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# Magnetisation process of $Fe_{61+x}Co_{10-x}Y_8W_1B_{20}$ bulk amorphous alloys


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## Abstract

Generally speaking, the structure of amorphous alloys can be difficult to describe accurately. The absence of repeating arrangements of atoms within the volume of the alloy generates unique material properties, but at the same time makes it difficult to describe systematically the structure. One of the exceptions to this rule is the class of amorphous alloys that exhibit ferromagnetic properties. The structure of these alloys can be assessed, in an indirect way, using the sensitivity of the magnetisation vector to any inhomogeneities in their volume. This paper presents the results of indirect structural research in accordance with the assumptions of H. Kronmüller's theory. $Fe_{61+x}Co_{10-x}Y_8W_1B_{20}$ alloys - with variable Co and Fe content-were investigated. The alloy samples were made using an injection-casting method. The structure of each of the produced materials was investigated using X-ray diffraction and by examining indirectly the course of the magnetisation process in the area known as the approach to ferromagnetic saturation. In the case of the tested alloys, it was found that the magnetisation process is related to the rotation of the magnetisation vector around linear defects.


## Introduction - essence

Amorphous ferromagnetic alloys that are based on the Fe matrix show so-called soft magnetic properties - i.e. a high value of saturation magnetisation and magnetic susceptibility as well as a low value of the coercive field. Soft magnetic properties are characteristic of classic amorphous alloys with a high content of Fe and Co [1-4]. In the case of bulk amorphous alloys, achieving soft magnetic properties is much more difficult due to the necessity to reduce the content of ferromagnetic elements, replacing them partially with other transition metals and glass-forming elements such as B, P or C [6,7]. Such soft-magnetic properties are demonstrated, inter alia, by alloys based on Fe-Me-B systems [8,9].

## Experimental procedure - highligts

X-ray diffraction (Bruker D8 Advance) was used to study the structure of each alloy. The diffractometer was equipped with a CuKα lamp. Measurements were carried out in the range of 2Θ angle from 30°-100°, with a measuring step of 0.02 ° and an exposure time of 5 seconds.

Primary magnetisation curves and static magnetic hysteresis loops were recorded using a LakeShore vibration magnetometer. This research was carried out in the range of external magnetic field of up to 2 T. The primary magnetisation curves were analysed according to the theory of H. Kronmüller.

## Results

| Fig. 1. X-ray diffraction patterns for the alloy samples: a) $Fe_{61}Co_{10}Y_8W_1B_{20}$, b) $Fe_{63}Co_8Y_8W_1B_{20}$ | Fig. 2. Static magnetic hysteresis loops for the alloys: a) $Fe_{61}Co_{10}Y_8W_1B_{20}$, b) $Fe_{63}Co_8Y_8W_1B_{20}$ |
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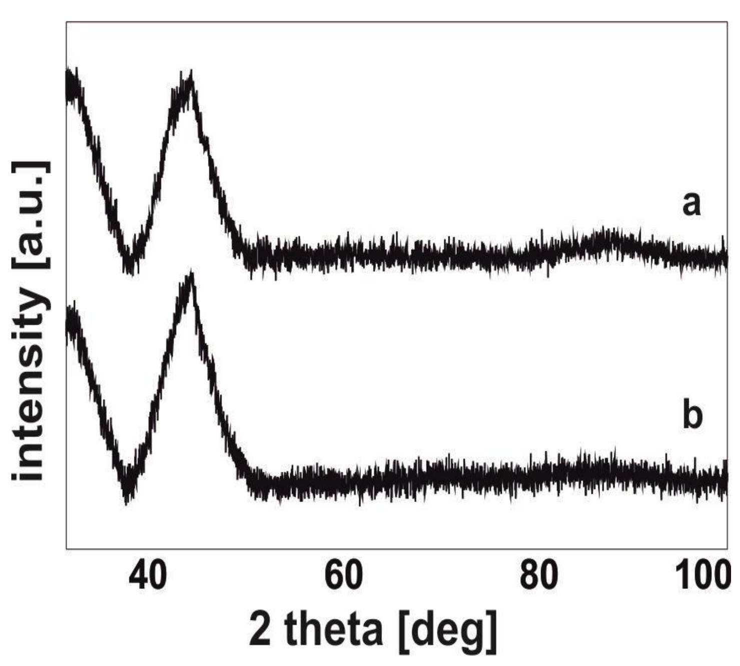


