Effect of Co Substitution on Structure and Magnetic Properties of High Induction $Fe_{85-(x+y)}Cu_xCo_yB_{15}$ Metallic Glasses

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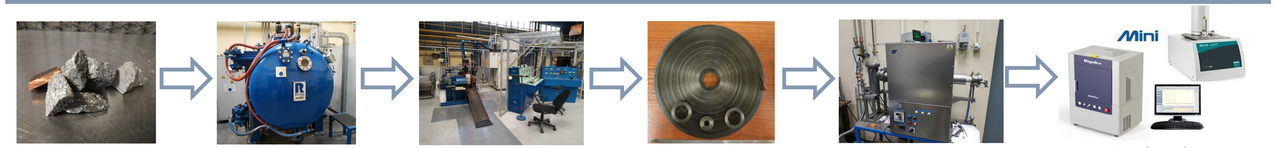
BACKGROUND AND IDEA

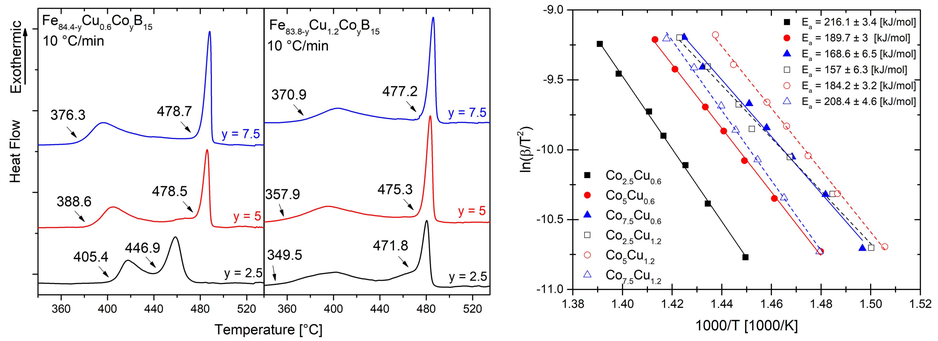
High-inductive amorphous and nanocrystalline Fe-based alloys are a new generation of materials that are increasingly used in power electronics, including industrial transformers, stator cores and induction devices. The saturation induction above 1.8 T and low core power losses are obtained through the appropriate chemical composition (mainly the presence of Fe and Co), as well as controlled annealing process. Due to the addition of Cu, it is possible to obtain a fine and homogeneous structure, which has a positive effect on the soft magnetic properties, and has a visible impact on the thermal stability of the material. The aim of the work is to investigate the effect of Co addition on thermal stability, structure and magnetic properties of Fe-Cu-B alloys. The copper content was determined on the basis of the minimum thermodynamic parameters Fe-Cu-B (Cu = 0.6%) and the maximum Cu content at which elastic ribbons could be obtained (Cu = 1.2%).

METHODOLOGY



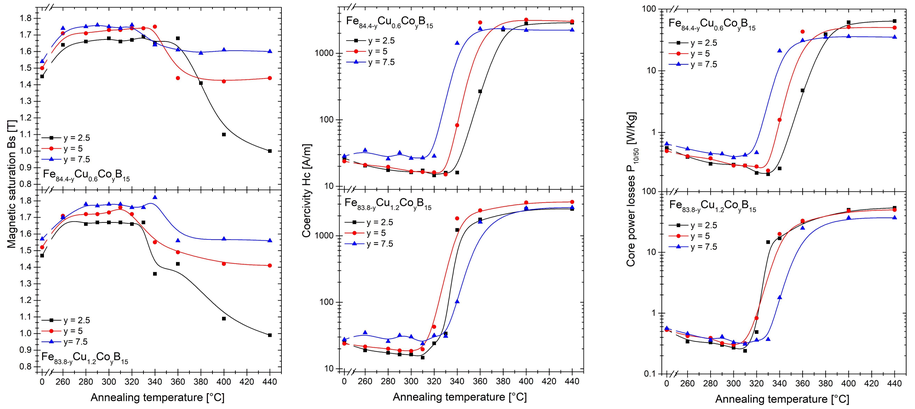
Initial materials | Preparing master-alloys | Melt spinning | Metallic ribbons | Annealing | Material studies

