https://doi.org/10.33263/Proceedings11.00130014

ISSN: 2668-6384 https://conferenceproceedings.international

Proceedings International

Proceedings, Abstract

Volume 1, Issue 1, Pages 0013-0014
2019

Received: 01.10.2019
Accepted: 10.10.2019
Published: 15.10.2019

Microstructure investigation of r.f. current annealed FINEMET cold drawn microwires by UHR-TEM

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The microstructure of FINEMET ($Fe_{73.5}Nb_3Cu_1Si_{13.5}B_9$, at %) ferromagnetic microwires with diameters of 30 μm obtained by cold drawn of 120 μm thicker conventional amorphous microwires followed by radio frequency current annealing has been investigated by ultra-high resolution transmission electron (UHR-TEM) microscopy.

The cold drawn microwires (CDWs) were annealed by radio frequency current of 375 mA@10MHz and 750 mA@10MHz, respectively, for 10 minutes to achieve cold drawn microwires with nano-crystalline structure.

The specimens for UHR-TEM investigation were prepared in the shape of lamella using Focus Ion Beam microscope. For each annealed CDNWs were obtained two lamella one from the edge of microwire and another one from the center of the wire. Each specimen has been examined by transmission electron microscopy (TEM) using a Libra200MC microscope operated at 200kV through the bright-field and dark-field TEM, HR-TEM, HAADF STEM and EDX method. Electron diffraction patterns are interpreted using the computer programs SingleCrystal® and JEMS®. Mean grain size is measured using ImageJ software and making a geometrical correction for film thickness.

The cold drawn microwires annealed at 350mA are largely amorphous, although containing occasional Fe_3Si regions of short-range order as presented in Figure 1 (a).

The cold drawn microwires annealed at 750mA present a nano-crystalline structures, with all nano-grains appearing to be of the bcc α-Fe(Si) structure as shown in Figure 1 (b). The estimated number density of nano-grains is 4.8 x 10^{23}, which corresponds to an estimated phase fraction of 25 vol.% for a nano-grain radius of 5 nm.

Line-scan EDX shows no particularly striking deviation from a homogenous distribution of elements for nanocrystalline sample, while a clustering behavior of elements for amorphous sample was observed.

Keywords: *FINEMET, microwires, UHR-TEM, Libra200MC.*

Cite This Work: Ababei, G.; Damian, A.; Stoian, G.; Dobrea, V.; Corodeanu, S.; Lupu, N.; Chiriac, H. Microstructure investigation of r.f. current annealed FINEMET cold drawn microwires by UHR-TEM. Proceedings Int **2019**, 1, 0013-0014. https://doi.org/10.33263/Proceedings11.00130014

Funding

Not applicable.

Acknowledgments

Work supported by the Romanian Ministry of Research and Innovation (MCI) under NUCLEU Program – contract no. 33N/2019, project PN 19 28 01 01 and Contract No.11PFE/16.10.2018.

Conflicts of Interest

The authors declare no conflict of interest.

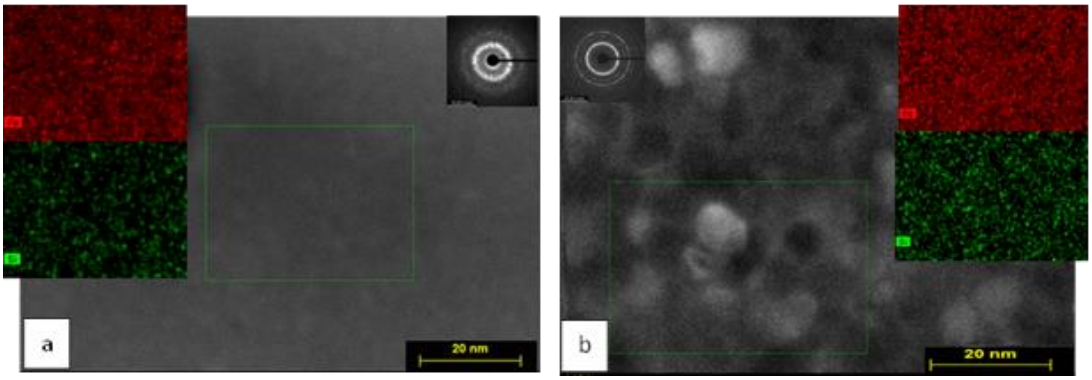

Figure 1. Microstructure of CDWs annealed at 375mA (a) and 750 mA (b) r.f. current.
Inset shows the EDX mapping of Fe (red) and Si (green) atoms in the CDWs microstructure.