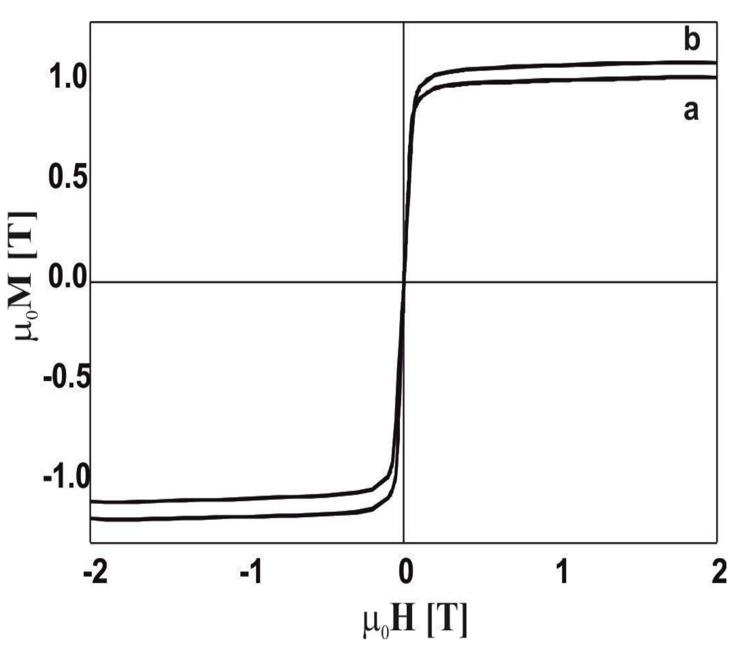


| Fig. 2. Magnetisation of the $Fe_{61}Co_{10}Y_8W_1B_{20}$ alloy, as a function of: a) $(m_0H)^{-2}$, b) $(m_0H)^{1/2}$ | Fig. 3. Magnetisation of the $Fe_{63}Co_8Y_8W_1B_{20}$ alloy, as a function of: a) $(m_0H)^{-2}$, b) $(m_0H)^{1/2}$ |
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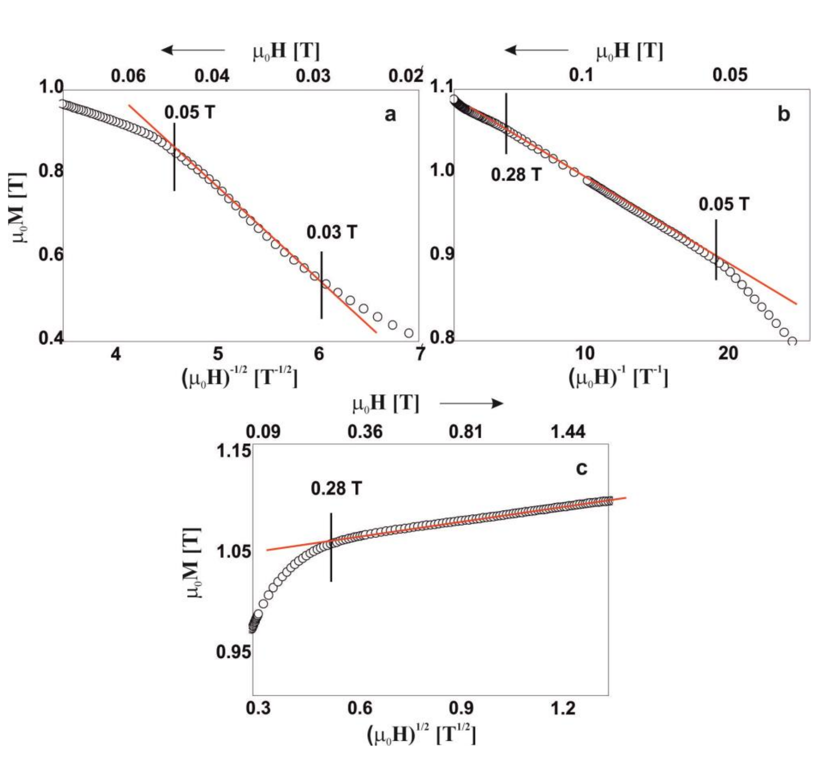

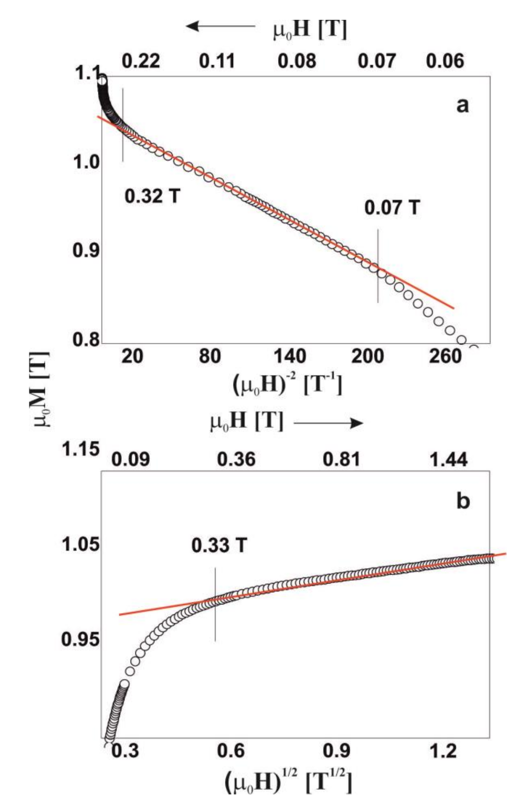

## Conclusions

This paper presents the results of research on the structural and magnetic properties of bulk amorphous alloys that are based on the Fe matrix. Indirect structural examination showed that, in the volume of the $Fe_{61}Co_{10}Y_8W_1B_{20}$ alloy, there are point defects and linear defects with dimensions not exceeding the exchange distance. The structure of the $Fe_{63}Co_8Y_8W_1B_{20}$ alloy is dominated by pseudodislocation dipoles with dimensions exceeding the exchange distance. Structural defects have a key impact on the creation of the soft magnetic properties of the tested alloys. The presence of defects with smaller dimensions results in a much lower value of coercive field than in the case of the alloy where the presence of defects meeting the relationship $D_{dip}$ <$1_H$ was identified. A smaller size of defects improves the exchange interactions, which facilitates the process of magnetisation. The higher magnetisation value of the $Fe_{63}Co_8Y_8W_1B_{20}$ alloy is related to the higher content of Fe atoms. The increase in the $D_{spf}$ parameter, with the increase in magnetisation, suggests a lack of antiferromagnetic order in the studied alloys.


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