Crystallisation progress in Si-rich ultra-soft nanocomposite alloy fabricated by melt spinning

Ngo D.-T., Sultan Mahmud M., Nguyen H.-H., Duong H.-G., Nguyen Q.-H., McVitie S., Nguyen C.
Department of Physics and Astronomy, University of Glasgow, Glasgow, G12 8QQ, United Kingdom; Department of Physics, University of Asia Pacific, Dhaka, 1209, Bangladesh; Center for Materials Science, College of Science, Vietnam National University Hanoi, 334 Nguyen Trai Road, Hanoi, Viet Nam

Abstract: The crystallisation process and the ultras-soft magnetic properties of amorphous/nanocomposite alloy $Fe_{73.5}$ $Si_{17.5}$ B_5 Nb_3 Cu_1 fabricated by conventional melt-spinning technique are systematically investigated in terms of thermal analysis and in-situ measurement of magnetisation dynamics. The thermal analysis using differential scanning calorimetry showed that crystallisation from Fe-based amorphous state to α-Fe(Si) started at 535 {ring operator} C. Further heating the sample leads to a transformation from the α-Fe(Si) to Fe-B phases at 670 {ring operator} C. Crystallisation activation energies were determined using two models: Kissinger and John-Mehl-Avrami (JMA), which were consistent to each other with a value of 2.81 ± 0.03 eV. High resolution transmission electron microscopy investigation revealed an ultrafine structure of α-Fe(Si) nanocrystallite with mean size of 12.5 nm embedded in an amorphous matrix. At a volume fraction of 86% of α-Fe(Si) phase, optimum soft magnetic properties were obtained with very high permeability of 110,000 and a very low coercivity of 0.015 Oe by annealing the amorphous alloy at 530 {ring operator} C in 40 min.

Author Keywords: Amorphous alloys; Finemet; Nanocrystalline materials; Permeability

Index Keywords: Amorphous matrices; Amorphous state; Coercivities; Crystallisation; Finemet; High permeability; In-situ measurement; Kissinger; Magnetisation; Mean size; Melt-spinning techniques; Permeability; Soft magnetic properties; Soft nanocomposites; Thermal analysis; Ultrafine structure; Activation energy; Amorphous silicon; Capillarity; Crystallization; Differential scanning calorimetry; High resolution transmission electron microscopy; Iron alloys; Magnetic properties; Melt spinning; Nanocrystalline alloys; Nanocrystalline materials; Niobium; Silicon; Silicon alloys; Thermoanalysis; Amorphous alloys

Year: 2010
Source title: Journal of Magnetism and Magnetic Materials
Volume: 322
Issue: 3
Page : 342-347
Cited by: 1
Link: Scorpus Link
Correspondence Address: Ngo, D.-T.; Department of Physics and Astronomy, University of Glasgow, Glasgow, G12 8QQ, United Kingdom; email: d.ngo@physics.gla.ac.uk
ISSN: 3048853
CODEN: JMMMD

DOI: 10.1016/j.jmmm.2009.09.054
Language of Original Document: English
Abbreviated Source Title: Journal of Magnetism and Magnetic Materials
Document Type: Article
Source: Scopus
Authors with affiliations:

- Ngo, D.-T., Department of Physics and Astronomy, University of Glasgow, Glasgow, G12 8QQ, United Kingdom, Center for Materials Science, College of Science, Vietnam National University Hanoi, 334 Nguyen Trai Road, Hanoi, Viet Nam
- Sultan Mahmud, M., Department of Physics, University of Asia Pacific, Dhaka, 1209, Bangladesh
- Nguyen, H.-H., Center for Materials Science, College of Science, Vietnam National University Hanoi, 334 Nguyen Trai Road, Hanoi, Viet Nam
- Duong, H.-G., Center for Materials Science, College of Science, Vietnam National University Hanoi, 334 Nguyen Trai Road, Hanoi, Viet Nam
- Nguyen, Q.-H., Center for Materials Science, College of Science, Vietnam National University Hanoi, 334 Nguyen Trai Road, Hanoi, Viet Nam
- McVitie, S., Department of Physics and Astronomy, University of Glasgow, Glasgow, G12 8QQ, United Kingdom
- Nguyen, C., Center for Materials Science, College of Science, Vietnam National University Hanoi, 334 Nguyen Trai Road, Hanoi, Viet Nam

References:

- Yoshizawa, Y., Oguma, S., Yamauchi, K., (1988) J. Appl. Phys., 64, p. 6044
- Chau, N., Chien, N.X., Hoa, N.Q., Niem, P.Q., Luong, N.H., Tho, N.D., Hiep, V.V., (2004) J. Magn. Magn. Mater., 282, p. 174
- Chau, N., Hoa, N.Q., The, N.D., Vu, L.V., (2006) J. Magn. Magn. Mater., 303, pp. e415
- Kang, E.Y., Kim, Y.B., Kim, K.Y., Chung, Y.H., (2006) J. Appl. Phys., 99, pp. 08F111
- Herzer, G., (1989) IEEE Trans. Magn., 25, p. 3327
- Kissinger, H., (1957) Anal. Chem., 29, p. 1702
- Al-Haj, M., Barry, J., (1997) J. Mater. Sci. Lett., 16, p. 1640
- Bigot, J., Lecaude, N., Perron, J.C., Milan, C., Ramiarinjaona, C., Rialland, J.F., (1994) J. Magn. Magn. Mater., 133, p. 299
- Leu, M.S., Chin, T.S., (1999) MRS Symp. Proc., 577, p. 557
- Hsiao, A.C., McHenry, M.E., Laughlin, D.E., Tamoria, M.R., Harris, V.G., (2001) IEEE Trans. Magn., 37, p. 2236
- Um, C.-Y., Johnson, F., Simone, M., Barrow, J., McHenry, M.E., (2005) J. Appl. Phys., 97, pp. 10F504
- Richter, F., Pepperhoff, W., (1974) Arch. Eisenhuettenwes., 45, p. 107