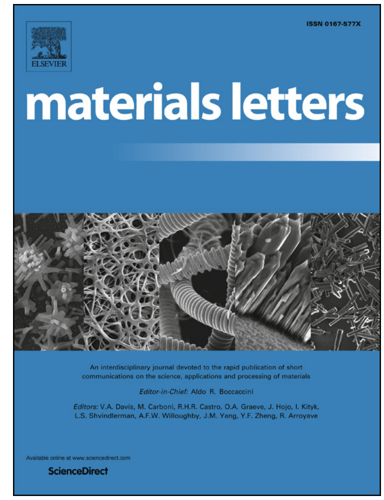

Synthesis of nanocrystalline $Ce_{13}Fe_{81}B_6$ alloy through mechanically driven disproportionation-recombination process

Y.P. Li, J.Y. Li, Z.Z. Wang, Y. Huang, B. Kong

PII: S0167-577X(18)31522-2
DOI: https://doi.org/10.1016/j.matlet.2018.09.134
Reference: MLBLUE 25002

To appear in: *Materials Letters*

Received Date: 9 July 2018
Revised Date: 20 September 2018
Accepted Date: 25 September 2018

Please cite this article as: Y.P. Li, J.Y. Li, Z.Z. Wang, Y. Huang, B. Kong, Synthesis of nanocrystalline $Ce_{13}Fe_{81}B_6$ alloy through mechanically driven disproportionation-recombination process, *Materials Letters* (2018), doi: https://doi.org/10.1016/j.matlet.2018.09.134

Synthesis of nanocrystalline $Ce_{13}Fe_{81}B_6$ alloy through mechanically driven disproportionation-recombination process

Y.P. Li[1, 2*], J.Y. Li[3], Z.Z. Wang[1, 2], Y. Huang[1, 2], B. Kong[1, 2]

(1. School of Materials Science and Engineering, Nanjing Institute of Technology, Nanjing 211167, China; 2. Jiangsu Key Laboratory of Advanced Structural Materials anf Application Technology, Nanjing 211167, China; 3. MIIT Key Laboratory of Thermal Control of Electronic Equipment, School of Energy and Power Engineering, Nanjing University of Science and Technology, Nanjing 211167, China)

Abstract: Nanocrystalline $Ce_{13}Fe_{81}B_6$ alloy powder was synthesized by mechanically driven disproportionation-recombination processing. The microstructure transformation of the alloy during different processing stages was characterized by XRD and TEM. The magnetic properties of the nanocrystalline powder were measured by VSM. The results showed that the $Ce_2Fe_{14}B$ matrix phase of the $Ce_{13}Fe_{81}B_6$ alloy was disproportionated into the nanostructured $CeH_{2.51}$, α-Fe, and Fe_2B phases by ball milling in hydrogen for 20h, and that these nanostructured phases could be desorbed and recombined to nanocrystalline $Ce_2Fe_{14}B$ phase again by subsequent vacuum annealing, with the remanence, coercivity, and maximum energy product of the as-synthesized alloy powders achieving 8.1kGs, 6.02kOe, and 8.51MGOe, respectively.

Key words: CeFeB alloy, ball milling, disproportionation-recombination, Crystal structure, nanocrystalline materials

1. Introduction

NdFeB permanent magnetic materials have attracted extensive interest since their discovery in the early 1980s[1-3]. These materials are widely applied in many fields, such as in automotive, office machine, audiovisual equipment, and wind generators. The wide application and mass production of NdFeB magnets has resulted in rising prices of raw materials (e.g., Nd, Pr, and Dy), which increases the material cost and restraints the development of the NdFeB industry[4]. Furthermore, the rare-earth material is a symbiotic ore, and the excessive consumption of less abundant rare-earth Nd and Pr causes an overstock of the more abundant rare-earth La and Ce[5]. Numerous investigations have been conducted to fabricate 2:14:1-type permanent magnetic materials using high abundant rare earth (e.g., Ce and La) to promote the rational utilization of natural resource. Theoretically, $Ce_2Fe_{14}B$, which has an anisotropy field of 26 kOe and a saturation magnetization of 11.7kGs, is a promising material for permanent magnets with hard magnetic properties intermediate between those of ferrite and NdFeB magnets[6]. However, the actual magnetic properties of $Ce_2Fe_{14}B$-type magnets prepared in the laboratory are markedly inferior to those of $Nd_2Fe_{14}B$-type magnets[7].

Grain refining is a general method to improve the magnetic properties of rare-earth permanent magnetic materials[8]. In most cases, the coercivity of rare-earth permanent magnetic materials increases with grain size reduction. Large coercivity can be obtained once the grain size is below the critical size of a single-domain[9]. Furthermore, the remanence of rare-earth magnetic materials can be greatly enhanced as the grain size becomes in the nanometer scale because of the exchange interaction between the nanograins[1]. Several previous investigations have reported the fabrication of nanocrystalline $Ce_2Fe_{14}B$-type magnetic materials through the melt spinning process[10-12]. However, the properties of these materials reported so far are significantly lower than expected possibly because of the deviation in their microstructure from theoretical modeling[1, 13]. Recently, a mechanically assisted HDDR process has been developed to fabricate