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Unveiling the Magnetic and Structural Properties of (X_2YZ; X = Co & Ni, Y = Fe & Mn and Z = Si) Full Heusler Alloy Microwires with Fixed Aspect Ratio

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Abstract: We studied Ni_2FeSi, Co_2FeSi and Co_2MnSi -based full Heusler alloy glass-coated microwires with the same geometric aspect ratio $\rho \approx 0.50 \pm 0.01$ prepared using Taylor-Ulitovsky method. The fabrication of X_2YZ; (X = Co & Ni, Y = Fe & Mn and Z = Si) based glass coated microwires with fixed aspect ratio is a quite challenging due to the different samples preparation conditions. The XRD analysis shows nanocrystalline microstructure for all the samples. Space group $Fm\bar{3}m$ (FCC) with disordered B2 and A2-types for Ni_2FeSi and Co_2FeSi and ordered $L2_1$-type for Co_2MnSi are observed. The change in the positions of Ni, Co and Mn, Fe in X_2YSi resulted in a variation in the lattice cell parameters and the average grain size of the sample. Room temperature magnetic behavior shows a dramatic change depending on the chemical composition, where Ni_2FeSi-MWs shows the highest coercivity (H_c) compared to Co_2FeSi-MWS and Co_2MnSi-MWs. The H_c–value of Ni_2FeSi-MWs is 16 times higher than that of Co_2MnSi-MWs and 3 times higher than that of Co_2FeSi-MWS. Meanwhile, the highest reduced remanence is reported for Co_2FeSi-MWS (M_r =0.92), , being about 0.33 and 0.22 for Ni_2FeSi-MWs and Co_2MnSi-MWs, respectively. From the analysis of the temperature dependence of the magnetic properties (H_c and M_r) of X_2YZ-MWs we deduced that H_c shows a stable tendency for Co_2MnSi-MWs and Co_2FeSi-MWs, meanwhile two flipped points are observed for Ni_2FeSi-MWs where the behavior of H_c changes with temperature. For M_r monotonic increase by decreasing the temperature is observed for Co_2FeSi-MWs and Ni_2FeSi-MWs and roughly stable for Co_2MnSi-MWs. The thermomagnetic curves at low magnetic field show irreversible magnetic behavior for Co_2MnSi-MWs and Co_2FeSi-MWs and regular ferromagnetic behavior for Ni_2FeSi-MWs. The current result illustrates the ability to tailor the structure and magnetic behavior of X_2YZ-MWs at a fixed internal stresses, i.e., with fixed aspect ratio. Additionally, a different behavior was revealed in X_2YZ-MWs depending on the degree of ordering and elements distribution. The tunability of magnetic properties of X_2YZ-MWs makes them suitable for sensing applications.

Keywords: full-Heusler alloys; glass-coated microwires; magnetic behavior; sensing applications

1. Introduction

Heusler alloys, characterized by their typical X_2YZ (full-Heusler) or XYZ (half-Heusler) compositions, represent a category of multifunctional materials [1–5]. Extensive research has been

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devoted to investigating the properties of Heusler alloys due to their diverse range of properties, such as the shape memory effect, substantial magnetic field-induced strain (MFIS), half metallic behavior, giant magnetocaloric effect (MCE), and exchange bias [3–9]. Heusler alloys are suitable for a variety of applications owing to their characteristics, especially in the fields of magnetic cooling, actuators, and energy harvesting [10–12]. Numerous bulk Heusler alloys have been successfully synthesized over time, and extensive study has been done on their structural and physical characteristics.

Arc melting, followed by additional thermal treatment, is the main technique used for producing Heusler alloys [2,3,10]. This method makes it possible to produce Heusler alloys in bulk form. However, miniaturization has been investigated as an alternative approach to improve the aforementioned characteristics of Heusler alloys [10]. The performance of Heusler alloys can be improved noticeably by minimizing the dimensions of the alloys. For instance, in the context of magnetic cooling applications, the surface-to-volume ratio can be enhanced to significantly improve the heat-exchange rate by using low-dimensional Heusler alloys.

In recent years, growing attention has been paid to the synthesis and investigation of different families of Heusler alloys with reduced dimensions, such as thin micro/nanowires, ribbons, nanoparticles and thin films [13–15]. However, the inherent brittleness of Heusler compounds, including Co, Fe and Ni-based full-Heusler alloys, poses a challenge for their fabrication using conventional metallurgical techniques. Consequently, significant efforts have been directed towards the development of novel fabrication methods for producing Heusler alloys in different physical forms for a specified application. These endeavors aim to overcome the limitations imposed by brittleness and explore the potential of low-dimensional Heusler alloys. Additionally, the preparation of composites incorporating Heusler alloys has emerged as a promising approach to address the aforementioned brittleness issue, becoming a topic of considerable interest in the development of this family of functional materials [3,10].

