SUPERCONFORMAL ELECTRODEPOSITION OF NICKEL IRON AND COBALT MAGNETIC ALLOYS

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit under 35 U.S.C. §119(e) of U.S. Provisional Application No. 61/023593, entitled "Superconformal Electrodeposition Of Ni—Fe—Co Magnetic Alloys", filed Jan. 25, 2008, which is hereby incorporated herein by reference in its entirety.

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

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CERTIFICATION OF EFS-WEB TRANSMISSION UNDER 37 C.F.R. 1.10

[0003]

I hereby certify that this New Application and the documents referred to as enclosed herein are being deposited with the United States Patent Office on date of signature via the EFS-Web Service.	__________ Signature Steve A. Witters, 53,923 Name, Reg. # __________ Date of Signature

[0004] 1. Field

[0005] Aspects of the present invention generally relate to using electrodeposition to fill recessed surface features of a substrate with metals and alloys in a substantially void free manner. More specifically, by using certain electrolyte additives void-free electrodeposition of ferromagnetic materials onto a three dimensional patterned substrate may be achieved.

[0006] 2. Background

[0007] As reflected in the literature, electrodeposition of ferromagnetic materials, such as Co, Ni, Fe, and related alloys has been used in the fabrication of recording heads and media for hard disk drives, magnetic sensors, inductors, three-dimensional (3-D) structures associated with ultralarge-scale integration (ULSI), micro-electromechanical systems (MEMS), 3-D packaging and actuators.

[0008] In the prior art, thin-film ferromagnetic microstructures have been produced by through-mask electroplating (also known as the LIGA). Through-mask deposition has been applied to a wide variety of materials ranging from metals to semiconductors, including applications in both passive and active devices. LIGA combines template production (e.g., lithography) with electrodeposition whereby metal deposition proceeds on the exposed sections of the underlying conductive seed layer. Two manifestations of this are metal plating in nanopores of a metal-backed anodized alumina membrane and selective plating on a metallized substrate patterned with an overlying insulating photoresist. This process yields microstructures that are the negative image of the template structure. The implementation of the process is effectively two-dimensional in nature. Developing complex multilayered three-dimensional (3-D) structures by through-mask deposition may be problematic, particularly with regard to electrical addressability as required for the electrodeposition process as well as subsequent electrical and/or thermal isolation of the final intricate structures.

[0009] The Damascene process, which is widely used for producing multilevel Cu interconnection in ultralarge-scale integration, has offered an alternative to the LIGA approach to building 3-D magnetic nanostructures. The Damascene process comprises metallizing a topographically 3-D patterned dielectric with a thin seed layer to ensure conductivity across the entire surface followed by metal electrodeposition across the entire surface. This may be effectuated by the addition of accelerating and inhibiting electrolyte additives in an electrolytic bath in combination with the consequences of area change that accompanies deposition in the 3-D pattern. A subsequent planarization step removes the overburden, leaving the desired metal structures embedded within the dielectric. The process can be repeated as needed to produce multilevel interconnected structures that may exceed ten layers. The Damascene metallization process may provide void-free bottom-up superconformal filling of the trenches and vias with Cu.

[0010] In the case of copper, silver, and gold, void-free superconformal feature filling has been demonstrated by the use of electrolyte additives that locally modify the rate of growth leading to bottom-up filling of recessed features, such as trenches and vias. However, such void free feature filling has not been realized for electrodeposition of ferromagnetic materials.

[0011] In the case of ferromagnetic materials, the effect of additives on the morphological evolution and physical properties of the deposits has been employed in the prior art to a limited extent. For example, the influence of dilute concentrations of species, such as saccharin, quinoline, thiourea, and coumarian on improving film properties such as internal stress, corrosion resistance, and leveling of the micro-roughness, has been reported. Among them, thiourea and coumarin are known levelers that reduce the difference in height between protruding and recessed surface features in large 3-D structures, over 10-100 μm wide. However, use of the Damascene process for the electroplating of ferromagnetic materials in a 3-D patterned dielectric substrate has been limited. Void-free filling of trenches and vias with ferromagnetic materials remains problematic, especially in a small scale. What is needed is a process for substantially void-free filling of recessed surface features such as trenches and vias in 3-D patterned substrates with ferromagnetic materials.

SUMMARY

[0012] Aspects of the present invention generally relate to using electrodeposition to fill recessed surface features of a substrate with metals and alloys in a substantially void free manner. More specifically, by using certain electrolyte additives, substantially void-free electrodeposition of ferromagnetic materials within a three dimensional patterned substrate may be achieved. The substrate may be electrically conductive such as a metal or a doped semiconductor. Alternatively the substrate may be a dielectric. With a dielectric substrate, the patterned surface may first be rendered conductive by deposition of a thin electrically conducting seed-layer at least within the three dimensional pattern.