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ORIGINAL RESEARCH

Effect of Sr on microstructure and aging behavior of Mg–14Li alloys

Bin Jiang[a,b,c,*], Ying Zeng[b], Hengmei Yin[a,b], Ruihong Li[a,b], Fusheng Pan[a,b]

[a]*National Engineering Research Center for Magnesium Alloys, Chongqing University, Chongqing 400030, China*
[b]*College of Materials Science and Engineering, Chongqing University, Chongqing 400030, China*
[c]*New Materials Center, Chongqing Academy of Science and Technology, Chongqing 401123, China*

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Abstract The as-cast and as-extruded Mg–14 wt%Li–xSr (x=0.14, 0.19, 0.39 wt%) alloys were, respectively, prepared through a simple alloying process and hot extrusion. The effects of Sr addition on microstructure and aging behavior of the Mg–14 wt%Li–xSr alloys were studied. The results indicated that β(Li) and Mg_2Sr were the two primary phases in the microstructures of both as-cast and as-extruded Mg–14 wt%Li–xSr alloys. Interestingly, with the increase of Sr content from 0.14 wt% to 0.39 wt%, the grain sizes of the as-cast and as-extruded Mg–14 wt%Li–xSr alloys markedly decreased from 5000 μm and 38 μm to 330 μm and 22 μm respectively, while no obvious changes of the micro-hardness and microstructure of the as-extruded alloys were observed during the aging treatment.

1. Introduction

Mg–Li alloys have the potential applications for the light-weight demand components in various industries, such as aviation, aerospace and electronics due to their good plasticity and low density [1,2]. It is worth noting that lithium content can definitely determine the microstructures and properties of Mg–Li alloys relying on different phase structures [3]. For an instance, Mg–14 wt%Li alloy has body center cubic structure of the single β(Li) phase, which is a Mg–Li solid solution, and has a lower strength, impeding its wide applications [4].

In order to improve the strength of Mg–Li alloys, various novel approaches, such as, composite reinforcement [5,6] and rapid solidification [7] were developed. Considering that the composite reinforcement sacrifices the plasticity and the rapid solidification processing is costly for mass production, traditional minor

*Corresponding author at: National Engineering Research Center for Magnesium Alloys, Chongqing University, Chongqing 400030, China. Tel.: +86 13594190166; fax: +86 23 65111140.
E-mail address: jiangbinrong@cqu.edu.cn (B. Jiang).

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alloying appears to be a simple and effective approach to strengthen the alloy through grain refinement without significant reduction of plasticity [8–10]. For example, Al and Zn are often selected as alloying elements of Mg–14 wt%Li alloy due to their obvious solid solution strengthening effects [2,11] and due to aging strengthening because of the formation of some intermetallic compounds like Li_2MgAl in Mg–14Li–1Al (LA141) or Li_2MgZn in Mg–14Li–1Zn (LZ141). However, Li_2MgAl or Li_2MgZn is metastable and will resolve at 66 °C or even at room temperature as $LiMgAl_2$ or LiMgZn, respectively, and hence has no strengthening effect for β(Li) with the increase of aging time [12–16], resulting in over-aging of LA141 or LZ141 [12–17]. Therefore, ideal candidates need to be explored and developed, pursuing the advanced Mg–14Li alloys with fine microstructure and no over-aging. The results of many researches show that Sr has a good grain refinement effect on Al alloys [18,19], and also has an effective role in grain refinement of Mg alloys, and hence improve their properties. For example, the benefit of Sr addition in AZ91 [20,21], ZK60 [22], and Mg–Al–Ca alloys [23] were successfully realized.