Rapid melt quenching has been recognized by scientists since the 1960s as a commonly used method for producing innovative materials with a variety of morphological characteristics, including amorphous or crystalline (micro-/nanocrystalline) structures, as well as metastable phases with reduced dimensions [16,17]. Using this technology, it is possible to obtain alloys with specified chemical compositions using rapid solidification, obtaining materials with more effective mechanical, magnetic, and corrosion properties [18–20]. Rapid melt quenching techniques have been developed for producing ribbons, wires, flakes, microwires, composite microwires, and other materials. The chosen alloy's phase diagram, the quenching conditions, and the geometry of the prepared materials are only a few of the specific fabrication features that are critical in determining the final structure of the materials that are produced.

As previously mentioned, crystalline rapidly quenched materials generally exhibit inferior mechanical properties compared to their amorphous counterparts [20]. However, other properties relevant to various applications, such as enhanced corrosion resistance and biocompatibility, are desirable [21]. Furthermore, the miniaturization of rapidly quenched materials has emerged as a challenge for numerous applications. Consequently, the development of preparation methods capable of meeting these expectations has garnered significant attention in recent years.

One particularly promising technology aiming the miniaturization of rapidly quenched materials while simultaneously improving magnetic, corrosion, and mechanical properties is the Taylor-Ulitovsky technique [22]. This technique enables the fabrication of thin metallic microwires (typically ranging from 0.02 to 100 μm in diameter) coated with a layer of glass [23–30]. The resulting thin glass-coated microwires, with either amorphous or nanocrystalline structures, can exhibit excellent magnetic softness. Additionally, the thin glass coating imparts new functionalities, including enhanced mechanical and corrosion properties, favourable adhesion with polymeric matrices, and biocompatibility [31–33]. In this regard, a few successful endeavors have been made to fabricate wires using either the in-rotating water technique [30] or glass-coated microwires employing the Taylor-Ulitovsky technique from Heusler alloys [33–41]. These advances represent a significant progress in the preparation of Heusler alloys in low-dimensional forms and have opened up opportunities for further exploration.

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One of the peculiarities of the Taylor-Ulitovsky technique is that it allows preparation of metallic microwires coated with insulating glass by simultaneous rapid solidification from the melt. This manufacturing method is intrinsically linked with internal stresses arising from the difference in the thermal expansion coefficients of glass coating and metallic alloys, which is the main source of internal stresses [18,42–44]. Moreover, the internal stresses magnitude, σ_i, correlates with the aspect ratio, ρ, between the metallic nucleus diameter, d_{metal}, and total diameter, D_{total}. In this way, the σ_i can be modified by changing the ρ –ratio [42,44].

In this study, we present an endeavor to produce a set of glass-coated microwires based on the X_2ZY composition. These microwires were designed with a fixed aspect ratio and a high Curie temperature exceeding 900 K. The objective was to examine the impact of the uniform internal stress induced by the glass layer coating on the magnetic and structure behavior of the samples, utilizing the Taylor-Ulitovsky process. The selection of this fabrication method was driven by the intriguing magneto-structural characteristics exhibited by glass-coated microwires derived from Heusler alloys, along with the advantageous functional properties associated with such microwires. We chose a series of Heusler alloys, i.e., Ni_2FeSi, Co_2FeSi and Co_2MnSi, with high Curie temperature, which have a significant contribution in advanced spintronic applications due to their unique physical, electronic and magnetic properties [2,12,14,17]. Strong dependence of the magnetic and structure properties of X_2YZ-based glass-coated microwires with fixed geometrical aspect ratio is observed and reveals the sensitivity of the internal stress on the microstructure ordering and the chemical composition of the metallic nuclei of X_2YZ-based glass-coated microwires.

