı Metaller Sempozyumu
Coffee Break / Kahve Molası					
14.30 - 15.50 Session **2** Oturum	**CRMS** **Critical Raw Materials and Rare Earth Elements Symposium** Kritik Hammaddeler ve Nadir Toprak Elementleri Sempozyumu	**14.20 - 15.40**	**NMS** **Nanomaterials Symposium** Nanomalzemeler Sempozyumu	**14.40- 16.00**	**NFMS** **Non-Ferrous Metals Symposium** Demir Dışı Metaller Sempozyumu
Coffee Break / Kahve Molası					
16.10 - 17.10 Session **3** Oturum	**AIMLS** **Artificial Intelligence and Machine Learning Symposium** Yapay Zekâ ve Makine Öğrenmesi Sempozyumu	**16.00 - 17.20**	**BMS** **Biomaterials Symposium** Biyomalzemeler Sempozyumu	**16.20 - 17.40**	**NFMS** **Non-Ferrous Metals Symposium** Demir Dışı Metaller Sempozyumu

23 OCTOBER 2026 FRIDAY
23 EKİM CUMA

	FUAYE RED HALL KIRMIZI SALON		HALL-6 BLUE HALL MAVİ SALON		HALL-5 PURPLE HALL MOR SALON
10.00 - 11.20 Session 1 Oturum	**URS** **Undergraduate Research Symposium** Lisans Öğrencileri Araştırma Sempozyumu	10.00 - 11.20	**STS** **Steel Symposium** Çelik Sempozyumu	10.00 - 11.00	**AMTS** **Additive Manufacturing Technologies Symposium** Eklemeli İmalat Teknolojileri Sempozyumu
Coffee Break / Kahve Molası					
11.40 - 12.50 Session 2 Oturum	**RSS** **Recycling and Sustainability Symposium** Geri Dönüşüm ve Sürdürülebilirlik Sempozyumu	11.40 - 12.40	**STS** **Steel Symposium** Çelik Sempozyumu	11.20 - 12.20	**AMTS** **Additive Manufacturing Technologies Symposium** Eklemeli İmalat Teknolojileri Sempozyumu
Lunch / Öğle Yemeği					
13.30 - 14.50 Session 3 Oturum	**RSS** **Recycling and Sustainability Symposium** Geri Dönüşüm ve Sürdürülebilirlik Sempozyumu	13.30 - 14.50	**STS PANEL** **Sustainability in Iron and Steel** Demir Çelikte Sürdürülebilirlik	13.30 - 15.20	**EMS** **Energy Materials Symposium** Enerji Malzemeleri Sempozyumu
Coffee Break / Kahve Molası					
15.10 - 16.30 Session 4 Oturum	**RSS** **Recycling and Sustainability Symposium** Geri Dönüşüm ve Sürdürülebilirlik Sempozyumu	15.10 - 16.30	**STS** **Steel Symposium** Çelik Sempozyumu	15.40 - 16.40	**CPMS** **Composite and Polymer Materials Symposium** Kompozit ve Polimer Malzemeler Sempozyumu
Coffee Break / Kahve Molası					
		16.50 - 17.50 Session 5 Oturum	**OHSS** **Occupational Health and Safety Symposium** İş Sağlığı ve Güvenliği Sempozyumu	17.00 - 18.00	**CPMS** **Composite and Polymer Materials Symposium** Kompozit ve Polimer Malzemeler Sempozyumu

