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Editorial

Advances in Processing and Mechanical Behavior in Lightweight Metals and Alloys

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1. Introduction and Scope

The demand for lightweight metals and related alloys is still the most suitable solution to many high-tech applications, including sports equipment and automotive components where alternate movements require low inertia. In this Issue, the term light alloy is focused on materials based on aluminum, titanium, and magnesium systems, including the intermetallic-reinforced matrices, and papers dealing with all of the three families have been published. Nevertheless, the processing of light alloys has always been faced with low-formability, narrow-thermal processing windows and even with corrosion issues with respect to the steel family; this is the reason for new processes in terms of both compositions and thermo-mechanical approaches. Emerging processes based on the powder metallurgy have been proposed and discussed, and interesting results have been obtained on complex and critical joining processes, which still stand and are also proposed for the emerging additive manufacturing process.

This Special Issue covers a wide scope in the research field of lightweight metals and alloys and has been intended to provide a space for sharing new ideas, and new research results for the various aspects of light alloy processing and characterisation.

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2. Contributions

Eight research articles have been published in this Special Issue of *Metals* and three lightweight metal families, aluminium, titanium and magnesium have been impacted. The subjects are multidisciplinary, including joining processes, friction stir welding (FSW) and Electron Beam Welding, (EBW), thermomechanical processes such as severe plastic deformation (SPD) by Equal Channel Angular Pressing (ECAP) of oxide dispersed Mg alloy.

Moreover, the Special Issue reports interesting improvements obtained by means of innovative thermal treatments, and last but not least, interesting data obtained from the characterisation of ODS nanostructured powder processing. The study of nanostructured metals is very interesting for broader and larger systems, because of the potential improvements in terms of mechanical performance [1], and the current proposed development of a model, by means of convolutional neural networks (CNNs) [2] for the prediction of the secondary dendrite arm spacing (SDAS), which has an industrially acceptable prediction accuracy for the aluminium alloys, is an important step towards a more efficient manufacturing industry.

Two papers investigate the dissimilar joints between Ti-TiB and (α+β)Ti Alloy.

Loboda et al. [2] reported the structural features of Ti-TiB and (α+β) Ti alloys before and after the electron beam weldment process, showing that it is possible to obtain sound joints, even if it is critical to control the TiB fibre orientation in order to avoid the transversal orientation of TiB-reinforcing fibres that can facilitate brittle fracturing.

Mortello et Al. [3] succeeded in obtaining by FSW hybrid AA5083 H111 aluminium alloy and S355J2 grade DH36 structural steel joints. These results are particularly interesting because of the industrial impact in mechanical structures and, as the authors pointed out which: " . . . enables the ability to design and fabricate components whose properties are customised to locally varying environmental conditions." [3].

Another paper from Nikolić et al. [4] proposed and adopted an automatic inspection model using a computer vision for secondary dendrite arm spacing (SDAS) in aluminium alloys, which represent an example of a Deep Learning (DL) model that has industrially acceptable prediction accuracy: this approach could be the basis for a next generation industrial heavy-metallurgy digitalisation.

Another paper on the development and characterisation of the Strengthening Mechanism and Influence of Hybrid Reinforcements (β-SiCp, Bi and Sb) on the Mechanical Properties of the AZ91 Magnesium Matrix has been proposed by Huang et al. [5]. It was proven that, during the Mg-alloy AZ91 melt–stir casting, a hybrid nano-reinforcements (β-SiCp) and micro-reinforcements (Bi and Sb) composites network was produced. These reinforcements are the base for further diffusion phenomena that result in the creation of Mg2Si (cubic) and SiC (rhombohedral axes), enhancing the microhardness by more than 18% in a 0.5 wt.% SiCp/AZ91 matrix.

The authors [6] studied the nanoprecipitation on the AA7050 aerospace high strength aluminium alloy, after an innovative thermal treatment, and it was proven to be able to increase the toughness in KIC laboratory testing.

The ECAP process is a useful process for metallurgical studies of light alloys and especially for Mg, as shown by Ou et al. [7], with the paper dealing with the Mg97Zn1Y2 alloy powders reinforced by Y_2O_3 particles prepared by simultaneous synthesising of Y_2O_3 particles and compacting of mechanically alloyed powders using equal channel angular pressing. They found that, after mechanical alloying for 20 h, the material consisted of α-Mg, Y and Y2O3 phases. The ECAP-compacted bulk alloy contained the α-Mg matrix and uniformly dispersed Y_2O_3 and MgO phases. A very impressive hardness value was reached (after ECAP route Bc for four passes) of 110 HV, along with an ultimate compressive strength of 185 MPa. The hardness observed in the ECAP-compacted alloy was mainly attributed to the dispersion hardening of Y_2O_3 particles [7].