2. Materials and Methods

The experimental condition for preparation Ni_2FeSi, Co_2FeSi and Co_2MnSi in bulk and glass-coating microwires is described in detail in our previous works [12,14,17]. The key point and the objective of the current study is to dress the samples with fix aspect ratio, to investigate the effect of the stress of covering glass layer on different series of X_2YZ-full Heusler -based glass-coated microwires. The following procedures are used to prepare Ni_2FeSi, Co_2FeSi and Co_2MnSi alloys by arc melting. The precursor elements for the Ni_2FeSi, Co_2FeSi and Co_2MnSi alloys are weighed to fit with the nominal ratio (X)2:(Y)1:(Z)1) and deposited in a graphite crucible, containing Ni (99.99%), Co (99.99%), Fe (99.9%), Mn (99.99%), and Si (99.99%). The ingots of Ni_2FeSi, Co_2FeSi and Co_2MnSi alloys (ingot) were created by combining the ingredients. For all alloys the melting process was repeated five times to make the alloys homogenous. The chemical compositions and the nominal ratio of the X_2YZ alloys were tested before proceeding to the glass-covering process. By using the Taylor-Ulitovsky technique we can obtain a wide range of Heusler -based glass-coated microwires with proper dimensions and length depending on the application and the purpose of the investigations [37,41–48]. Controlling of the casting process rate of the melting ingot, i.e., Ni_2FeSi, Co_2FeSi and Co_2MnSi is able us to obtain glass-coating microwires with fixed nuclei diameter and well controlling the thickness of the covering glass layer. Thus, fixed aspect ratio is easily obtained in the current alloys. After preparation of the Ni_2FeSi-MWs, Co_2FeSi-MWs and Co_2MnSi-MWs we estimated the geometrical parameters d_{metal} (μm), D_{total} (μm) then the aspect ratio ($\rho = d_{metal}/ D_{total}$) by using the optical microscope and Scanning Electron Microscopy (SEM) and Energy Dispersive X-ray (EDX) (JEOL-6610LV, JEOL Ltd., Tokyo, Japan) to determine the aspect ϱ -ratio of Ni_2FeSi-MWs, Co_2FeSi-MWs and Co_2MnSi-MWs samples and its related nominal chemical composition (See Table 1). After confirming the nominal ratio and the chemical compositions of Ni_2FeSi-MWs, Co_2FeSi-MWs and Co_2MnSi-MWs the microstructure analysis was performed at room temperature by using X-ray diffraction (XRD) BRUKER (D8 Advance, Bruker AXS GmbH, Karlsruhe, Germany). The magnetic characterizations were performed as follow: first we have measured the hysteresis (M-H) loops at room temperature by applied magnetic field parallel and perpendicular to the metallic nuclei axis of Ni_2FeSi-MWs, Co_2FeSi-MWs and Co_2MnSi-MWs samples to checked the magnetic anisotropy and confirmation the easy axis of the magnetization. Then we checked the magnetic behavior of the samples in a wide range of temperature (5-400 K) by measuring the M-H-loops parallel to the wire's axis, i.e., easy magnetization axis. Finally, the thermal magnetization curves i.e., field cooling (FC)

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and field heating (FH) magnetizations curves at applied low external magnetic field to check the irreversibility behavior or magnetic phase transition in Ni_2FeSi-MWs, Co_2FeSi-MWs and Co_2MnSi-MWs. All magnetization curves were measured using a PPMS (Physical Property Magnetic System, Quantum Design Inc., San Diego, CA) vibrating-sample magnetometer.

Table 1. The geometrical parameters d_{metal} (μm), D_{total} (μm), aspect ratio, nominal ratio and average (Av.) of atomic percentage of Ni, Co, Fe, Mn and Si elemental composition in as prepared Ni_2FeSi, Co_2FeSi and Co_2MnSi glass-coated microwires.

Sample	d_{metal} (μm)	D_{total} (μm)	Aspect ratio ($\rho = d_{metal}/D_{total}$)	Chemical composition	Nominal ratio
Ni_2FeSi	9.79± 0.1	20.02± 0.1	0.49± 0.02	$Ni_{51}Fe_{23}Si_{26}$	2:1:1
Co_2FeSi	9.65± 0.1	19.88± 0.1	0.49± 0.01	$Co_{48}Fe_{25}Si_{31}$	2:1:1
Co_2MnSi	9.83± 0.1	19.94± 0.1	0.50± 0.01	$Co_{46}Mn_{24}Si_{30}$	2:1:1

3. Results

3.1. Chemical, nominal composition and microstructure analysis

As mentioned in previous section, the morphological and main geometrical parameters are evaluated using the optical microscope and SEM. Table 1 shows the estimation of the metallic nucleus, d_{metal}, and the total diameters, D_{total}, of Ni_2FeSi-MWs, Co_2FeSi-MWs and Co_2MnSi-MWs. By calculating d_{metal} (μm) and D_{total} (μm) we can easily obtain the aspect ratio. The differences of the aspect ratios of all samples is around (± 0.1). The EDX analysis was used to confirm the chemical compositions of the samples .we used As shown in Table 1, all the samples achieved the stoichiometry 2:1:1 with slightly higher amount of Si is observed in Co_2FeSi-MWs and Co_2MnSi-MWs due to the additional a signal of Si comes from the covering glass-layer.

