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(54) **Low magnetostriction amorphous metal alloys.**

(57) A magnetic alloy that is at least 50 percent glassy, having the formula $(Ni_{0.5}Co_{0.5-x}T_x)_{100-b}M_b$, where T is at least one of Mn, Cr and V, B is at least one of B, Si, P, C and Ge, x is less than 0.25, and b ranges from 17 to 22 atom percent, said alloy containing up to 2 atom percent of at least one of B, Si, P, C and Ge, having a value of magnetostriction of about -8×10^{-6} to $+2 \times 10^{-6}$ and a saturation induction of about 0.3 to 0.8T.

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Description

Low Magnetostriction Amorphous Metal Alloys

Background of the Invention

1. Field of the Invention

This invention relates to amorphous metal alloys that include metalloid elements.

2. Description of the Prior Art

There are three physical parameters which can inhibit the easy magnetization and demagnetization of magnetic materials: strong anisotropy, non-zero magnetostriction and, at high frequencies, low resistivity. Metallic glasses generally show resistivities greater than 100 micro ohm cm, whereas crystallinie and polycrystalline magnetic metals generally show sesistivities below 50 micro ohm cm. Also, because of their randomly disordered structures, metallic glasses are typically isotropic in their physical properties, including their magnetization. Because of these two characteristics, metallic glasses have an initial advantage over conventional magnetic metals. However, metallic glasses do not generally show zero magnetostriction. When zero magnetostriction glasses can be found they are generally good soft magnetic metals (R.C. O'Handley, B.A. Nesbitt, and L.I. Mendelsohn, IEEE Trans Mag-12, p. 942, 1976, U.S. Patents Nos. 4,038,073 and 4,150,981), because they satisfy the three approved criteria. For this reason, interest in zero magnetostriction glasses has been intense as indicated by the many publications on low magnetostriction metallic glasses (A.W. Simpson and W.G. Clements, IEEE Trans Mag-11, p. 1338, 1975; N. Tsuya, K.I. Arai, Y. Shiraga and T. Masumoto, Phys. Lett. A51, p. 121, 1975; H.A. Brooks, Jour. Appl. Phys. 47, p. 334, 1975; T.Egami, P.J. Flanders and C.D. Graham, Jr., Appl. Phys. Lett. 26, p. 128, 1975 and AIP Conf. Proc. No. 24, p. 697, 1975; R.C. Sherwood, E.M. Gyorgy, H.S. Chen, S.D. Ferris, G. Norman and

H.J. Leamy, AIP Conf. Proc. No. 24, p. 745, 1975; H. Fujimori, K.I. Arai, H. Shiraga, M. Yamada, T. Masumoto and N. Tsuya, Japan, Jour. Appl. Phys. 15, p. 705, 1976; L. Kraus and J. Schneider, phys.stat. sol. a39, p. K161, 1977; R.C. O'Handley in Amorphous Magnetism, edited by R. Levy and R. Hasegawa (Plenum Press, New York 1977), p. 379; R.C. O'Handley, Solid State Communications 21, p. 1119, 1977; R.C. O'Handley, Solid State Communications 22, p. 458, 1977; R.C. O'Handley, Phys. Rev. 18, p. 930, 1978; H.S. Chen, E.M. Gyorgy, H.J. Leamy and R.C. Sherwood, U.S. Patent No. 4,056,411, Nov. 1, 1977).

The existence of a zero in the magnetostriction of Co-Mn-B glasses has been observed by H. Hiltzinger of Vacuumschmeltze A.G., Hanau, Germany.

Reference to Co-rich glasses containing 6 atom percent of Cr is made by N. Heiman, R.D. Hempstead and N. Kazama in Journal of Applied Physics, Vol. 49, p. 5663, 1978. Their interest was in improving the corrosion resistance of Co-B thin films. No reference to magnetostriction is made in that article.

Saturation moments and Curie temperatures of $Co_{80-x}T_xP_{10}B_{10}$ glasses (T = Mn, Cr, or V) were recently reported by T. Mizoguchi in the Supplement of the Scientific Reports of RITU (Research Institutes of Tonoku University), A June 1978, p. 117. No reference to their magnetostrictive properties was reported.

In Journal of Applied Physics, Vol. 50, p. 7597, 1979, S. Ohnuma and T. Masumoto outline their studies of magnetization and magnetostriction in Co-Fe-B-Si glasses with light transition metal (Mn, Cr, V, W, Ta, Mo and Nb) substitutions. They show that the coercivity decreases and the effective permeability increases in the composition range near zero magnetostriction.

New applications requiring improved soft zero-magnetic materials that are easily fabricated and have excellent stability have necessitated efforts to develop further compositions.

