

Localized - Gradient Magnetic Field as a Tool for Tailoring Dealloying and Galvanic Ag Replacement on Multicomponent Ferromagnetic Alloys

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Spontaneous electrochemical reactions like selective dealloying and galvanic metal replacement offer simple, current-free routes to engineer high-surface-area and bimetallic coatings. Yet the influence of static magnetic fields on these processes remains largely unexplored, particularly for multicomponent ferromagnetic substrates that can themselves reshape the external field.

Here we investigate the effect of a ≈ 0.4 T permanent magnet on Ni–Co–Fe and high-entropy Co–Ni–Fe–Mo–W alloy films immersed in 0.1 M HNO₃, for dealloying or containing 1 mM AgNO₃ for galvanic replacement modification. Open-circuit potential is monitored in real time to capture field-dependent reaction kinetics, while X-ray fluorescence and X-ray diffraction performed before and after immersion quantify elemental redistribution and lattice distortion.

We hypothesize that:

- (i) Strong local magnetic-field gradients, arising from flux-line distortion by the ferromagnetic alloy itself, generate additional force-driven micro-convection that accelerates selective dissolution of Co, Ni and Fe.
- (ii) The same gradients enhance mass transport of silver ions toward the surface, increasing nucleation density and coverage despite Ag⁺ weak magnetic susceptibility.
- (iii) The combined effects yield measurable shifts in OCP profiles, greater compositional contrast in XRF, and broadened or shifted diffraction peaks associated with lattice depletion and Ag incorporation.

The study provide the systematic evidence that a small, static magnetic field can act as an effective “field catalyst” for zero-current surface transformations on complex ferromagnetic alloys, opening a new pathway for controlled corrosion, catalyst design and functional surface modification without external power input.

Keywords: magnetic field, dealloying, galvanic replacement, Ni–Co–Fe alloy, high-entropy alloy, Ag deposition, magnetohydrodynamics

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