Figure 1 illustrates the microstructure investigation of Ni_2FeSi-MWs, Co_2FeSi-MWs and Co_2MnSi-MWs measured by XRD at room temperature. The pattern starts from $2\Theta = 23.8°$ to exclude the amorphous halo which comes from the covering glass layers. As shown in Figure 1, all the samples show crystalline structure with main peaks at $2\Theta = 46.3°$ which distinctive for Heusler compounds. In spite that the samples have the same internal stress i.e., the same aspect ratio, change in the microstructure is observed. Ni_2FeSi-MWs and Co_2MnSi-MWs shared two peaks at $2\Theta = 68.6°$ and $2\Theta = 85.1°$ with (400) and (420) reflections, respectively. Due to the absence of (111) and (200) reflection the at Ni_2FeSi-MWs, thus the FCC single phase microstructure with B2-type, i.e., (disordered) is supposed. Meanwhile, well defined FCC single phase with $L2_1$ ordered -type is found for Co_2MnSi-MWs. However, the two super lattices diffraction (111) and (200) peaks are significantly weaker, compared to other elements belonging to the same period of the periodic table [49]. The intensities of these peaks may therefore be essentially undetectable, if the majority or all the elements in the presented alloys belong to the same period in elemental periodic table. For Co_2FeSi-MWs the existence of two peaks only at $2\Theta = 46.3°$ and $2\Theta = 85.1°$ which corresponding with (220) and (420) reflections fit very well with FCC single phase with A2-type, i.e., disordered.

From detailed analysis of the XRD pattern of Ni_2FeSi-MWs, Co_2FeSi-MWs and Co_2MnSi-MWs sample we find that the lowest lattice parameters is detected for Co_2FeSi-MWs, where a = 2.81Å. The cell parameters for Ni_2FeSi-MWs and Co_2MnSi-MWs are very near, where a = 5.78 Å and 5.71 Å, respectively. However, the samples have the same space group, i.e., $Fm\bar{3}m$ (FCC) type, the crystallite size is different as illustrated in Table 2. The Co_2FeSi and Co_2MnSi glass-coated microwires have roughly similar crystallite size (≈ 37 nm) and reduced to ≈ 21 nm for Ni_2FeSi-MWs. The values of crystallite size and the degree of microstructure ordered have a strong effect on the magnetic behavior of the samples.

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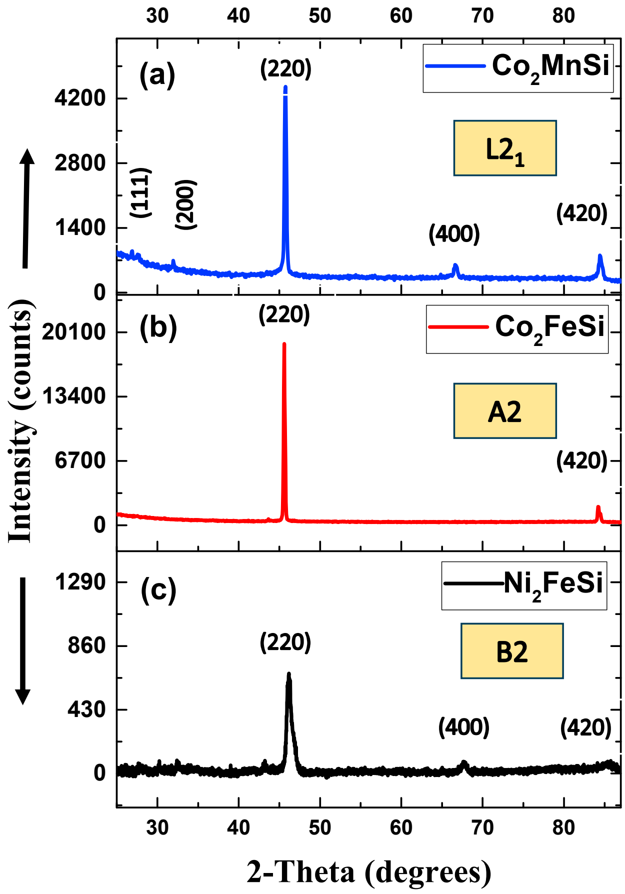

Figure 1. X-ray diffraction pattern of as prepared Ni_2FeSi, Co_2FeSi and Co_2MnSi glass-coated microwires at room temperature.

Table 2. Crystallographic information as prepared Ni2FeSi, Co2FeSi and Co2MnSi glass-coated microwires with fixed aspect ratio.

Sample	Crystallite size (nm)	Space group	Cell parameters (a (Å))	Strukturbericht Designation
Ni_2FeSi	21.3± 0.3	Fm3¯m (FCC)	5.78	B2 (disordered)
Co_2FeSi	37.3± 0.5	Fm3¯m (FCC)	2.81	A2 (disordered)
Co_2MnSi	36.92± 0.5	Fm3¯m (FCC)	5.71	$L2_1$ (ordered)

3.2. Magnetic characterization

3.2.1 Room temperature magnetic properties

To check the magnetic behavior of Ni_2FeSi-MWs, Co_2FeSi-MWs and Co_2MnSi-MWs at room temperature, we performed the magnetic measurements at two directions, axial, i.e., parallel to the metallic nuclei axis and out-of-plane, i.e., perpendicular to the wire axis by using PPMS magnetometer. The out-of-planes loops appeared linear with vanishing coercivity and reduced remanence, i.e., H_c and $M_r \approx$ zero (not shown). The vanishing H_c and M_r indicate that all the magnetization lies in the in-plane (axial) direction and the out-of-plane direction is the hard easy magnetization axis s for all MWs-samples.