Summary of the Invention

The present invention provides low magnetostriction and zero magnetostriction glassy alloys that are easy to fabricate and thermally stable. The alloys are at least 50 percent glassy and consist essentially of compositions defined by the formula $(Ni_{0.5}Co_{0.5-x}T_x)_{100-b}M_b$, where T is at least one of Mn, Cr and V, B is at least one of B, Si, P, C and Ge, x is less than 0.25, and b ranges from 17 to 22 atom percent , said alloy containing up to 2 atom percent of at least one of B, Si, P, C and Ge, having a value of magnetostriction of about -8×10^{-6} to $+2 \times 10^{-6}$ and a saturation induction of about 0.3 to 0.8T, or by the formula $(Ni_{0.75}Co_{0.25-x}T_x)_{100-b}M_b$, where T is at least one of Mn, Cr and V, M is at least one of B, Si, P, C and Ge, x ranges up to about 0.25, and b ranges from about 17 to 22 atom percent , said alloy containing up to 2 atom percent of at least one of B, Si, P, C and Ge, having a value of magnetostriction of about -6×10^{-6} to $+2 \times 10^{-6}$ and a saturation induction of about 0.1 to 0.7T.

Preferrably M is essentially boron.

The purity of the above composition is that found in normal commercial practice.

Description of the Preferred Embodiments

The amorphous alloys of the invention can be formed by cooling a melt of the composition at a rate of at least about 10^5°C/sec. A variety of techniques are available, as is now well-known in the art, for fabricating splat-quenched foils and rapid-quenched continuous ribbons, wire, sheet, etc. Typically, a particular composition is selected, powders of the requisite elements (or of materials that decompose to form the elements, such as nickel-borides, etc.) in the desired proportions are melted and homogenized, and the molten alloy is rapidly quenched either on a chill surface, such as a rotating cooled cylinder, or in a suitable fluid medium, such as a chilled brine solution. The amorphous alloys may be formed in air. However, superior mechanical properties are achieved by forming these amorphous alloys in a partial vacuum with absolute pressure less than about 5.5 cm of Hg, and preferably about 100 μm to 1 cm of Hg, as disclosed in U.S. Patent No. 4,154,283 to Ray et al.

The amorphous metal alloys are at least 50 per cent amorphous, and preferably at least 80 per cent amorphous, as measured by X-ray diffraction. However, a substantial degree of amorphousness approaching 100 per cent amorphous is obtained by forming these amorphous metal alloys in a partial vacuum. Ductility is thereby improved, and such alloys possessing a substantial degree of amorphousness are accordingly preferred.

Ribbons of these alloys find use in soft magnetic applications and in applications requiring low magnetostriction, high thermal stability (e.g., stable up to about 100°C) and excellent fabricability.

Ni-rich glasses are easily made and are more stable if the "late" transition metal Ni is balanced to a certain extent by an "early" TM, e.g., Mn, Cr, V. Examples of such glasses include $Ni_{50}Mn_{30}B_{20}$, $Ni_{60}Cr_{20}B_{20}$, or $Ni_{70}V_{10}B_{20}$.

Based on the evidence of $\lambda_s = 0$ alloys set forth above and the known stabilizing effects of light TM's on Ni-rich glasses, new low magnetostriction glasses rich in Ni have been developed in the region below or near the $\lambda_s = 0$ line in Figure 8 (i.e., glasses initially showing $\lambda_s < 0$) by the addition of Mn, Cr, and/or V. Thus, for example,

$(Co_{.25}Ni_{.75})_{80}B_{20}$ can be rendered more fabricable and more stable in the glassy state, and its negative magnetostriction can be increased to near zero by substituting Mn, Cr or V for Co: $(Ni_{.75}Co_{.25-x}T_x)_{80}B_{20}$.

Claims:

1. A magnetic alloy that is at least 50 percent glassy, having the formula $(Ni_{0.5}Co_{0.5-x}T_x)_{100-b}M_b$, where T is at least one of Mn, Cr and V, B is at least one of B, Si, P, C and Ge, x is less than o.25, and b ranges from 17 to 22 atom percent , said alloy containing up to 2 atom percent of at least one of B, Si, P, C and Ge, having a value of magnetostriction of about -8×10^{-6} to $+2 \times 10^{-6}$ and a saturation induction of about 0.3 to 0.8T.

2. A magnetic alloy that is at least 50 percent glassy, said alloy having the formula $(Ni_{0.75}Co_{0.25-x}T_x)_{100-b}M_b$, where T is at least one of Mn, Cr and V, M is at least one of B, Si, P, C and Ge, x ranges up to about 0.25, and b ranges from about 17 to 22 atom percent , said alloy containing up to 2 atom percent of at least one of B, Si, P, C and Ge, having a value of magnetostriction of about -6×10^{-6} to $+2 \times 10^{-6}$ and a saturation induction of about 0.1 to 0.7T.

3. A magnetic alloy, as recited in either claim 1 or 2, wherein M is essentially boron.

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EUROPEAN SEARCH REPORT

0161393

Application number

EP 85101589.1

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl 4)
A	DE - A1 - 2 553 003 (ALLIED CHEMICAL CORP.) * Page 2, lines 10-21 * --	1-3	C 22 C 19/03 C 22 C 19/05 H 10 F 1/14
D,A	US - A - 4 056 411 (CHEN) * Abstract * --	1-3	
A	US - A - 4 081 298 (MENDELSOHN) * Column 2, lines 47-65 * ----	1-3	
			TECHNICAL FIELDS SEARCHED (Int. Cl 4)
			C 22 C H 01 F

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
VIENNA	23-07-1985	ONDER

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document