

LOW OXYGEN CONTENT ALLOY COMPOSITIONS

Field of the Invention

[0001] The invention concerns low oxygen content Mn-In alloy compositions, and more particularly concerns low oxygen content Mn-In alloy compositions having magnetic properties useful in magnetic memory applications.

Background of the Invention

[0002] Magnetoresistive (MR) heads and Magnetic Random Access Memory (MRAM) are expected to be key technologies for future generations of vertical magnetic recording and cell phone memory applications. New materials are being studied in order to improve designs that will increase memory area density and reduce the size of memory chips. Not only must these new materials possess particular magnetic properties for use in these technologies, they must also have high purity levels.

[0003] Material purity plays a significant role in the performance of thin film materials used in magnetic data storage and MRAM applications. For example, the presence of impurities such as oxygen, nitrogen, sulfur and alkalides alters the lattice structure of a thin film material and thereby displaces atoms in the lattice. This effect on the structural order of the material degrades the material's magnetic properties and therefore its performance in magnetic memory applications. In addition, the presence of impurities such as oxygen can produce short diffusion paths through the thin film material into the magnetic layers. Accordingly, there is a need to identify and develop thin film materials having particular magnetic properties as well as high levels of purity.

Summary of the Invention

[0004] The present invention comprises a series of Mn-In alloy compositions having preferred magnetic properties for use in magnetic memory applications. The Mn-In alloy compositions form ordered compounds having $L1_0$ or $L1_2$ type crystalline structures within the claimed compositional ranges. In addition, the Mn-In alloy compositions of the invention have low levels of impurities, such as oxygen and sulfur, which provide better performance in magnetic memory applications. The Mn-In alloy compositions preferably are formed into sputtering targets used for thin film applications.

[0005] The oxygen content of the alloy compositions of the invention is 500ppm or less and preferably 100 ppm or less. Additionally, the sulfur content of the alloy compositions is 100 ppm or less and preferably 50 ppm or less.

[0006] The foregoing summary of the invention has been provided so that the nature of the invention may be understood quickly. A more complete understanding of the invention can be obtained by reference to the following detailed description of the invention.

Brief Description of the Drawings

[0007] Figure 1 is an SEM micrograph of an as-cast In50Mn at. % alloy.

Detailed Description of the Invention

[0008] The inventors identified and developed Mn-In alloy compositions that exhibited preferred magnetic characteristics and had low impurity levels. The alloy compositions of the invention form ordered compounds having $L1_0$ or $L1_2$ type crystalline structures. In addition, the oxygen and sulfur content of the alloy compositions was significantly reduced.

[0009] Table 1 summarizes the relevant compositional and structural data for various alloy compositions. Specifically, Table 1 identifies the ordered phase symbol, the structure designation, the composition range in which the phase of interest exists, and the compositional range in which the phase of interest could coexist with other phase types. The alloy system of the present invention is the Mn-In alloy system. The phase symbols used in Table 1 were obtained from phase diagrams found in Binary Phase Diagrams, 2nd Edition (Thaddeus B. Massalski, ed.).

TABLE 1

Alloy System X-Y	Ordered Phase Symbol	Structure Designation	Composition at.% Y	Compositional Range at.% Y
Mn-Ga	γ	L1 ₀	55-63	50-70
Mn-In	InMn ₃	L1 ₀ or L1 ₂	75	50-85
Mn-Ni	η'	L1 ₀	47-55.5	44-60
Ni-Mn	γ	L1 ₂	15-29	10-30
Zn-Mn	α	L1 ₂	25-31	20-40
Zn-Mn	α_1'	L1 ₀	25-30	20-40
Fe-Pt	Fe ₃ Pt	L1 ₂	16-33	16-35
Fe-Pt	FePt	L1 ₀	35-55	35-59
Fe-Pt	FePt ₃	L1 ₂	57-79	57-83
Fe-Pd	FePd(a)	L1 ₀	48.5-60	30-63
Fe-Pd	FePd ₃ (b)	L1 ₂	63-86	60-88
Co-Pt	CoPt(a)	L1 ₀	42-74	40-76
Co-Pt	CoPt ₃ (b)	L1 ₂	75-88	75-90
Co-Pd	α'	L1 ₀	48-52	30-58
Co-Pd	α	L1 ₂	60-90	58-94

[0010] The first group of alloys listed in Table 1 comprises Mn alloys which exhibit L1₀ or L1₂ crystalline structures. These Mn alloys possess antiferromagnetic properties desirable for thin film materials used in magnetic data storage and MRAM applications. Specifically, these Mn alloys are of interest for use in anisotropic magnetoresistive (AMR) and giant magnetoresistive (GMR) spin-valve sensors used in high-density recording. These Mn alloys are also of interest since the alloy constituents used with Mn are lower cost materials than those typically used, such as Pt, Pd, Ir or Rh. Example 1 below describes the Mn-In alloy system, according to the present invention.

[0011] Example 1: A melt test was conducted using 2427 grams of 99.9% pure Mn flakes and 5073 grams of 99.9% pure In rods. In addition to the Mn and In constituents, 25 grams of CaSi_2 and 10 grams of Ce were added as deoxidizers. The melt charge was preheated to 500 F under a 0.07 mbar partial vacuum in an MgO crucible within a VIM unit chamber. The VIM unit chamber was then back filled with argon to 500 mbar and the melt charge melted by applying 5kW to the VIM unit for 20 minutes and increasing the power by 5kW every 5 minutes for an additional 20 minutes. The melt charge was then cast into a graphite mold.

[0012] Figure 1 is an SEM micrograph depicting the microstructure of the as-cast In50Mn at. % alloy. The microstructure depicted in this micrograph consists of three phases: a light Indium matrix, an (In,Mn) solid solution shown as a light gray phase, and an InMn_3 compound shown as dark gray grains. The black spots in the micrograph are pores. The chemical composition of the as-cast material was analyzed, the results of which are shown below in Table 2.

TABLE 2

Si Ppm	Cu ppm	Al ppm	Ni ppm	Fe ppm	O ppm	C Ppm	N ppm	S Ppm	Mn at.%
15	2	10	6	23	40	62	19	33	50.7

[0013] The foregoing examples are intended to illustrate examples of alloy compositions according to the present invention. These examples are not intended to limit the scope and the invention, which should be interpreted from the claims set forth below.

[0014] While the foregoing has described what are considered to be the best mode and/or other examples, it is understood that various modifications may be made therein and that the subject matter disclosed herein may be implemented in various forms and examples, and that they may be applied in numerous applications, only some of which have been described herein.

What is Claimed Is:

1. An alloy composition comprising 50-15 at. % Mn and 50-85 at. % In, wherein the alloy composition contains 500 ppm or less O and 100 ppm or less S.

2. The alloy composition according to Claim 1, wherein the alloy composition comprises 25 at. % Mn and 75 at. % In.

3. The alloy composition according to Claim 1, wherein the alloy composition contains 100 ppm or less O and 50 ppm or less S.