Figure 2 shows M-H loops of Ni_2FeSi-MWs, Co_2FeSi-MWs and Co_2MnSi-MWs at room temperature with an applied magnetic field parallel to the microwire axis, i.e., axial direction. Ni_2FeSi-MWs and Co_2FeSi-MWs show a squared hysteresis loops shape, meanwhile the hysteresis loop of Co_2MnSi-MWs sample is not perfectly squared. For Co_2MnSi-MWs, it appears that the easy magnetization axis is not perfectly axial and is possibly tilted with an angle away from the wire axis.

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Unfortunately, we do not have the possibilities to measure the angular magnetic behavior to determine accurately the magnetic anisotropy of the sample.

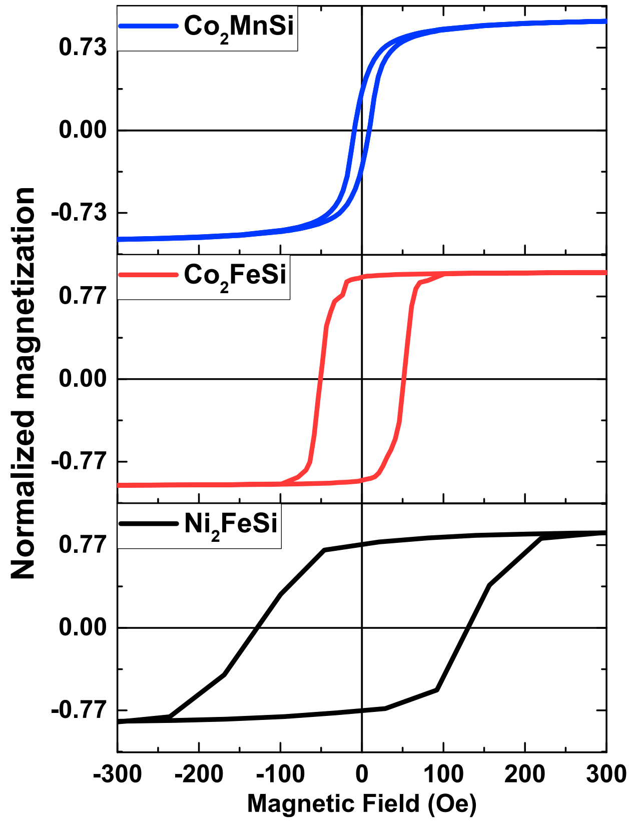

Figure 2. (a) Hysteresis loops at room temperature of as prepared Ni_2FeSi, Co_2FeSi and Co_2MnSi glass-coated microwires with fixed aspect ratio.

Ni_2FeSi-MWs show hard magnetic behavior with coercivity 138 Oe which 16 times higher than Co_2MnSi-MWs and 4 times higher than Co_2FeSi-MWs (see Table 1). The increase in the coercivity and the in-plane anisotropy field of Ni_2FeSi-MWs must be attributed to the different of microstructure. Surprisingly, the smallest value of crystallite size is observed in Ni_2FeSi sample. Therefore, high coercivity of Ni_2FeSi sample may be associated with the disordered microstructure of B2-type , which strongly affects the magnetization reversal process, domain structures and its movement.

In addition, the magnetocrystalline anisotropy play an important role for the overall magnetic behavior. Thus, the enhance coercivity detected inNi_2FeSi-MWs and the high reduced remanent magnetization of Co_2FeSi-MWs suggest the scenario, when the crystalline texture affects the magnetic anisotropy. In particular, easy magnetization axis can be aligned along the (220) and (420) reflections. However, the Co_2MnSi-MWs sample shows a well-defined ordered structure with $L2_1$-type The lowest reduced remanence and coercivity observed in Co_2MnSi-MWs sample can be due to the mismatching between the magnetocrystalline anisotropy and the crystalline structure. As demonstrated in our previous research, the magnetic anisotropy behavior of Heusler-based glass-coated microwires is primarily influenced by two main factors: uniaxial magnetic anisotropy and cubic magnetocrystalline anisotropy [14,17]. It has been reported elsewhere [18–21,30] that the ρ-ratio is directly related to the strength of internal stresses. Therefore, it is expected, that ρ-ratio affects the relative content of the crystalline phase and correlates with modifications in the magnetic properties. Specifically, cubic magnetocrystalline anisotropy emerges as the predominant factor governing magnetic anisotropy. Regrettably, at present, experimental measurement of this type of anisotropy remains unfeasible. However, the presence of a perfectly squared hysteresis loop strongly indicates its significant impact on the magnetic properties of the Ni_2FeSi-MWs and Co_2FeSi-MWs samples.