24 OCTOBER 2026 SATURDAY
24 EKİM CUMARTESİ

	FUAYE RED HALL KIRMIZI SALON		HALL-6 BLUE HALL MAVİ SALON		HALL-5 PURPLE HALL MOR SALON
10.00 - 11.20 Session 1 Oturum	**STCS** **Surface Treatment and Coating Symposium** Yüzey İşlemler ve Kaplama Sempozyumu	10.00 - 11.00	**CGRS** **Ceramics, Glass, Refractory Materials Symposium** Seramik, Cam, Refrakter Malzemeler Sempozyumu	10.00 - 10.40	**WNTS** **Welding and Non-Destructive Testing Symposium** Kaynak ve Tahribatsız Muayene Sempozyumu
Coffee Break / Kahve Molası					
11.40 - 12.50 Session 2 Oturum	**STCS** **Surface Treatment and Coating Symposium** Yüzey İşlemler ve Kaplama Sempozyumu	11.20 - 12.40	**CGRS** **Ceramics, Glass, Refractory Materials Symposium** Seramik, Cam, Refrakter Malzemeler Sempozyumu	11.20 - 12.40	**FAHTS** **Failure Analysis and Heat Treatment Symposium** Hasar Analizi ve Isıl İşlem Sempozyumu
Lunch / Öğle Yemeği					
14.00 - 15.00 Session 3 Oturum	**CWS** **Corrosion and Wear Symposium** Korozyon ve Aşınma Sempozyumu	14.00 - 14.40	**CGRS** **Ceramics, Glass, Refractory Materials Symposium** Seramik, Cam, Refrakter Malzemeler Sempozyumu		

Undergraduate Research
Lisans Öğrencileri Araştırma

URS-1
The Influence of Porosity on Laser Cutting of Cu-Ni-Mo Based Steel Foams

Mustafa Ali KAÇAN, Esra ÜNAL, Pelin KAYA, Gizem KARABULUT ŞEVK, Nuray BEKÖZ ÜLLEN

İstanbul University-Cerrahpaşa
Türkiye

URS-2
Copper-Based Porous Metals: An Overview of Manufacturing and Applications

Azra ASLAN, Sıla KUZU, Çisem CERAN, Gizem KARABULUT ŞEVK, Nuray BEKÖZ ÜLLEN

İstanbul University-Cerrahpaşa
Türkiye

URS-3
Microstructure Properties of Ni-Mn-O Based Spinel Oxide Ceramics

Hasan Kutay VERİM[1], Gökhan HARDAL[2], Caner İLDEŞ[3], Berat Yüksel PRICE[1]

[1]İstanbul University-Cerrahpasa, [2]İstanbul University, [3]Yozgat Bozok University
Türkiye

URS-4
Effect of Electrolyte Composition on the Properties of PEO Coatings Synthesized on Al-9Cu Alloy

Talha ÖZASLAN, MuhammeT Taha DALGIC, Harun BİRİNCİ, Kral Ali COŞAN, Mehmet TARAKCI, Yücel GENCER

Gebze Technical University
Türkiye

URS-5
Role of Mg and Ti Additions in Controlling the Microstructure and Mechanical Properties of Compacted Graphite Iron

Ahmet Buğra KEYVANKLI[1], Ahmet ÖZEL[2], Süleyman Can KURNAZ[2], Tan EMİR[1]

[1]Ferro Döküm, [2]Sakarya University
Türkiye

URS-6
A Review on Titanium-Based Biomaterials for Orthopedic Applications

İlkim ASLAN

Gazi University
Türkiye

URS Undergraduate Research Symposium

Human Factors in NDT: Human Error, Reliability, and Improvement Strategies 275
Eren BİLEN, Necip ÜNLÜ
İstanbul Technical University
Türkiye

Development of a Sustainable Magnesium Production Method and Assessment of By-Products 279
Mehmet Akif ASLAN, Semih GÜVEN, Muhammed Enes DEMİRBAŞ, Selçuk KAN, Çağdaş Ekin ZÖHRA, Onuralp YÜCEL
İstanbul Technical University
Türkiye

Determination of the Sintering Behavior and Tribological Properties of Boron Carbide Reinforced Copper-Tin Metal Matrix Composites 283
Yağmur KİBRİTÇİ, Cansu DEMİR, Gürsoy ARSLAN, Ertuğrul İŞLEK
Eskişehir Technical University
Türkiye

Rheology and Sedimentation Behavior of Magnetorheological Fluids: An Experimental and Data-Driven Study 287
Aynil AYDIN, Ömer Tarık KARAKAYA, Ufkun Murat ODABAŞ, Neslihan ALPAY, Seval GENÇ
Marmara University
Türkiye

