ICSMA19 Metz, France, June 26 - July 1, 2022
International Conference on Strength of Materials

Mitigating the detrimental effects of galvanic corrosion in high strength Mg composites by nanoscale architecture design

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The low strength and poor corrosion resistance of magnesium (Mg) has prevented its use for load-bearing bone fracture fixations. Core of this limitation is Mg's low solubility for most elements combined with its low electrochemical potential. This favors precipitation of secondary phases (i.e., micro-galvanic elements) but also excludes Mg-based composites (highly active galvanic couples), e.g., Refs. [1, 2], both of which would allow to improve strength significantly. Alternative concepts for high-strength yet slowly degrading Mg-based materials thus need to be developed. Here, we present promising results, indicating that the detrimental effects of galvanic corrosion might be overcome by manipulating the composite architecture at the nanoscale. Using nanostructured Mg-Fe composites – so far thought an incompatible materials combination – we find that a reduction of the phase spacing significantly slows down Mg-corrosion rates, achieving even the ultra-low corrosion rates of ultra-high purity Mg. However, in contrast to UHP Mg, the nanoscale composite spacing allows for strength levels from 500 MPa up to 1 GPa. We discuss possible mechanisms enabling this advanced material performance and outline indications for future applications based on the enormous extension of the property space for Mg-based materials.

Keywords: strength; nanocomposite; magnesium; severe plastic deformation; corrosion;

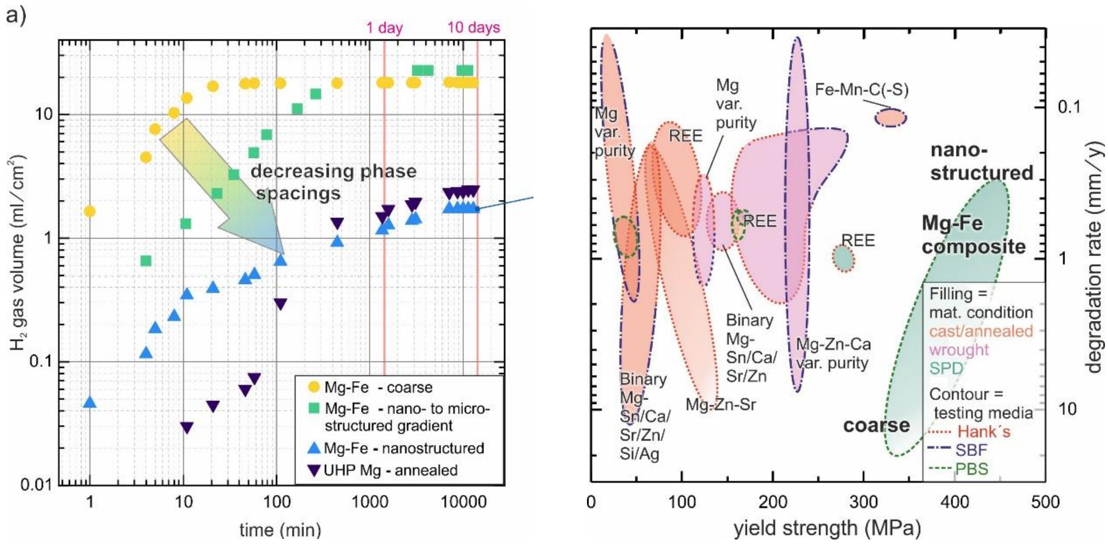

Fig.1 Tailoring the architecture of Mg-based composites allows to tailor not only strength but also the degradation rate, allowing for an enormous extension of the property space.

References:

[1] Yang, L. et al. Effect of iron content on the corrosion of pure magnesium: Critical factor for iron tolerance limit. Corros. Sci. 139, 421–429 (2018).

[2] Virtanen, S. Biodegradable Mg and Mg alloys: Corrosion and biocompatibility. in Materials Science and Engineering B: Solid-State Materials for Advanced Technology 176, 1600–1608 (2011).