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Table 3. The coercivity (H_c), reduced remanence (M_r) and in-plane anisotropy field (H_k) as prepared Ni_2FeSi, Co_2FeSi and Co_2MnSi glass-coated microwires. glass-coated microwires with fixed aspect ratio measured at room temperature.

Sample	H_c (Oe)	M_r	H_k (Oe)
Ni_2FeSi	138 ± 0.5	0.33± 0.01	350 ± 0.5
Co_2FeSi	45 ± 0.5	0.92 ± 0.01	88 ± 0.5
Co_2MnSi	7 ± 0.5	0.22 ± 0.01	45 ± 2

3.2.2 Thermomagnetic properties

It is worth noting that the temperature stability of ferromagnetic materials is a crucial characteristic for their possible applications in spintronic and sensing devices. Hence, we investigated the magnetic behavior of Ni_2FeSi-MWs, Co_2FeSi-MWs and Co_2MnSi-MWs with fixed ρ- ratio for a wide range of measurement temperatures, 5-400 K. The shape of the loops follows the same trend, observed at room temperature: non-squared for the Co_2MnSi-MWs and quite squared for Ni_2FeSi-MWs and Co_2FeSi-MWs samples. In Figures 3 and 4, the M-H loops, and the evolution of H_c and M_r with the temperature is shown. This behavior can be explained considering that for Ni_2FeSi-MWs and Co_2FeSi-MWs samples, cubic magnetocrystalline anisotropy prevails up to 400 K.

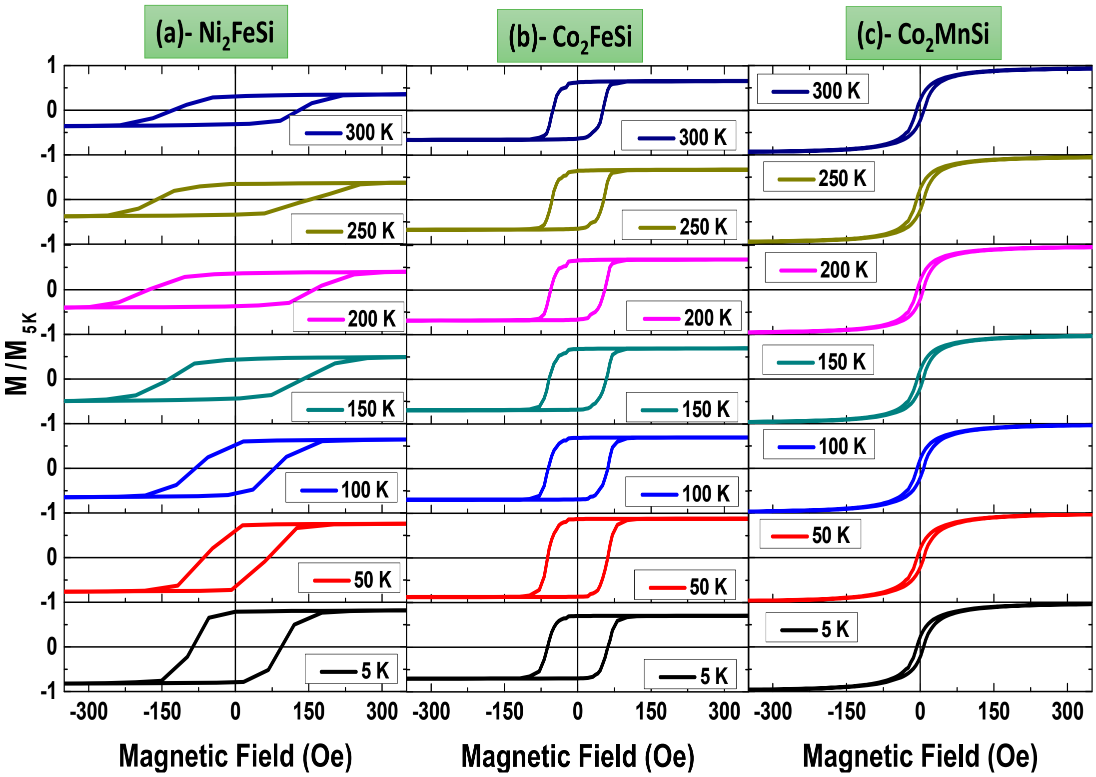

Figure 3. Hysteresis loops at different temperature of as prepared Ni_2FeSi, Co_2FeSi and Co_2MnSi glass-coated microwires with fixed aspect ratio. All loops have been measured at a temperature range from 300 K to 5 K.

