Study on coercivity angle changes of aligned Cobalt nanowires in magnetic field

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ABSTRACT

Magnetic nanowires have many usages in magnetic hard disks for information storage, permanent magnets and in everyday products, including motors, generators, etc., which have been considered in recent years. There are different methods to fabricate nanowires, among which the electrochemical deposition is the most common one. Recently, liquid phase synthesis has been suggested due to its ease and high rate of crystallization. Here, cobalt magnetic nanowires are synthesized in different forms and dimensions during cobalt carboxylate salt recovery Co(II) in 1,2-Butanediol process by using a solvothermal method. Based on the (TEM) analysis, the length of the synthesized nanowires ranges from 200 to 300 nm, Also, in accordance with X-ray diffraction analysis, by aligning of cobalt nanowires under an applied magnetic field, the (002) peak only remains, and the rest of peaks are eliminated. By aligning of cobalt nanowires, the coercivity value increases almost two times. In other words, the coercivity of cobalt nanowires with random orientation is 4200 Oe, and that of nanowires aligned under the applied magnetic field is 7800 Oe. This is related to aligning of the magnetic moments in the same direction, leading to the coercivity enhancement. Based on the discrepancy between coercivity values of nanowires aligned in 0° and 90 °degree angles, the alignment degree could be realized as well. Angular measurement of hysteresis loop shows that in nanowires aligned under the magnetic fields, the coercivity decreases by increasing the angle from 0 to 90 degrees. According to the results, residual magnetism goes through a downward trend by increasing the angle as well.

MATERIAL AND METHOD

In a typical synthesis, cobalt (II) laurate (3.5 mmol), $RuCl_3$ (0.008 mmol), Hexadecylamine (3.4 mmol) and 40 mL of 1, 2 Butanediol were introduced inside a teflon enclosure (100 mL) with the Ru/Co molar ratio fixed at 0.5%. The contents within the enclosure were then mixed for 60 min using the ultrasonic function of the water bath. Next, the teflon enclosure was removed from the water bath and fitted within an autoclave reactor. The autoclave reactor was transferred to a furnace and heated from room temperature then maintained at 250°C for 75 min. After cooling to room temperature, the black powder consisting of cobalt nanowires was separated from reaction fluid by centrifugation at 4000 rpm for 15 min. The sample was centrifuged once again at 6000 rpm for 15 min and the toluene discarded. This purification step was repeated two more times. After the purification, cobalt nanowires were dried in a vacuum oven at 50C then stored within a glove box with Ar atmosphere.

RESULTS

Figure 1 shows the morphology of the Co nanowires synthesized via a solvothermal chemical process shows that the cobalt nanowires are cylindrical in shape and have an elliptical tip. In fact, with this structure, maximum cobalt-shaped anisotropy can be used. The length of the nanowires made is between 200 nm and 300 nm and its diameter is 20 nm.

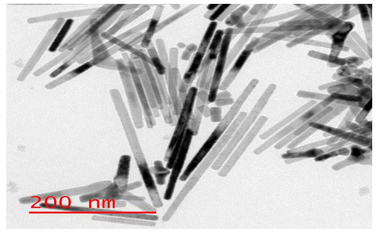

Figure 1: TEM image of cobalt nanowires

Figure 2 shows XRD patterns of the Co nanowires prepared using different HDA concentrations. XRD patterns of the randomly oriented Co nanowires are shown in Fig. 2a. The synthesized Co nanowires exhibit typical diffractions at 2θ values of 41.7, 44.5 and 47.5, corresponding to the (100), (002), and (101) planes with hcp structure, respectively. Figure 3 shows XRD patterns of the aligned wires along the magnetic field direction. All the wires are aligned with their c-axis (002) parallel to the magnetic field direction, while other diffraction peaks all disappear. For all the diffraction patterns, no cobalt oxide is detected.

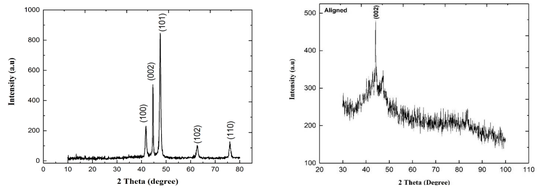

Figure2: XRD pattern of the Co nanowires in random orientation and aligned

Figure 4 shows the hysteresis loop randomly oriented nanowires of cobalt and the coercivity of 4200 Oe and the magnetization of the emu/g 59.32. By align the nanowires of cobalt in the magnetic field, the coercivity of 7800 Oe is reached. So the latest single crystal nanowires of cobalt makes large magnetocrystalline anisotropy of single axis formed resulting in high coercivity is achieved in such a way amounts to 86% increase in coercivity.

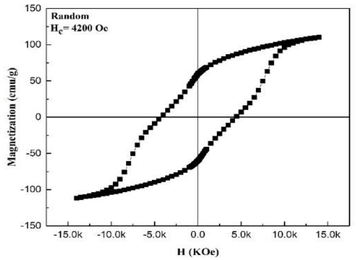

Figure 4: Hysteresis loops of a randomly oriented Co nanowires

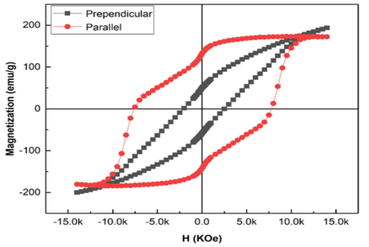

Figure 5: Magnetization loops of aligned Co nanowires along parallel and perpendicular direction

Figure 5 shows the hysteresis loop between cobalt nanowires aligned with the magnetic field angle of parallel and perpendicular. Coercivity of 1900 Oe equal to 90 degrees as seen in the coercivity significant difference that shows nanowires of cobalt in the epoxy are mostly aligned in one direction as well.

CONCLUSION

Cobalt nanowires according to the shape anisotropy and magnetocrystalline anisotropy top of the building for the expansion of the permanent magnets are ideal. In this study it is shown that the magnetic field to align the nanowires of cobalt in epoxy under X-ray diffraction pattern with respect to the plates (002) are located along the axis of the crystal easy. The high coercivity consequence of large magnetocrystalline anisotropy uniaxial created in the context of a cobalt nanowires.

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