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Editorial

Advanced Aerospace Materials: Processing, Microstructure, Mechanical Properties and Applications

Yufei Zu [1,*], Huifang Pang [2] and Fan Wu [3]

[1] School of Materials Science and Engineering, Dalian University of Technology, Dalian 116024, China
[2] Engineering Research Center of Continuous Extrusion, Ministry of Education, School of Materials Science and Engineering, Dalian Jiaotong University, Dalian 116034, China; huifangpang@dlut.edu.cn
[3] AVIC Manufacturing Technology Institute, Beijing 100024, China; wufandut@163.com
* Correspondence: yfzu@dlut.edu.cn

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1. Advanced Aerospace Materials for Deformation Processing

Advanced aerospace alloy deformation processing (contribution 1–3) is investigated in this collection. Zhu et al. (contribution 1) present an exploration of the flow stress constitutive model and the deformation mechanism of Nb521, both critical for its practical application. The stress–strain behavior of Nb521 was assessed, leading to the development of three constitutive models: the Johnson–Cook model, the modified Johnson–Cook model and the Arrhenius model. During the deformation process, it was consistently observed that the hardening effect surpassed the softening effect during plastic deformation, with no observable occurrence of steady-state deformation. The modified Johnson–Cook model offers superior predictive accuracy. The elucidation of a constitutive model and underlying deformation mechanisms are discussed in the paper, offering indispensable insights into the hot-deformation behavior of Nb521.

Wang et al. (contribution 2) studied the 2219 aluminum alloy, seeking to elucidate its hot-deformation behavior and obtain its optimal hot-processing parameters. A new and precise constitutive model based on high-order differences was constructed, and the predictive accuracies of the new model and the Arrhenius model were compared. Moreover, hot-processing maps of the 2219 aluminum alloy were constructed by using the new model, and its optimal hot-processing parameters were validated with metallographic experiments. The new constitutive model and hot-processing maps reported in the paper can be used to guide the hot working process formulation of 2219 aluminum alloy.

Tokarski et al. (contribution 3) studied the texture formation of Cu-8%Al alloys using single crystals after a drawing process. In order to examine the texture in detail, XRD and EBSD measurements were carried out. A description of low-stacking fault energy (SFE) single-crystal fragmentation during the drawing process is provided, and the influence of many microstructural factors is also explained. During all deformation processes up to 1.1 true strain, the orientation of the inner volume of the crystal was stable. As a result of a lack of additional shear components, no twinning was observed, with following twin shear polarization phenomena. The results showed that approximation of the drawing process stress state by a tensor with only normal components cannot be used during analysis of the activation of deformation systems.

2. Advanced Aerospace Materials for Extreme Environments

With the rapid development of aerospace technology, the demand for materials that are suitable for extreme-environment applications has generated significant interest in the research and development of high-entropy materials [1–4]. Zu et al. (contribution 4) proposed a novel preparation method for high-entropy ceramics based on the reactive sintering of pre-alloyed metals at a relatively low sintering temperature. The high-entropy (Ti,Zr,Nb,Mo,W)B_2-SiC ceramics were prepared by using TiZrNbMoW high-entropy alloy powders and nonmetals with Si, B, and C_4B as the raw materials. The phase composition and microstructural results indicated that the primary MeB_2 solid solution and SiC phases could be successfully formed during reactive sintering at a low sintering temperature of 1650 °C. Moreover, the mechanical properties and oxidation behavior of the as-sintered MeB_2-SiC ceramic were also investigated in the paper.

Eze et al. (contribution 5) studied the microstructure and properties of $Cu_{40}Nb_{30}(TiB_2)_{20}C_{10}$ multi-principal element alloys. The sintering mode, microstructures, microhardness, density, relative density, wear behavior and corrosion properties of the alloys were investigated and compared to ascertain those most suitable for aerospace applications. Nano (14 nm)- and micron (44 μm)-sized Nb particles were both used as Nb resources for the raw materials. The results indicated that the alloys with nano-particles of Nb could be sintered faster and had the lowest wear rate and lowest coefficient of friction. Meanwhile, the alloys with micro-particles exhibited the best anti-corrosion characteristics in a sulfuric acid environment. The results obtained in this study correspond to the requirements for high-performance engineering materials, which will make these novel materials relevant in the aerospace industry.

3. Light-Weighting Advanced Aerospace Materials

Light-weighting is a substantial issue in the development of aerospace materials due to its decisive impact on the comprehensive performance and operational efficiency of such equipment [5–7]. Ciobanu et al. (contribution 6) report a new titania-based aero-nanomaterial and systematically study their microstructure evolution and properties. Firstly, TiO_2 thin films were deposited on a sacrificial network of ZnO microtetrapods by using atomic layer deposition (ALD). Then, thermal treatment and etching of the sacrificial template were conducted. The morphology, composition and crystal structure of the produced aero-materials were investigated depending on the annealing temperature and the sequence of the technological steps. The performed photoluminescence analysis suggests that the developed aero-materials are potential candidates for photocatalytic applications.

In order to optimize the mechanical performances of magnesium–aluminum alloys, it is critical to understand the electrical construction and mechanical performance of this interphase. Xiao et al. (contribution 7) calculated the mechanics, electronic density, and crystal structure of the β-$Mg_{17}Al_{12}$ interphase under a variety of pressures using first-principles calculations. The stability of the mechanical performance as well as the anisotropy were derived from a first-principles study using the generalized density function theory. The work provides information on a theoretical framework for examining how the presence of the β-$Mg_{17}Al_{12}$ intermediate phase affects the properties of the Mg-Al alloy. In addition, a theoretical foundation was developed for future investigations into how the intermediate β-$Mg_{17}Al_{12}$ phase impacts the properties of Mg-Al alloys.

Carbon-fiber-reinforced polymer matrix composites (CFRPs) are typical aerospace materials. Recently, 3D-printed CFRPs have attracted significant attention. Bussiba et al. (contribution 8) investigated the mechanical response and fracture of pultruded T-700 carbon fibers with thermoset epoxy resin under tension, compression, and shear loading. In the presence of holes, the remote fracture stress in the various modes of loading did not change significantly compared to uniform coupons; however, some localized delamination crack growth occurred in the vicinity of the holes, manifested by load drops up to the final fracture. Finite element analysis (FEA) results showed that the shear values were unaffected by manufacturing imperfections, coupon thickness, or asymmetrical gripping of up to 3 mm, with a minor effect in the case of a small deviation from the load line.

We hope that this collection of papers will meet the expectations of readers seeking new developments in the field of advanced aerospace materials, as well as it inspiring further research work.

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