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Controlling structural and magnetic properties in CoNi and CoNiFe nanowire arrays by fine-tuning of Fe content

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Abstract

Herein, Co₇₀Ni₃₀ and Co_xNi_yFe_z (45 ≤ x ≤ 70; 22 ≤ y ≤ 33; 5 ≤ z ≤ 30) nanowire (NW) arrays with a length of approximately 15 μm and diameter of 30 nm have been fabricated using a pulse electrochemical deposition technique in anodic aluminum oxide templates. Increasing the Fe additive concentration (ranging between 0.0035 and 0.05 M) in electrolyte solution has a considerable effect on the composition and crystalline characteristics of the resulting NW arrays, changing the *hcp*-Co and *fcc*-Ni phases into the *bcc*-Fe phase in Co₄₅Ni₂₅Fe₃₀ NWs. On the other hand, hysteresis curves obtained from Co₇₀Ni₃₀ NWs show that, while the average coercivity (H_c^{Hyst}) of parallel and perpendicular applied fields is nearly the same (H_c^{Hyst} ~ 400 Oe), the corresponding squareness ratio is greater in the latter case, indicating a perpendicular anisotropy of NWs. Changing the Fe content in the range of 8-11% causes shape anisotropy to dominate the CoNiFe NW system with the *bcc*-Fe crystalline phase, allowing for controllable magnetic properties. The advanced analysis of angular first-order reversal curves (AFORCs; 0° ≤ θ ≤ 90°) revealed that the FORC coercivity (H_c^{FORC}) in Co₆₂Ni₂₉Fe₉ NWs increases from 700 Oe at θ = 0° to 950 Oe at θ = 90°, thereby evidencing a vortex domain wall mode (VDW). However, for Co₅₅Ni₂₂Fe₂₃ NWs with a dominant *bcc*-Fe phase, H_c^{FORC} reaches 2700 Oe at θ = 77°, starting from 1400 Oe at θ = 0°. In addition to occurring the VDW mode, a single vortex appeared in the Co₅₅Ni₂₂Fe₂₃ NWs when 68° ≤ θ ≤ 77°, followed by its annihilation for θ > 77°.

Keywords: CoNi nanowires, CoNiFe nanowires, anodic aluminum oxide template, Fe additive, magnetic properties, angular first-order reversal curves.

Keywords: A. nanostructured materials; B. chemical synthesis; C. microstructure; D. magnetic measurements.

Abbreviations: Nanowire (NW); anodic aluminum oxide (AAO); angular first-order reversal curves (AFORCs); average coercivity (H_c^{Hyst}); FORC coercivity (H_c^{FORC}); vortex domain wall (VDW); single vortex (SV).

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