The Influence of Porosity on Laser Cutting of Cu-Ni-Mo Based Steel Foams 288
Mustafa Ali KAÇAN, Esra ÜNAL, Pelin KAYA, Gizem KARABULUT ŞEVK, Nuray BEKÖZ ÜLLEN
İstanbul University-Cerrahpaşa
Türkiye

Copper-Based Porous Metals: An Overview of Manufacturing and Applications 292
Azra ASLAN, Sıla KUZU, Çisem CERAN, Gizem KARABULUT ŞEVK, Nuray BEKÖZ ÜLLEN
İstanbul University-Cerrahpaşa
Türkiye

Microstructure Properties of Ni-Mn-O Based Spinel Oxide Ceramics 296
Hasan Kutay VERİM[1], Gökhan HARDAL[2], Caner İLDEŞ[3], Berat Yüksel PRICE[1]
[1]İstanbul University-Cerrahpasa, [2]İstanbul University, [3]Yozgat Bozok University
Türkiye

Effect of Electrolyte Composition on the Properties of PEO Coatings Synthesized on Al-9Cu Alloy 297
Talha ÖZASLAN, MuhammeT Taha DALGIC, Harun BİRİNCİ, Kral Ali COŞAN, Mehmet TARAKCI, Yücel GENCER
Gebze Technical University
Türkiye

Role of Mg and Ti Additions in Controlling the Microstructure and Mechanical Properties of Compacted Graphite Iron 299
Ahmet Buğra KEYVANKLI[1], Ahmet ÖZEL[2], Süleyman Can KURNAZ[2], Tan EMİR[1]
[1]Ferro Döküm, [2]Sakarya University
Türkiye

A Review on Titanium-Based Biomaterials for Orthopedic Applications 300
İlkim ASLAN
Gazi University
Türkiye

Interconnected Materials and Process Simulation Tools for Predicting Microstructure-Property Relationship in Industrial Scale 301
Selenay ESER, Arcan F. DERİCİOĞLU
Middle East Technical University
Türkiye

Copper-Based Porous Metals: An Overview of Manufacturing and Applications

Azra ASLAN, Sıla KUZU, Çisem CERAN, Gizem KARABULUT ŞEVK, Nuray BEKÖZ ÜLLEN
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Türkiye

Keywords: Porous metal, Copper Alloys, Energy Storage

Abstract
Copper-based porous materials have received particular interest owing to the excellent thermal and electrical conductivity of copper combined with the structural advantages of cellular architectures. The incorporation of alloying elements such as Zn, Ni, Sn, and Mo further enhances mechanical strength, wear resistance, corrosion resistance, and energy absorption capacity. As a result, porous copper and its alloys have found applications in heat exchangers, thermal energy storage systems, batteries, fuel cells, vibration-damping components, and impact-absorbing structures. Furthermore, their interconnected pore networks enable the development of self-lubricating bearings through lubricant impregnation, providing superior tribological performance. In addition, the intrinsic antimicrobial activity of copper ions makes porous copper a promising material for biomedical devices, hygienic surfaces, and advanced filtration systems. This review summarizes the historical development, manufacturing routes, and application areas of porous copper and copper-based porous alloys, with particular emphasis on the space holder technique and the relationship between microstructural design and functional performance.

1. Introduction

Porous metals are cellular materials that contain a high-volume fraction of gas-filled voids within their internal structure. Depending on their pore morphology, these materials are generally classified into two categories: open-cell structures, in which pores are interconnected and form a continuous network, and closed-cell structures, in which pores are isolated from one another as discrete cavities [1-2]. A schematic representation of open and closed pore structures is given in Figure 1.

