# The microstructure, high performance magnetic hardness and magnetic after-effect of an α- $FeCo/Pr_2Fe_{14}B$ nanocomposite magnet with low Pr concentration

Ngo D.-T., Duong H.-G., Nguyen H.-H., Nguyen C., Basith M., Hoang D.-Q.

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, Hanoi, Viet Nam

Abstract: In this paper, a systematic investigation of the microstructure, high performance magnetic hardness as well as novel magnetic memory effect of the $Pr_4Fe_{76}Co_{10}B_6Nb_3Cu_1$ nanocomposite magnet fabricated by conventional melt-spinning followed by annealing at temperatures ranging from 600 to 700 °C in Ar gas for nanocrystallization are presented and discussed. Transmission electron microscopy (TEM) observation confirms an ultrafine structure of bcc-Fe(Co) as a magnetically soft phase and $Pr_2Fe_{14}B$ as a hard magnetic phase with a spring-exchange coupling in order to form the nanocomposite state. Electron diffraction analysis also indicates that the Co atoms together with Fe atoms form the $Fe_{70}Co_{30}$ phase with a very high magnetic moment ($2.5\mu_B$), leading to a high saturation magnetization of the system. High magnetic hardness is obtained in the optimally heat-treated specimen with coercivity $H_c$ = 3.8kOe, remanence $B_r$ = 12.0kG, $M_r/M_s$ = 0.81 and maximum energy product $(BH)_{max}$ = 17.8MGOe, which is about a 25% improvement in comparison with recent results for similar compositions. High remanence and reduced remanence are the key factors in obtaining the high performance with low rare-earth concentration (only 4at.%). High-resolution TEM analysis shows that there is a small amount of residual amorphous phase in the grain boundary, which plays a role of interphase to improve the exchange coupling. Otherwise, in terms of magnetic after-effect measurement, a magnetic memory effect was observed for the first time in an exchange-coupled hard magnet. 

Index Keywords: Coercivity; Electron diffraction analysis; Energy products; Fe atoms; Hard magnetic phase; Hard magnets; Heat-treated specimens; High-resolution TEM analysis; High-saturation magnetizations; Key factors; Magnetic after effects; Magnetic hardness; Magnetic memories; Melt-spinning; Nanocomposite magnets; Rare-earth; Residual amorphous phase; Systematic investigations; Tem; Ultra fine structures; Atoms; Exchange coupling; Grain boundaries; Hardness; Iron compounds; Magnetic moments; Magnetic storage; Magnets; Microstructure; Nanocomposites; Nanocrystallization; Niobium; Rare earth elements; Remanence; Saturation magnetization; Sodium compounds; Transmission electron microscopy; Magnetic materials; boron; cobalt; copper; iron; nanocomposite; nanocrystal; nanomaterial; nanoparticle; nanoribbon; niobium; praseodymium; article; concentration process; electron diffraction; energy; hardness; magnet; magnetic field; magnetism; nanochemistry; nanofabrication; particle size; priority journal; temperature; transmission electron microscopy

Year: 2009

Source title: Nanotechnology

Volume: 20

Issue: 16
Art. No.: 165707
Link: Scorpus Link
Chemicals/CAS: boron, 7440-42-8; cobalt, 7440-48-4; copper, 15158-11-9, 7440-50-8; iron, 14093-02-8, 53858-86-9, 7439-89-6; niobium, 7440-03-1; praseodymium, 7440-10-0
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: 9574484
CODEN: NNOTE
DOI: 10.1088/0957-4484/20/16/165707
Language of Original Document: English
Abbreviated Source Title: Nanotechnology
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, Hanoi, Viet Nam
- Duong, H.-G., Center for Materials Science, College of Science, Vietnam National University Hanoi, 334 Nguyen Trai, Hanoi, Viet Nam
- Nguyen, H.-H., Center for Materials Science, College of Science, Vietnam National University Hanoi, 334 Nguyen Trai, Hanoi, Viet Nam
- Nguyen, C., Center for Materials Science, College of Science, Vietnam National University Hanoi, 334 Nguyen Trai, Hanoi, Viet Nam
- Basith, M., Department of Physics and Astronomy, University of Glasgow, Glasgow G12 8QQ, United Kingdom
- Hoang, D.-Q., Department of Physics and Astronomy, University of Glasgow, Glasgow G12 8QQ, United Kingdom

References:

- Kneller, E.F., Hawig, R., (1991) IEEE Trans. Magn., 27 (4), p. 3588
- Skomski, R., Coey, J.M.D., (1993) Phys. Rev., 48 (21), p. 15812
- Coehoorn De Mooij R, D.B., De Waard, C., (1989) J. Magn. Magn. Mater., 80 (1), p. 101
- Bader, S.D., (2006) Rev. Mod. Phys., 78 (1), p. 1
- Zeng Li Liu Wang P J J H, Z.L., Sun, S., (2002) Nature, 420 (6914), p. 395
- Chang Chang Chiu W H W C, C.H., Chang, W.C., (2005) J. Appl. Phys., 97 (10), pp. 10N117
- Lee Hilton Liu Zhang Hadjipanayis Y S S J D, G.C., Chen, C.H., (2003) IEEE Trans. Magn., 39 (5), p. 2947
- Liu Sui Zhou Sun Chen Zhang L C K X J C Y W, Z.D., Sellmyer, J.D., (2005) J. Appl. Phys., 97 (10), pp. 10K303
- The Chau Vuong N D N, N.V., Quyen, N.H., (2006) J. Magn. Magn. Mater., 303 (2), p. 419
- The Hoa Oh Yu Vu C S K S Q N D N, L.V., Chau, N., (2007) J. Phys. D: Appl. Phys., 40 (1), p. 119
- Pawlik Pawlik Davies Kaszuwara A H K P, W., Wyslocki, J.J., (2007) J. Magn. Magn. Mater., 316 (2), p. 124
- Chiu Chang Chang W H H C, C.W., Chang, W.C., (2008) J. Magn. Magn. Mater., 320 (16), p. 2079
- MacLaren Schulthess Butler Sutton H W C T M J, R., McHenry, M., (1999) J. Appl. Phys., 85 (8), p. 4833
- Zhang Matsushita W, M., Inoue, A., (2001) J. Appl. Phys., 89 (1), p. 492
- Patel El-Hilo O'Grady M V, K., Chantrell, R.W., (1993) J. Phys. D: Appl. Phys., 26 (9), p. 1453

- Cornejo Villas-Boas R D, V., Missell, F.P., (1998) J. Appl. Phys., 83 (11), p. 6637
- Sun Salamon Garnier B M Y, K., Averback, R.S., (2003) Phys. Rev. Lett., 91 (16), p. 167206
- Sasaki Jonsson Takayama E P M, H., Nordblad, N., (2004) Phys. Rev. Lett., 93 (13), p. 139701
- Zheng Gu K R, H., Zhang, X.X., (2004) Phys. Rev. Lett., 93 (13), p. 139702