CRYSTALIZATION STUDIES

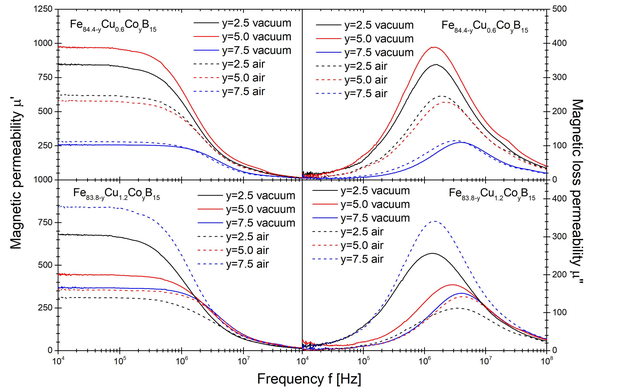


DSC signals and Kissinger plot for alfa- Fe crystallization of amorphous alloys

MAGNETIC PROPERTIES STUDIES

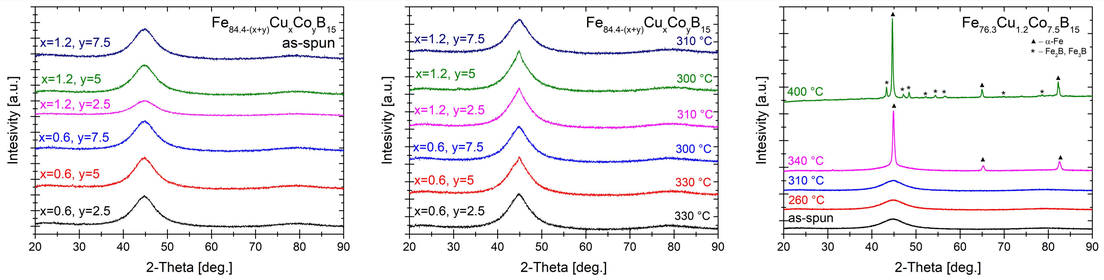


Magnetic properties: saturation induction Bs , coercivity Hc and core power losses Ps in a function of annealing temperature

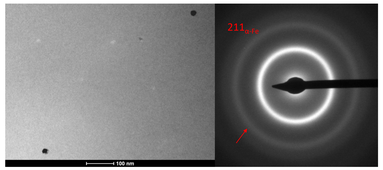


Magnetic permeability for samples annealed at the optimal annealing temperature in vaccum and air

STRUCTURE STUDIES



XRD patterns of as-spun, annealed at optimal temperatures and structure evolution depending on the annealing temperature



TEM images of $Fe_{76.3}Cu_{1.2}Co_{7.5}B_{15}$ annealed at 310 °C

CONCLUSION

- The addition of Co in the **$Fe_{84.4-y}Cu_{0.6}Co_yB_{15}$** alloys has a **positive effect** on the thermal stability and **decreases** the activation energy of the α-Fe crystallization. (**ΔT ↑, E_a ↓). However, the increase in Co content in the $Fe_{83.2-y}Cu_{1.2}Co_yB_{15}$** alloys has the opposite effect (**ΔT ↓, E_a ↑).**
- The addition of Co significantly **increases** the value of the saturation induction **(Bs ↑)** , but also **increases** the coercivity and core power losses **(Hc, $P_{10/50}$ ↑).**
- Composite nanomaterials of α-Fe nanocrystals in an amorphous matrix have optimal magnetic properties (**lowest $P_{10/50}$**); Optimal values were obtained after 20 minutes isothermal annealing proces at: 330 °C for Cu=0.6, Co= 2.5, 5; 300 °C for Cu=0.6, Co= 7.5 and Cu=1.2, Co=5; 310°C for Cu=1.2, Co= 2.5, 7.5.
- The material with the highest saturation induction Bs=1.84 T (**$Fe_{76.3}Cu_{1.2}Co_{7.5}B_{15}$ annealed at 340 °C**) has a fully α-Fe nanocrystalline structure.
- For the series with Cu = 0.6, the initial increase in the Co content cause an increase in the μ' value , then, at Co = 7.5, the μ' value significantly decrease. For the series with Cu = 1.2, the μ' value decrease and the cut-off frequency shifted to higher frequencies with the increase of Co content. Annealing in air causes a decrease in the value of μ' (exception is Fe76.3Cu1.2Co7.5B15 , where causes a significant increase in the μ' value).

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