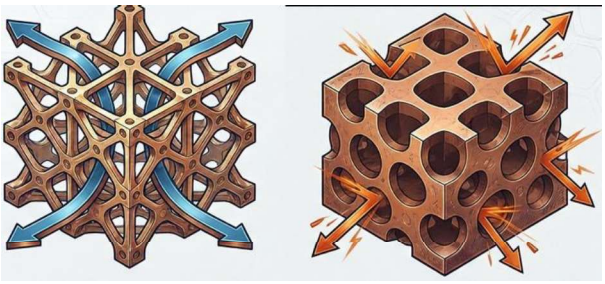

Figure 1. Open and closed cell porous metal

Open-cell structures are widely utilized in applications requiring fluid permeability and high surface area, such as heat exchangers, filtration systems, and electrodes. In contrast, closed-cell structures are preferred in the automotive, aerospace, and defense industries due to their low density, lightweight nature, high stiffness, and superior vibration and impact energy absorption capabilities [1]. Among the metallic materials commonly used in porous form for industrial and scientific applications are aluminum, titanium, steel, nickel, and copper [2]. In particular, copper-based porous metals have attracted increasing attention in recent years owing to their high thermal and electrical conductivity, good corrosion resistance, and controllable pore architecture [3-5]. These materials are especially advantageous in structural and functional applications where lightweight design, high surface area, fluid permeability, and efficient heat transfer are required. Compared to other metallic systems, copper and its alloys provide significantly higher thermal conductivity in porous structures [6]. This characteristic makes copper-based porous metals ideal candidates for high-performance heat exchangers and thermal energy storage systems, where rapid heat dissipation is critical [7]. Furthermore, due to copper's excellent electrical conductivity, open-cell porous copper can serve effectively as an electrode material in batteries and fuel cells [8]. Its large specific surface area facilitates enhanced ion exchange, while its low internal resistance minimizes energy losses. In addition, whereas titanium and aluminum may exhibit limited wear resistance in frictional applications, copper has traditionally been used as a bearing material [8-9]. By impregnating lubricants into the open pores of porous copper, self-lubricating bearings that require minimal external maintenance can be produced [9]. Copper-based porous metals are predominantly manufactured through powder metallurgy combined with space-holder techniques. Processing parameters, including powder particle size, compaction pressure, sintering temperature, and sintering atmosphere, play a decisive role in densification behavior, pore interconnectivity, and mechanical properties [2]. The addition of alloying elements such as Zn, Sn, Ni, and Mo can further enhance mechanical strength, wear resistance, and corrosion performance. For instance, Cu–Sn and Cu–Zn alloys improve hardness and wear resistance, whereas Cu–Ni systems provide superior corrosion resistance in aggressive environments. In structural applications, porous copper alloys offer a favorable balance between weight reduction and mechanical integrity, demonstrating potential in vibration damping and impact energy absorption [10]. Moreover, the intrinsic antimicrobial properties of copper support its use in hygienic surface applications. Despite these advantages, optimizing the trade-off between high porosity and mechanical strength, as well as achieving cost-effective large-scale production, remains a significant research challenge. Future studies focusing on process optimization, microstructural modeling, and the utilization of recycled copper feedstocks are expected to accelerate the integration of these materials into sustainable, high-performance applications. In this context, the present study aims to provide a comprehensive review of the principal manufacturing

methods and primary application areas of porous structures produced from copper and copper alloys, based on an extensive evaluation of the relevant literature, thereby serving as a systematic reference for researchers working in this field.

2. Production Techniques of Copper-based Porous Metals

Porous metals were first introduced in 1948 through the pioneering work of Benjamin Sosnick, who investigated the foaming of aluminum using mercury [1]. In this early approach, porous structures were produced by melting aluminum and mercury under high pressure, followed by the evaporation of mercury, which generated the porous architecture. With subsequent technological advancements, porous structures can now be fabricated from materials in four different states of matter. Consequently, production methods are generally classified in the literature according to the initial physical state of the primary feedstock. These methods are categorized as solid-state, liquid-state, gas-state, and ionic-state routes, each offering distinct advantages compared to the others. A classification of these production methods is presented in Table 1. For instance, in liquid-state processing, Sánchez-Martínez et al. [3] investigated the centrifugal infiltration method for the fabrication of open-cell Zn–22Al–2Cu alloy foams with a controlled macroscopic cellular structure. In solid-state processing, Wang et al. [4] developed an integrated powder lamination and simultaneous sintering strategy to produce copper foam sandwiches (CFSs) with high structural integrity. Finally, regarding ionic-state methods, Gurgul et al. [5] demonstrated an electrochemical deposition approach combined with anodization to create hierarchical nanoporous configurations, significantly increasing the specific surface area of the metallic matrix. Recent developments in three-dimensional (3D) printing technologies have further expanded the manufacturing possibilities for porous metals, enabling the production of complex porous architectures with enhanced control over pore geometry and distribution [11].

