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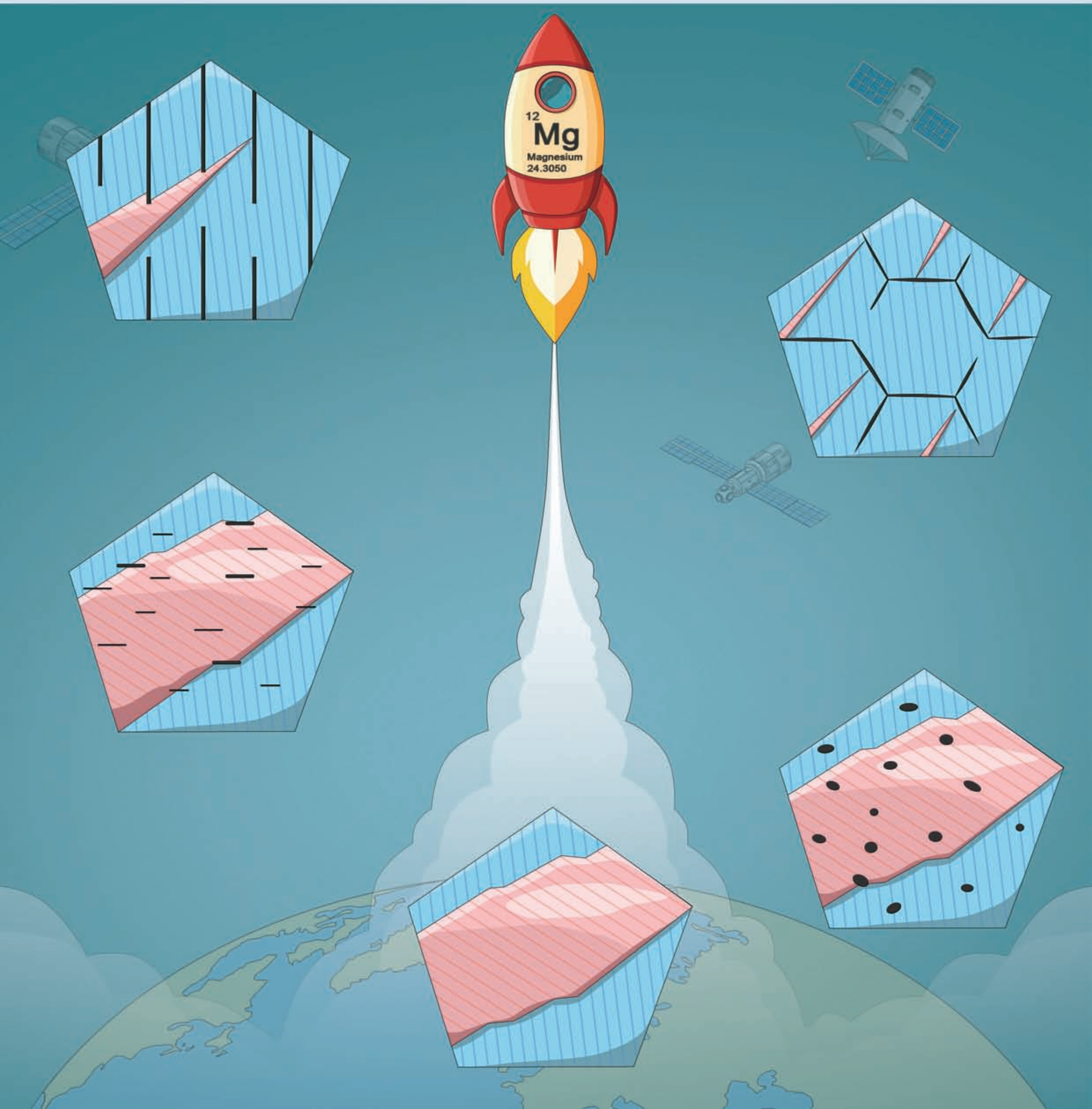

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Insight from *in situ* microscopy into which precipitate morphology can enable high strength in magnesium alloys

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ABSTRACT

Magnesium alloys, while boasting light weight, suffer from a major drawback in their relatively low strength. Identifying the microstructural features that are most effective in strengthening is therefore a pressing challenge. Deformation twinning often mediates plastic yielding in magnesium alloys. Unfortunately, due to the complexity involved in the twinning mechanism and twin-precipitate interactions, the optimal precipitate morphology that can best impede twinning has yet to be singled out. Based on the understanding of twinning mechanism in magnesium alloys, here we propose that the lamellar precipitates or the network of plate-shaped precipitates are most effective in suppressing deformation twinning. This has been verified through quantitative *in situ* tests inside a transmission electron microscope on a series of magnesium alloys containing precipitates with different morphology. The insight gained is expected to have general implications for strengthening strategies and alloy design.

1. Introduction

Lightweight magnesium (Mg) alloys are being actively pursued for their energy saving potential in fuel intensive transport [1,2]. However, the low strength of Mg alloys seriously hampers their broad applications. The idea of age hardening, inspired by success with Al alloys [3], has been widely applied to Mg alloys by introducing precipitates to enhance the strength. However, the strengthening effect is unsatisfactory [4] (Fig. S1). Different from Al alloys whose plasticity is governed exclusively by dislocation slips, yielding of Mg is usually subsidized by both dislocation slips on basal plane and deformation twinning (DT) on $\{10\bar{1}2\}$ plane (Fig. S2) [5]. The suppression of both basal slip and $\{10\bar{1}2\}$ DT is necessary in strengthening Mg alloys. For basal slips, the resistance from precipitates can be well quantified by Orowan model [6–8] and the strengthening effect is reliable [8–13]. However, from the experimental point of view, a consensus has yet to be reached whether the $\{10\bar{1}2\}$ DT can be effectively suppressed by precipitates [9–15] (Table S1). Although a few microscopy studies suggested that twin

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