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The Electrodeposition of the Magnetic Shape Memory Alloy Ni-Mn-Ga

Kenneth McDonald Department of Materials Science and Engineering, Boise State University

Jessica Drache *TU Dresden*

Dr. Uwe Gaitzsch Leibniz-IFW Dresden

Introduction

Shape memory alloy (SMA): Material capable of overcoming large strains to return to a pre-deformed shape via a thermally induced martensitic phase transformation. In magnetic SMA, the shape change can be induced with a magnetic field.

Research Purpose

• Purpose:

• To determine the feasibility of producing thin films of the magnetic shape memory alloy Ni-Mn-Ga through electrodeposition





Electrodeposition Vs. Sputter Deposition

Less expensive Equipment

More Energy Efficient

•Less Metal Waste



5. Verify presence of Ni-Mn-Ga alloy

Electrodeposition of the Magnetic Shape Memory Alloy Ni-Mn-Ga

Ken McDonald¹, Uwe Gaitzsch^{1,2}, Jessica Drache^{1,3}, Peter Müllner¹, Paul Lindquist¹

¹ Boise State University, Boise ID USA, ² Leibniz-IFW Dresden, Dresden, Germany, ³ TU Dresden, Dresden, Germany

Deposition Parameters

Metal	Bath Composition	Current Density	pH Range	Avg. cathode
				efficiency
Nickel	0.3M H ₃ BO ₃	50mA/cm ²	3.8-4.2	99%
	0.5M NiCl ₂			
Manganese	1M (NH ₄) ₂ SO ₄	65mA/cm ²	3.0-4.7	65%
	0.59M MnSO ₄			
Gallium	0.3M Ga ₂ Cl ₃	40mA/cm ²	10.5-11.7	60%
	0.5M NaH ₂ C ₆ H ₅ O ₇			

Ga/Mn/Ni

Annealing Parameters Table below depicts diffusion length of Nickel in Ni-Mn-Ga in micrometers at corresponding temperature and time.

T Celsius/ t-min	700	750	800	900
10	1.38µm	2.15µm	3.21µm	6.45µm
30	2.40µm	3.73µm	5.56µm	11.2µm
60	3.39µm	5.27µm	7.86µm	15.8µm
180	5.88µm	9.13µm	13.6µm	27.4µm
600	10.7µm	16.7µm	24.9µm	49.9µm

Ga/Mn/Ni layer order produced little alloying due to high oxide deposition when plating Mn onto Ga thus Ga/Ni/Mn order was used.



Layer Order: GaNiMn

GaNiMn

- Metallic Manganese deposits onto Gallium
- Manganese oxidation prevention needed
- Oxalic Acid
- Removes Manganese Oxide
- Forms bi-layer barrier
- Cannot plate after treatment

acetone



Oxalic Acid Treatment

Acetone Prevents oxidation Bi-layer or induced phase transformation to α-Mn

Can plate after treatment







