metals

Editorial

Shape Memory Alloys 2020

Gabriel A. López

Physics Department, University of the Basque Country UPV/EHU, 48940 Leioa, Spain;
gabrielalejandro.lopez@ehu.eus; Tel.: +34-9-4601-8028

1. Introduction

Shape memory alloys (SMAs), in comparison to other materials, have the exceptional ability to change their properties, structures, and functionality, depending on the thermal, magnetic, and/or stress fields applied. As is well-known, in recent decades, the development of SMAs has allowed innovative solutions as alternatives in biomedical applications, advanced engineering structures for aerospace and automotive industries, as well as in sensor and actuation systems, among other sectors. Irrespective of this, design and engineering with these special smart materials requires a solid background in materials science in order to consolidate their importance in these fields and to broaden their relevance in other new applications. The goal of this Special Issue is to foster the dissemination of some of the latest research devoted to these special materials from different perspectives.

2. Contributions

Raising the martensitic transformation temperature of SMAs (above 100 °C) is still a challenge, although there are already some materials that are used in different applications. In this Special Issue, Yamabe-Mitarai reviewed TiPd and TiPt-based alloys as important families of high-temperature SMAs [1]. In the context of a detailed investigation it was concluded that multi-component alloys can be good candidates for HT-SMAs, indicating as well that the limitations that need to be overcome entail the suppression of the transformation strain reduction and temperature hysteresis increment. In the search for other alternative high-temperature alloys a great deal of work has been devoted to the study of the CuZr intermetallic. In regards to this system, Biffi et al. [2] introduced interesting work on the effects of Al addition to CuZr-based SMAs in terms of the evolution of the martensitic transformation upon thermal cycling and elucidated important conclusions from a practical point of view.

Other smart alloys that have attracted a great deal of attention in recent years are ferromagnetic SMAs. Among several candidates that have been investigated recently, Co-V-(Si, Al) Heusler alloys are considered an inexpensive SMA for high-temperature applications. In this context, Nakamura et al. [3] provided an interesting investigation of a $Co_{64}V_{15}(Si_{21-x}Al_x)$ alloy and proposed it as a new multifunctional magnetic material. Another remarkable group of ferromagnetic SMAs are the so-called metamagnetic ones and, paying attention to their critical role in material properties, the influence of structural defects in $Ni_{45}Co_5Mn_{37}In_{13}$ alloy was investigated by Pérez-Landazábal et al. [4]. In addition, keeping in mind potential applications, the refrigeration capacity of micro-particles of this alloy as well as the damping properties of the designed SMA-polymer composites have been tested.

It is well-known that the emergence of additive manufacturing technologies has enabled the layer-by-layer production of components. SMAs are not an exception and such techniques have attracted a great deal of interest, although crack formation is still the main challenge. Against this background and paying attention to the latest developments, Ewald et al. [5] innovatively applied laser powder bed fusion to produce crack-free samples of a low-cost Fe-based SMA and achieved a good shape recovery by means of an optimized

check for updates

Citation: López, G.A. Shape Memory Alloys 2020. *Metals* **2021**, *11*, 1618. https://doi.org/10.3390/met11101618

Received: 28 September 2021
Accepted: 8 October 2021
Published: 12 October 2021

heat treatment route. Applying a different approach to achieve optimized materials, Brailovski et al. [6] demonstrated that simulation-driven processing maps can be used to relate the main laser powder bed fusion parameters to the control of density and grain structure of superelastic Ti-18Zr-14Nb alloys. To complete this section of the Special Issue, NiTi, as the most successful SMA, also produced via additive manufacturing could not be absent. Many works have been dedicated to this SMA, and here Biffi et al. [7] provided an experimental comparison of the properties of complex 3D structures and bulk samples, highlighting the main differences.

Characterization techniques are crucial for the development and optimization of new SMAs and production methodologies. In addition to the traditional ones, further advances that shed light on the materials' properties is necessary. In line with this, Sedlak et al. [8] discussed the suitability of laser-based resonant ultrasound spectroscopy (RUS) for the characterization of soft shearing modes in single crystals using three typical examples of SMAs (Cu-Al-Ni, Ni-Mn-Ga, and Ni-Ti), showing special access to high-temperature analysis due to the contactless character of the laser-based arrangement.