Table 1. Classification of porous metal production methods

Liquid-State Routes	Solid-State Routes	Gas-State Routes	Ionic-State Routes
Melt Foaming	Space Holder Technique	Chemical Vapor Depositon	Electrochemical Deposition
Gas Injection	Foaming of Powder Compacts	Physical Vapor Deposition	
Investment Casting	Sintered Powder Slurries		

Among these techniques, the space holder sintering method stands out by providing the most precise control over pore size, porosity level, interconnectivity, and the mechanical integrity of the final structure. The ability to directly tailor the porosity fraction, pore size, and pore distribution of the target material represents one of the most significant advantages of this manufacturing approach. While enabling the production of highly porous structures, the combination of compaction and sintering processes also promotes the retention of fine pores within the material. In Figure 2, schematically abstract of the space holder sintering method is given. The resulting cellular architecture effectively balances a high specific surface area with enhanced fluid permeability. The space holder technique generally consists of four main stages: (i) homogeneous mixing of metal or alloy powders, which form the matrix, with space holder particles possessing the desired size and morphology; (ii) compaction of the powder mixture to produce a green body with sufficient structural integrity; (iii) removal of the space holder particles through thermal decomposition and/or solvent-assisted dissolution processes; and (iv) sintering of the remaining metallic sample under controlled atmospheric conditions to establish permanent metallurgical bonds [2]. The physical and chemical properties of the space holder agent employed in this process directly influence the purity of the resulting foam structure [9]. One of the major challenges reported in the literature is the incomplete removal of the space holder from the matrix, which may lead to contamination and consequently promote localized corrosion phenomena [2]. For this reason, sodium chloride and carbamide (urea) are considered among the most industrially viable space holder materials. Both agents are cost-effective and can be removed from the structure without leaving significant residues after processing. Sodium chloride can be readily eliminated through water dissolution, whereas carbamide can be removed by thermal treatment due to its decomposition and volatilization at relatively low temperatures. As a result, the chemical purity and structural integrity of the metallic skeleton can be effectively preserved.

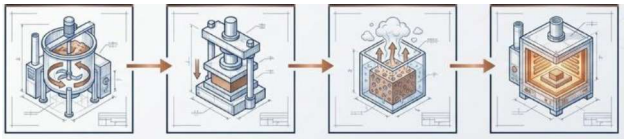

Figure 2. Space holder sintering process

In copper-based systems, research on the space holder sintering technique, one of the most widely employed solid-state processing routes, has primarily focused on balancing pore geometry and mechanical performance. For example, Al-Zubaidi et al. [6] fabricated open-cell copper foams by mixing copper powders with potassium carbonate as a salt-based space holder. Their findings demonstrated that optimizing the compaction pressure significantly enhanced the load-bearing capacity of the porous structure. Similarly, Sharma et al. [7] investigated the influence of compressible space holder materials on the characteristics of the cell walls and established a clear relationship between compaction pressure, sintering temperature, and the resulting structural performance of the foam.

3. Usage of Copper-Based Porous Metals

The application areas of porous copper and its alloys are determined by the combination of structural and functional properties offered by the material. Despite the functional advantages of pure porous copper, its relatively low yield strength and elastic modulus limit its use as a stand-alone structural material. To overcome these mechanical limitations, various alloying elements are incorporated into the copper matrix, the most common being Zn, Ni, Sn, and Mo. For instance, Cu–Sn and Cu–Zn foams exhibit enhanced

strength and wear resistance through the mechanism of solid-solution strengthening. Likewise, Cu–Ni systems provide superior corrosion resistance, making them attractive for applications in aggressive environments. Furthermore, alloying can improve the energy absorption capability of the material during plastic deformation, thereby expanding its potential applications as vibration-damping and impact-absorbing components in the automotive and defense industries. Consequently, porous copper alloys have attracted considerable attention as multifunctional materials that combine lightweight characteristics with enhanced mechanical, thermal, and corrosion-resistant properties.

