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Magnetic Properties of Microwires and Filiform Nanostructures with Elongated Magnetic Inclusions[1]

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Abstract—We developed technological procedures for preparation of filiform nanostructures (FNSs) on the basis of stretching microwires with magnetic material cores. It is shown that disruptions of the microwire core occur for these materials during technological process of stretching due to relatively high melting temperature of magnetic alloys. As a result, FNSs with elongated magnetic inclusions are produced. An installation for the production of FNSs as well as an experimental complex for measuring magnetic properties of the produced magnetic FNSs is described in this paper. The morphology of the produced FNSs from microwires with magnetic bistability is investigated by means of scanning electron microscopy, while magnetic properties, such as magnetic response with remagnetizing pulses, hysteresis loop, and coercive force, are investigated on the developed experimental complex. The magnetic interaction during remagnetizing processes of several microwires with different coercive forces assembled in a bunch, as well as the reaction of a bunch assembled from a big number of bistable mirowires of two types with different coercive forces (soft magnetic and hard magnetic cores) upon increasing external magnetic field are also investigated. Some potential applications of the produced magnetic structures are suggested.

Keywords: filiform nanostructures, microwires, magnetic alloys, magnetic hysteresis, coercive force, magnetic bistability, remagnetization

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INTRODUCTION

Filiform nanostructures (FNSs) including nanowires and nanotubes acquire increasing interest in various fields of applications in electronics, optics, sensors, and biomedicine to name but a few [1–6]. While semiconductor nanowires are well investigated, less attention has been paid to magnetic material filiform structures. Nanowires based on various materials have been successfully produced by different methods, among which templated nanofabrication techniques are usually used to fabricate large assemblies of nanowires with templates based on alumina or silica, ion tracked inorganic materials, and semiconductor nanosieves [7–9]. Nanowires have been also successfully produced by vapor–liquid–solid synthesis on seeded substrates [10, 11], thermal evaporation [12], electron beam evaporation [13], etc. However, nanowires with a maximum length of just a few hundreds of micrometers can be produced with these techniques. Moreover, though there are many methods to produce complex nanowire structures, their integration and interfacing to macro systems is far from maturity [14]. In this respect, an alternative method has been proposed for the production of long FNSs densely packed in arrays of isolated nanowires in glass envelopes [15–18]. This method is based on heating and stretching a preform consisting of stacked microwires in a glass envelope so as to reduce the diameter of microwires to nanometer dimensions.

In this paper we report the application of this method for the preparation of FNSs from magnetic materials.

TECHNOLOGICAL DETAILS

The applied technology comprises the following steps [18]: (i) the formation of a magnetic alloyed microwire in glass insulation by capillary drawing from

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