In the present investigation, minor Sr addition was used to prepare the Mg–14Li–*x*Sr alloys with body center cubic structure through a simple alloying process and hot extrusion. In the Mg–14Li–*x*Sr alloys, Mg–Sr intermetallic compound preferentially formed during solidification since the difference in electro-negativity (ΔEN = 0.36) between Mg and Sr is higher than that between Li and Sr (ΔEN = 0.33) [24]. Through the crystallography examination using the edge-to-edge matching model which has successfully predicted AlN [25], ZnO [26], Al_2Y [27–29], TiB_2 [30] compounds as an effective grain refiner for Mg–3Al–1Zn, Mg–10Y and Mg–5Li–3Al alloys, there is a crystallography matching relationship between Mg_2Sr and Li. Mg_2Sr can be considered as a potential grain refiner for the Mg–14Li–*x*Sr alloys. Additionally, according to Mg–Sr and Li–Sr binary phase diagram [31], the Mg_2Sr compound has higher melting point than Li–Sr compounds. Therefore, Mg_2Sr has higher thermal stability and should not be decomposed during the aging treatment of the Mg–14Li–*x*Sr alloys,

Table 1 Chemical compositions of the experiment alloys (wt%).

Designed composition	Measured composition
Mg–14Li–1Al	Mg–14.01Li–1.09Al
Mg–14Li–0.1Sr	Mg–13.63Li–0.14Sr
Mg–14Li–0.3Sr	Mg–14.10Li–0.19Sr
Mg–14Li–0.5Sr	Mg–14.27Li–0.39Sr

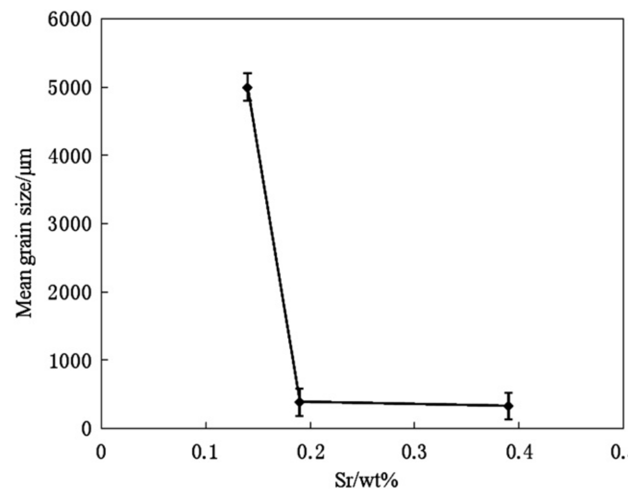

Fig. 2 Variation of grain size of the as-cast Mg–14 wt%Li alloys with various contents of Sr.

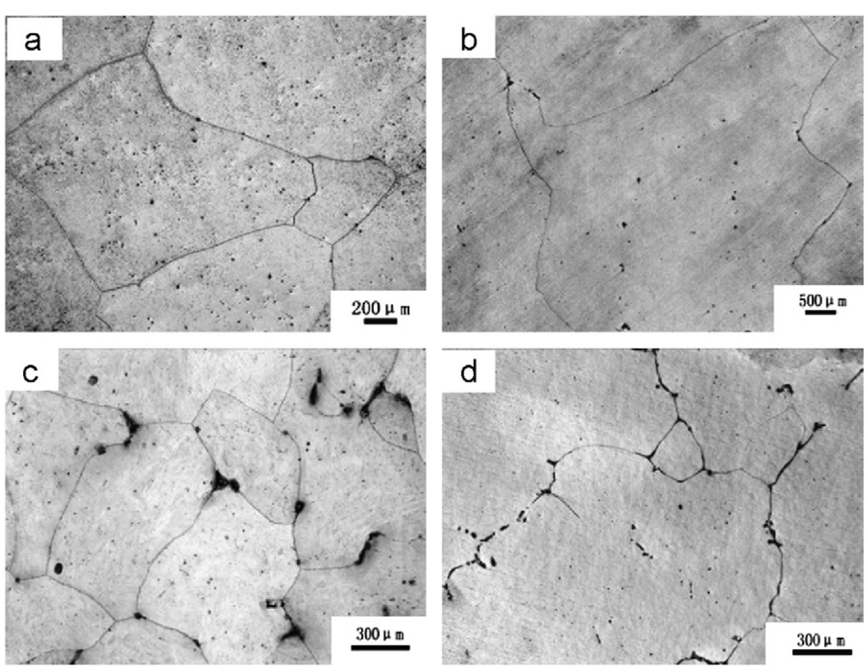

Fig. 1 As-cast microstructures of LA141 alloy (a) and Mg–14Li alloys with different Sr contents (b) 0.14 wt%, (c) 0.19 wt%, and (d) 0.39 wt%.