Another interesting paper in the scope of the Special Issue, submitted by Yang et al. [8] deals with the preparation of layered metal matrix composites and characterisation of the reactions between nickel and germanium after the incorporation of a titanium interlayer on germanium (100) substrate. The results show that, after a microwave annealing (MWA), the nickel germanide layers are formed from 150 °C to 350 °C for 360 s (under nitrogen atmosphere) and the titanium interlayer becomes a titanium cap-layer. These results can be useful for potential precursors for the Secure Digital (S/D) cards contact technology in state-of-the-art Ge-based devices.

The last paper, from Shanmugam et al. [9], faces another important technological aspect: the machining of beta titanium alloys. The original research presents the results of the influence of the additive manufactured (AM) tool in electrochemical micromachining (ECMM) on the machining of a beta titanium alloy. It was shown that the additive manufactured tool can produce a better circularity and overcut than a bare tool. The reason for this result has been discussed and was found to mainly be related to the AM-tool's higher corrosion resistance and higher electrical conductivity.

3. Conclusions and Outlook

This Special Issue covered a variety of topics, presenting recent developments in the synthesis, characterisation, joining and processing of lightweight alloys of the three Al, Mg and Ti families. Moreover, some of the results can provide a basis for effective electronic and industrial applications; however, there are still many challenges to overcome.

As a Guest Editor, I really hope that all the scientific results in this Special Issue can contribute to the advancement of future research on lightweight metal and find application in real industrial environments and markets.

Finally, I would like to thank all the reviewers for their valuable contributions and efforts in improving the academic quality of the research published in this Special Issue. I

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References

1. Sanctis, M.D.; Fava, A.; Lovicu, G.; Montanari, R.; Richetta, M.; Testani, C.; Varone, A. Mechanical Characterization of a Nano-ODS Steel Prepared by Low-Energy Mechanical Alloying. *Metals* **2017**, *7*, 283. [CrossRef]
2. Loboda, P.; Zvorykin, C.; Zvorykin, V.; Vrzhyzhevskyi, E.; Taranova, T.; Kostin, V. Production and Properties of Electron-Beam-Welded Joints on Ti-TiB Titanium Alloys. *Metals* **2020**, *10*, 522. [CrossRef]
3. Ou, K.-L.; Chen, C.-C.; Chiu, C. Production of Oxide Dispersion Strengthened Mg-Zn-Y Alloy by Equal Channel Angular Pressing of Mechanically Alloyed Powder. *Metals* **2020**, *10*, 679. [CrossRef]
4. Testani, C.; Barbieri, G.; Di Schino, A. Analysis of Nanoprecipitation Effect on Toughness Behavior in Warm Worked AA7050 Alloy. *Metals* **2020**, *10*, 1693. [CrossRef]
5. Yang, J.; Ping, Y.; Liu, W.; Yu, W.; Xue, Z.; Wei, X.; Wu, A.; Zhang, B. Ti Interlayer Mediated Uniform NiGe Formation under Low-Temperature Microwave Annealing. *Metals* **2021**, *11*, 488. [CrossRef]
6. Nikolić, F.; Štajduhar, I.; Čanađija, M. Casting Microstructure Inspection Using Computer Vision: Dendrite Spacing in Aluminum Alloys. *Metals* **2021**, *11*, 756. [CrossRef]
7. Shanmugam, R.; Ramoni, M.; Thangamani, G.; Thangaraj, M. Influence of Additive Manufactured Stainless Steel Tool Electrode on Machinability of Beta Titanium Alloy. *Metals* **2021**, *11*, 778. [CrossRef]
8. Huang, S.-J.; Diwan Midyeen, S.; Subramani, M.; Chiang, C.-C. Microstructure Evaluation, Quantitative Phase Analysis, Strengthening Mechanism and Influence of Hybrid Reinforcements (β-SiCp, Bi and Sb) on the Collective Mechanical Properties of the AZ91 Magnesium Matrix. *Metals* **2021**, *11*, 898. [CrossRef]
9. Mortello, M.; Pedemonte, M.; Contuzzi, N.; Casalino, G. Experimental Investigation of Material Properties in FSW Dissimilar Aluminum-Steel Lap Joints. *Metals* **2021**, *11*, 1474. [CrossRef]