To conclude the Special Issue, two very practical situations were introduced as examples of the wide variety of possible SMA applications. On the one hand, taking into account the importance of a precise characterization, Sun et al. [9] clarified the influence of texture type and intensity on the shape memory effect in NiTiNb SMA pipe joints, revealing the causes for the anisotropy of SME via texture changes. Recommendations about the texture effect on the shape memory effect for potential engineering applications were provided. The last contribution, by González et al. [10], investigated the hysteretic behavior and the ultimate energy dissipation capacity of large-diameter NiTi bars subjected to low- and high-cycle fatigue, keeping an eye on the real-life importance of protection from seismic actions. The model was validated with tests conducted on a concrete prototype equipped with large diameter NiTi bars as energy dissipation devices.

Funding: This research was funded by University of the Basque Country, grant number GIU19/019.

Acknowledgments: Support from the University of the Basque Country under the GIU19/019 project is acknowledged.

Conflicts of Interest: The author declares no conflict of interest.

References

1. Yamabe-Mitarai, Y. TiPd- and TiPt-Based High-Temperature Shape Memory Alloys: A Review on Recent Advances. *Metals* **2020**, *10*, 1531. [CrossRef]
2. Biffi, C.A.; Fiocchi, J.; Coduri, M.; Tuissi, A. Effect of Al Addition on Martensitic Transformation Stability and Microstructural and Mechanical Properties of CuZr Based Shape Memory Alloys. *Metals* **2020**, *11*, 1141.
3. Nakamura, K.; Miyake, A.; Xu, X.; Omori, T.; Tokunaga, M.; Kainuma, R. Influence of Structural Defects on the Properties of Metamagnetic Shape Memory Alloys. *Metals* **2021**, *11*, 226.
4. Pérez-Landazábal, J.I.; Sánchez-Alarcos, V.; Ricarte, V.; Lambri, O.H.; Bonifacich, F.G.; Khanna, D.L.R.; Unzueta, I.; García, J.A.; Plazaola, F.; López-García, J.; et al. Influence of Structural Defects on the Properties of Metamagnetic Shape Memory Alloys. *Metals* **2020**, *10*, 1131. [CrossRef]
5. Ewald, F.C.; Brenne, F.; Gustmann, T.; Vollmer, M.; Krooß, P.; Niendorf, T. Laser Powder Bed Fusion Processing of Fe-Mn-Al-Ni Shape Memory Alloy—On the Effect of Elevated Platform Temperatures. *Metals* **2020**, *11*, 185.
6. Brailovski, V.; Kalinicheva, V.; Letenneur, M.; Lukashevich, K.; Sheremetyev, V.; Prokoshkin, S. Control of Density and Grain Structure of a Laser Powder Bed-Fused Superelastic Ti-18Zr-14Nb Alloy: Simulation-Driven Process Mapping. *Metals* **2020**, *10*, 1697. [CrossRef]
7. Biffi, C.C.; Bassani, P.; Fiocchi, J.; Tuissi, A. Microstructural and Mechanical Response of NiTi Lattice 3D Structure Produced by Selective Laser Melting. *Metals* **2020**, *10*, 814. [CrossRef]
8. Sedlák, P.; Janovská, M.; Bodnárová, L.; Heczko, O.; Seiner, H. Softening of Shear Elastic Coefficients in Shape Memory Alloys Near the Martensitic Transition: A Study by Laser-Based Resonant Ultrasound Spectroscopy. *Metals* **2020**, *10*, 1383. [CrossRef]
9. Sun, M.; Fan, Q.; Wang, Y.; Yang, Q.; Chen, J.; Huang, S.; Zhang, Y. {111}<110> Orientation Induced Anisotropy of Shape Memory Effect in NiTiNb Pipe Joints. *Metals* **2020**, *10*, 776. [CrossRef]
10. González-Sanz, G.; Galé-Lamuela, D.; Escolano-Margarit, D.; Benavent-Climent, A. Hysteretic Behavior and Ultimate Energy Dissipation Capacity of Large Diameter Bars Made of Shape Memory Alloys under Seismic Loadings. *Metals* **2019**, *9*, 1099. [CrossRef]