

Special Issue on Metal-Based Composite Materials: Preparation, Structure, Properties and Applications

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The Special Issue is aimed at analyzing modern trends and recent advances in the synthesis of new metal-based composite materials. Such composites are increasingly used in civil, automotive, and aerospace engineering, shipbuilding, robotics, nuclear power, portable energy devices, biomedicine, electronic devices, and portable aircrafts.

Non-ferrous metals are often used as the matrix of composites, aluminum, magnesium, nickel, titanium and their alloys, and can act as modifiers with boron, carbon structures, borides, carbides, nitrides, and oxides of refractory metals and high-strength steel. For high-temperature composites, tungsten or molybdenum fibers are used. Despite the large number of scientific works in this area, new methods for the synthesis of such composites in order to improve and optimize their structure and properties are still needed. In this regard, experimental and theoretical works aimed at developing and optimizing methods for the synthesis of composite materials, as well as the search for new materials, have been successfully published in this Special Issue.

Thirteen papers devoted to the development of composite materials for different applications are published in this Special Issue [1–13]. Among them, the main scientific topics include the following:

- Light metals (Al)-based materials and alloys (Al–Mg, Al–Mg–Zn) [1–3,8,9,13] with modifying and reinforced additions (Fe [2], SiC [3,13], Al₂O₃ [8]) used as structural materials and coatings [9], as well as the steel-filament-reinforced carbon fiber for general use [6];
- Silicon-containing materials for lithium-ion batteries with increased specific capacity [4,12];
- Oxide materials for modern energetic devices [7,11];
- Multi-layer structures based on graphene for the synthesis of semiconductive materials [10];
- Materials for catalysis [5].

The applicability of these developed materials goes far beyond the declared topics of the Special Issue. Here, we provide a brief description of the published papers. The authors of work [1], using a molecular dynamics method, aim to investigate the details of the fabrication techniques of an Al–Mg composite with improved mechanical properties. It is shown that shear strain has a crucial role in the mixture process. According to the tensile tests, a fracture occurred in the Mg part of the final composite sample, which means that the interlayer region, where the mixing of Mg and Al atoms is observed, is much stronger than the pure Mg part.

The aim of work [2] is to investigate the microstructural and mechanical properties of a nanostructured Al-based matrix reinforced with Fe₄₀Al intermetallic particles. The results indicate that the hardness varies linearly with the increase in the concentration



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of the Fe₄₀Al intermetallic phase present in the composite material, and it grows almost linearly with the rising dislocation density and with the reduction in the grain size.

Paper [3] shows the applicability of data on the evolution of the elastic modulus measured by the instrumented microindentation technique to determine the accumulated damage in metal matrix composites under high temperature deformation. A composite material with the 7075 aluminum alloy matrix and SiC reinforcing particles is studied here. The results show that at the deformation temperature of 500 °C, the plastic properties of the material are significantly lower than at 300 and 400 °C.

The work [4] takes into consideration the questions regarding the electrolytic production of nanosized silicon from low-fluoride molten salts. The obtained silicon deposits are used to fabricate a composite Si/C anode for a lithium-ion battery. The galvanostatic cycling of the anode half-cells reveals a better capacity retention and higher coulombic efficiency of the Si/C composite based on silicon synthesized from a KCl–K₂SiF₆–SiO₂ melt. The capacity of the obtained material is estimated in the paper.

In work [5], a selective dissolution of a tungsten (85 wt.%)–rhenium (15 wt.%) alloy, with rhenium in hydrochloric acid at the temperature of 298 K, and anodic polarization modes are carried out. A thermodynamic description of the processes occurring during the anodic selective dissolution of a binary alloy is proposed. The existence of a bimodal structure on the tungsten surface after dealloying is proven.

The work [6] focuses the reader's attention to the investigation of the quasi-unidirectional continuous fiber reinforced thermoplastics joined with metal sheets. The unique novelty of the method is the use of non-rotational symmetric pin structures for material production. The created samples are consequently mechanically tested, and the failure behavior of the single lap shear samples is investigated.

Manuscript [7] provides results on the ab initio molecular dynamics studies of the mechanism of proton motion in a LaScO₃ perovskite crystal. It is shown that initial location and interaction between the proton and its nearest environment are of great importance to the character of the proton movement, while the magnitude and direction of the initial velocity and electric field strength are secondary factors characterizing its movement through the LaScO₃ crystal.