Copper possesses excellent thermal and electrical conductivity, making it one of the most attractive materials for functional engineering applications [8]. Open-cell porous copper structures exhibit an exceptionally high specific surface area, which significantly increases the heat transfer interface between the metallic matrix and the working fluid. This characteristic makes porous copper an ideal candidate for heat exchangers and thermal energy storage systems [9]. For example, thermal performance studies reported in the literature have demonstrated that open-cell copper foams substantially enhance the boiling heat transfer coefficient compared with flat copper surfaces due to their high porosity [12]. Moreover, in internal flow applications, these structures have been shown to provide several-fold improvements in heat transfer performance. In addition to their thermal advantages, porous copper materials are highly suitable for electrochemical applications owing to their continuous conductive network and low internal electrical resistance. These characteristics enable their use as electrode materials in batteries and fuel cells. The interconnected pore structure facilitates ionic transport within the electrolyte, while the conductive copper matrix minimizes energy losses associated with electron transfer. As a result, porous copper combines superior thermal management capabilities with excellent electrochemical performance, making it a promising material for advanced energy and heat-transfer technologies.

Within the scope of these functional applications, Wang et al. [4] proposed an integrated manufacturing approach combining powder lamination and simultaneous sintering processes to fabricate copper foam sandwich (CFS) structures with high structural integrity. Their study demonstrated that these specialized geometries can be efficiently integrated into microchannel cooling systems as vapor separators and employed as electrode current collectors in battery technologies. Furthermore, the continuous metallic framework of the structure minimizes internal electrical resistance, thereby enhancing electrical conductivity and extending the operational service life of the component.

Open-cell porous copper structures can also be utilized for the production of self-lubricating bearings that operate without the need for external maintenance. These systems are manufactured by impregnating liquid lubricants into the interconnected pore network of the copper matrix. During operation, thermal effects and capillary forces promote the migration of the lubricant from the pores to the contact interface, thereby continuously replenishing the lubricating film and reducing friction and wear. In an experimental study on powder metallurgy-produced Cu–Sn capillary bearings, it was reported that the addition of 10 wt.% Sn combined with a sintering temperature of 800 °C optimized the porosity level to 18.23%, resulting in an exceptionally low wear rate of 4.76 × 10^{-6} mm³/mm and a compressive strength of 440 MPa [12]. These findings highlight the critical balance between porosity and mechanical strength required for the development of durable self-lubricating components. Supporting this observation, Karadağ and Aslan [12] demonstrated that processing parameters directly influence the structural performance of Cu–Sn bearings produced by powder metallurgy, confirming that a properly engineered porous matrix provides an ideal foundation for wear-resistant and self-lubricating industrial applications.

In addition to their tribological advantages, porous copper materials exhibit intrinsic antimicrobial properties arising from the ability of copper ions to disrupt microbial cell membranes. Consequently, these materials have attracted considerable attention for use in high-hygiene applications, including hospital surfaces, water treatment units, and filtration systems. In a study focusing on biomedical and hygienic surface applications, Zheng et al. [13] investigated the antimicrobial performance of porous copper alloys fabricated by powder metallurgy using the space holder technique. The authors reported that the interconnected pore network provided a substantially increased surface area, promoting the rapid release of copper ions into the surrounding environment. These ions were found to directly damage bacterial cell membranes, resulting in highly effective antimicrobial activity. When evaluated in filtration applications, the porous copper structures achieved bacterial elimination rates as high as 99.9%, demonstrating their strong potential for advanced filtration and sterilization systems.

4. Conclusion

Copper-based porous metals can be fabricated by powder metallurgy (including space-holder and foaming routes), multiple additive manufacturing techniques, electrochemical deposition and dealloying, and wet-chemical methods, each offering distinct control over pore size, connectivity, and shape. Porosity strongly influences mechanical, thermal, electrical, and surface properties, enabling designers to tailor materials for specific roles. Current applications range from heat exchangers, filters, and catalysts to advanced energy storage, thermal management, and biomedical systems, with ongoing work focused on multiscale architecture control, surface functionalization, and scalable, green manufacturing routes.

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