By analyzing M-H loops measured at temperature range, 5–400 K of Ni_2FeSi-MWs, Co_2FeSi-MWs and Co_2MnSi-MWs with fixed ρ- ratio, an interesting magnetic behavior is found for the temperature dependence of H_c in Ni_2FeSi-MWs. First Ni_2FeSi-MWs show highest coercivity value at all temperature ranges compared to the Co_2-based glass-coated samples with same aspect ratio. In addition, H_c temperature dependence does not show uniform behavior, where two flipped points at T = 200 K and 50 K is observed. At these points the tendency of H_c dramatically change with temperature (see Figure 4a). Meanwhile the temperature dependence of H_c for Co_2FeSi-MWs and Co_2MnSi-MWs shows a quite stable tendency with temperature. The improved coercivity stability

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observed at Co_2MnSi-MWs is strongly related to the high ordered microstructure with $L2_1$-type (see Figure 1). However, both Ni_2FeSi-MWs and Co_2FeSi-MWs have disordered microstructure with B2-type and A2-type, respectively. The Co_2FeSi-MWs show higher coercivity thermal stability due to A2-type microstructure show higher energy stability compared to B2-type [50–52]. Thus, Co_2FeSi-MWs its Hc vs T appears more stable compared to Ni_2FeSi-MWs. Additionally, M_r vs T tendency has regular ferromagnetic behavior with temperature, where monotonic increasing of M_r by decreasing T is observed (see Figure 4b). Both Ni_2FeSi-MWs and Co_2FeSi-MWs have higher M_r values for the all range of measuring temperatures compared to Co_2MnSi-MWs. The higher values of M_r for Ni_2FeSi-MWs and Co_2FeSi-MWs suggested the dominant cubic magnetocrystalline anisotropy at a wide range of measuring temperatures.

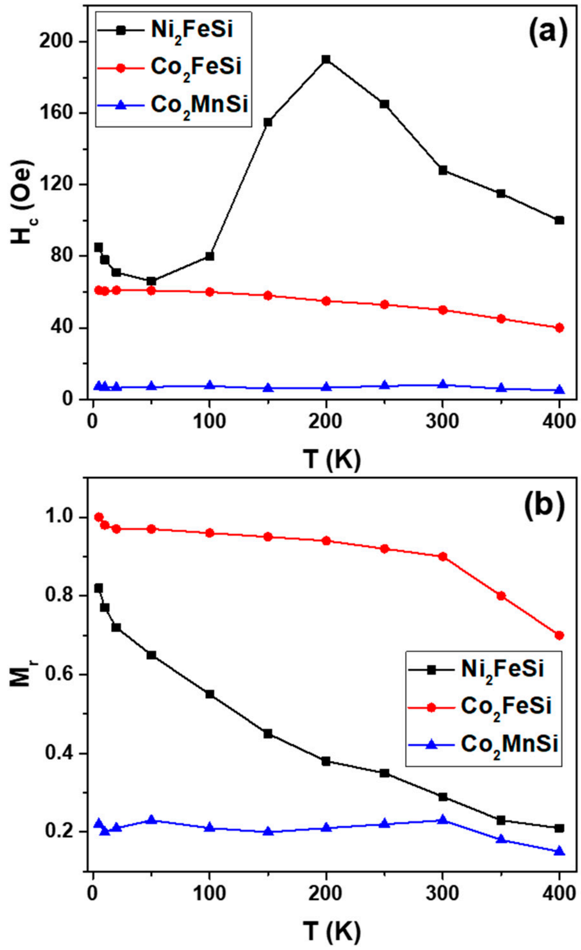

Figure 4. Temperature dependence of the coercivity (**a**) and normalized remanence (**b**) of as prepared Ni_2FeSi, Co_2FeSi and Co_2MnSi glass-coated microwires with fixed aspect ratio. (Lines for eye guide).

Figure 5 shows the complete thermomagnetic behavior of Ni_2FeSi-MWs, Co_2FeSi-MWs and Co_2MnSi-MWs with fixed ρ- ratio. We studied the FC and FH temperature dependence of magnetization to check any possible phase transition. Thus, the measurements were performed at low magnetic field 50 Oe. Ni_2FeSi-MWs shows regular ferromagnetic behavior where the FC and FH curves increase by decreasing the temperature from 400 to 5 K. For Co_2FeSi-MWs and Co_2MnSi-MWs FC and FH magnetizations curves show non-homogonous behavior, besides an irreversible magnetic behavior at T = 125 K takes place. Among the factor that affect irreversible behavior of magnetization versus temperature are the induced martensitic transition and the changing in the internal stresses associated with the glass-coating layer with temperature. As illustrated in Figure 5, the FC and FH magnetizations. curves have a perfect matching and monotonic increasing by decreasing the temperature from 400 to 5 K in Ni_2FeSi sample (see Figure 5a). Accordingly, we can assume that the internal stress induced by the covering glass-layer during the fabrications process have stable and

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uniformed effect on magnetic properties of Ni_2FeSi sample. Meanwhile, for Co_2FeSi-MWs and Co_2MnSi-MWs, the internal stress does not show a uniform effect at all temperature range, where from 400 to 300 K FC and FH have a good matching behavior, by decreasing the temperature below 300 K the mismatching start appears. Due to the disordered microstructure nature of Co_2FeSi-MWs FC and FH do not have a smoothing behavior with temperature compared to Co_2MnSi-MWs.