Paper [8] presents a new method for the industrial production of metal-matrix composites with improved properties, and an aluminum matrix reinforced by “in situ” α -Al₂O₃ nanoparticles is fabricated and tested. Under static uniaxial tension, the cast aluminum composites containing aluminum oxide nanoparticles demonstrate the increased tensile strength, yield strength, and ductility. The microhardness and tensile strength of the composite material are 20–30% higher than those of the metallic aluminum.

The goal of article [9] is the consideration of the Zn–Al–Mg-coated steel HC340LAD + ZM due to its excellent corrosion resistance, self-healing properties, and good surface hardness. It is shown that the presence of the Zn–Al–Mg coating slightly affects the mechanical properties of welding joints. The corrosion current of the body material containing Zn–Al–Mg plating is 7.17 times that of the uncoated plate.

In the paper [10], single- and multi-layer graphene sheets are obtained on a highly textured Cu substrate using the chemical vapor deposition method. Plasma-assisted molecular beam epitaxy is applied to carry out the GaN graphene-assisted growth. The effect of graphene defectiveness and thickness on the quality of the GaN epilayers is studied. The density functional theory is used to calculate the energy of interaction between graphene and its substrates.

The work [11] investigates oxygen-deficient defects in TiO₂ nanoparticles synthesized by the sol–gel method and laser evaporation of ceramic targets. The nanopowders are subjected to vacuum annealings to modify the defective structure in nanoparticles. The behavior of the defects in TiO₂ nanoparticles is under consideration. According to the results, the concentration of the defects can vary in wide limits via vacuum annealings of nanopowders, which can lead to the formation of a solid film of titanium atoms 1–2 monolayers in thickness on the surface of oxide nanoparticles.

In work [12], a new and promising approach for the carbothermal synthesis of C/SiC composite mixtures with SiC particles of fibrous morphology, with a fiber diameter of 0.1–2.0 μm and with an increased energy density for lithium-ion batteries is proposed. As a result, the energy characteristics of the mixtures are determined, and the potential use of the obtained mixtures as anode materials for a lithium-ion battery is presented. The authors declare the Coulombic efficiency of the samples during cycling to be over 99%.

Paper [13] investigates the rheological behavior and microstructuring of an AlMg6/10% SiC metal matrix composite. The paper proposes a new method of adding data to a training sample, which allows neural networks to correctly predict the behavior of microstructure parameters, such as the average grain diameter, and the fraction and density of low-angle boundaries with little initial experimental data. It is shown that at strain rates ranging from 0.1 to 4 s^{-1} and temperatures ranging from 300 to 500 $^{\circ}\text{C}$, the main softening processes in the AlMg6/10% SiC composite are dynamic recovery and continuous dynamic recrystallization, accompanied by geometric recrystallization.

In conclusion, some statistics pertaining to the papers published in this Special Issue should be mentioned (see Table 1). Of the 15 papers submitted, 13 of them were successfully accepted for publication and published. The average length of the publication period is 33 days, while the review process lasts from 3 up to 12 days. The rest of the time spent preparing this Special Issue involves the authors' processing of the article. Thanks to this Special Issue, MDPI journals have received more than 50 new citations and over 12,000 views. By the time this Editorial is published, some of the papers will already have significant view and citation metrics.

Table 1. Statistics and geography of published papers (27 March 2023).

Ref	Days before Publication	CrossRef	WoS	Scopus	Google Scholar	Views 16 March 2023	MDPI Refs
1	59	2	1	2	9	1128	0/42
2	33	1	1	1	1	1233	0/36
3	22	1	1	1	1	791	1/42
4	25	5	7	6	10	1476	0/54
5	52	2	2	2	2	1023	1/33
6	15	-	-	-	2	876	0/21
7	32	-	-	-	-	637	1/31
8	25	-	1	1	2	876	1/43
9	38	-	-	-	-	605	3/30
10	30	-	-	-	-	534	2/66
11	27	1	1	1	1	524	0/31
12	25	-	-	-	-	571	25/54
13	43	-	-	-	-	444	5/68
Average 33		12	13	14	28	>12,000	All 39

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