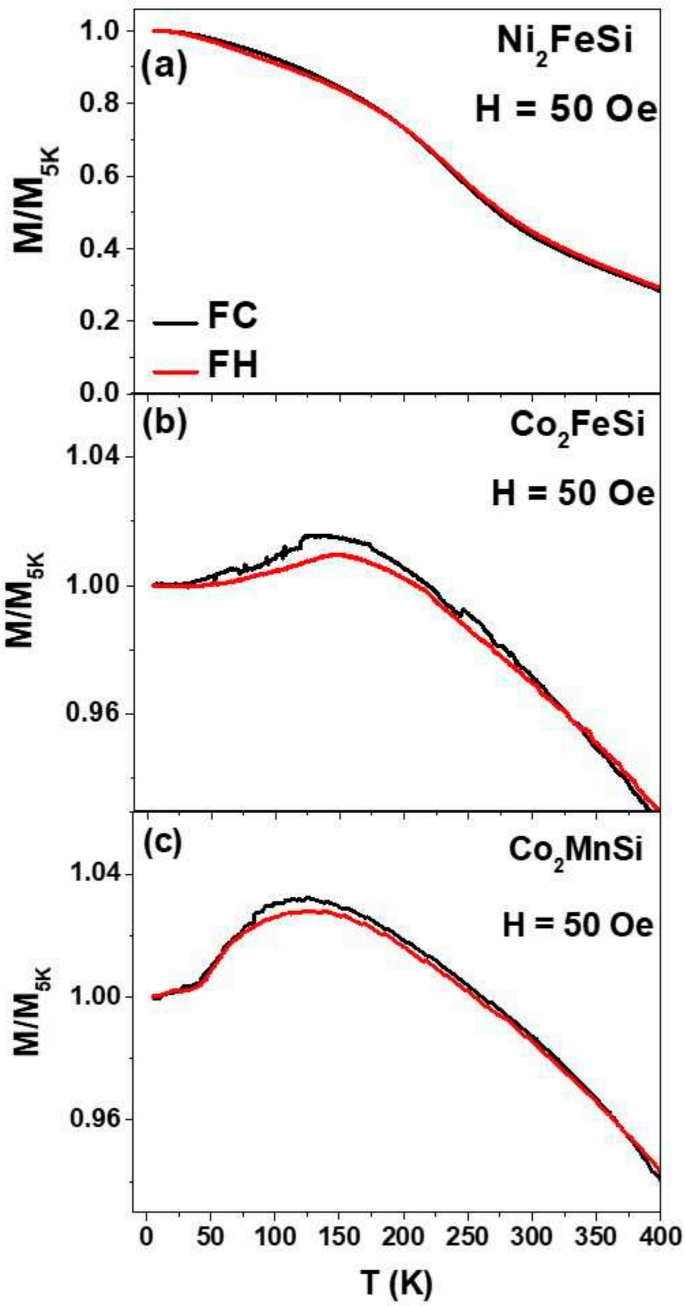

Figure 5. Temperature dependence of magnetization measured of as prepared (**a**) Ni_2FeSi, (**b**) Co_2FeSi and (**c**) Co_2MnSi glass-coated microwires with fixed aspect ratio with applied external magnetic field 50 Oe.

The current outcome result reveals the influence of the internal stress induced by the glass coating layer is very sensitive to the chemical compositions and the microstructure ordering of X_2YX-based glass-coated microwires. As a result, different magnetic and structure response is observed in glass-coated microwires with different metallic nucleus chemical compositions. In our previous work, we illustrated how the internal stress is strongly related to the geometric dimensions, and how important are the external applied field, annealing temperature/time condition and microstructure ordering of the host metallic alloys.

5. Conclusions

In summary, we succeeded in preparing of X_2YZ-based glass-coated microwires with same aspect ratio. In such X_2YZ-based glass-coated microwires we studied the effect of different chemical composition of magnetic materials, i.e., metallic nuclei, on the internal stress. Notable variation in magnetic and structured properties have been observed. For the microstructure investigation different microstructure features are detected varied between the disordered (A2-type and B2-Type) for Co_2FeSi-MWs and Ni_2FeSi-MWs, respectively. Meanwhile, well defined ordered $L2_1$-type is observed at Co_2MnSi-based glass-coated microwires. The variation in the microstructure has a strong effect on the magnetic behavior of the samples, where a notable change in H_c, H_k, M_r, FC and FH tendency with temperature and magnetic field. The high coercivity thermal stability observed in Co_2MnSi and Co_2FeSi-based glass-coated microwires make them promising candidates for different industrial applications.

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