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INFLUENCE OF TEMPERATURE ON STRUCTURE FORMATION OF Gd_2Fe_{17} AMORPHOUS FILMS

V. Prysyazhnyuk, O. Mykolaychuk

Ivan Franko National University of Lviv, Department for Metal Physics
e-mail: prysyazhnyuk@physics.wups.lviv.ua

INTRODUCTION

An interest to the investigations of structure of Gd_2Fe_{17} films is caused by their pecularity among other compounds of tne type of rare-earth metal – iron (R_2Fe_{17}). This pecularity consists in existence in equilibrium of two different by structure phases quite close by composition to Gd_2Fe_{17} [1]. Moreover one of these phases exists at the excess of Fe in equilibrium with *a-Fe*, and another – at deficiency of Fe in equilibrium with compound similar to $GdFe_5$. The posibility of the existence of many phases in equilibrium prompts for a variety of structure and substructure formation of processes of the films depending on technological conditions of their deposition.

EXPERIMENT

The Gd_2Fe_{17} films of thickness of 100-1000 A were obtained by method of a thermal vacuum evaporation of polycrystal fusion mixture of Gd_2Fe_{17} composition. The film of thickness about 100 A for studying density nucleating were formed. The films of 500-600 A thickness were prepared on the chops of NaCl and KCl monocrystals for structural investigations. The substrate temperature varied within 300-400 K range. Structural investigations of films were carried out on electron microscope UEMV-100K. Thermal resistance and a kinetics of crystallization of amorphous Gd_2Fe_{17} films were explored by their direct heating in a column of the electron microscope. The boundaries of thermal influence within of 300-800 K range, at heating rates of 5-30 K/minutes.

RESULTS AND DISCUSSION

The electron diffraction investigations of the films precipitated at T_s=300K prove, that these condensates are amorphous (fig.1).

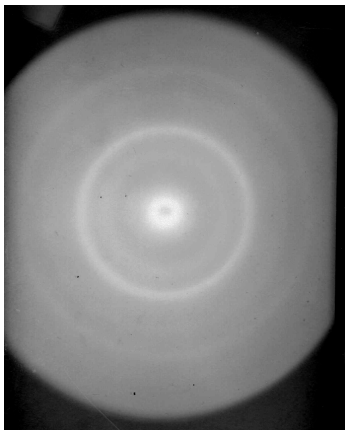
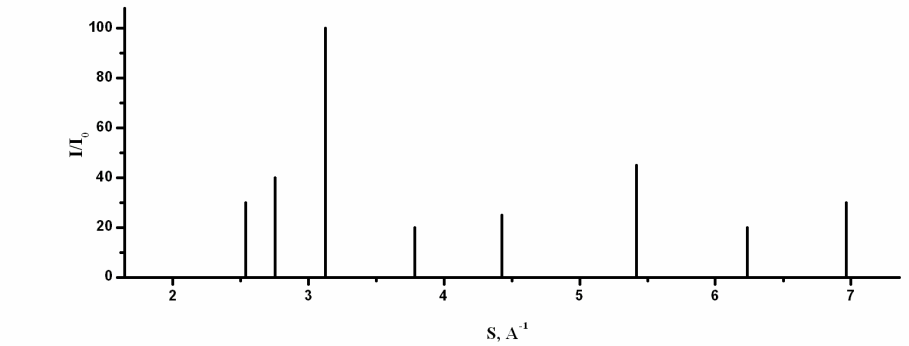


Figure 1. The electron diffraction of amorphous Gd_2Fe_{17} film (T_s=300K)

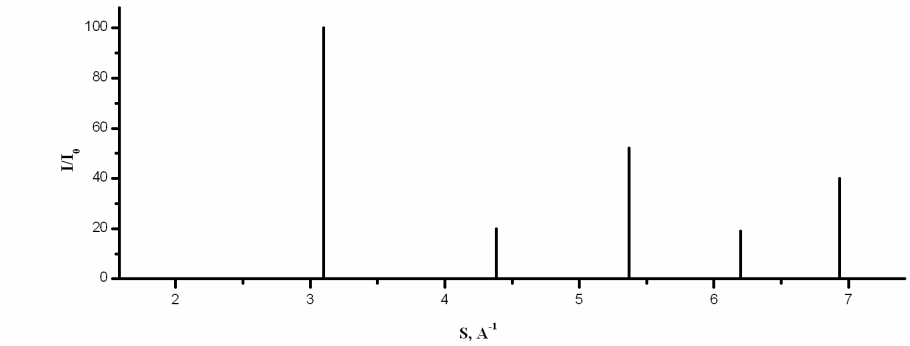
It is determined, that at heating of such films the initial phase of crystallization consist of *a-Fe* crystallites with sizes increasing with temperature. This is proved by reduction of a half-width of the diffraction peaks in electron diffraction patterns and as well indicated by estimations of the sizes of crystallites on the electron-microscopic images. At further increase of temperature (more 100K higher than temperature of an initial *a-Fe* crystallization) the crystallization of Gd enriched amorphous matrix starts and as result Gd_6Fe_{23} crystallites are formed (structural type Gd_6Fe_{23}, space group Fm-3m). Crystallization of amorphous Gd_2Fe_{17} films completed by forming of polycrystalline film *a-Fe* and Gd_6Fe_{23} (fig.2).

The appereance of Gd_6Fe_{23} phase is not strange, as far as this compounds is one of the most in Gd-Fe system. Furthermore even in a massive state in Gd-Fe system at the attempts to synthesize compounds with high abundance of Fe ($GdFe_5$, Gd_2Fe_{17}) without special technologies the phase of Gd_6Fe_{23} is always present [2,3].

The significantly different picture is observed in phase formation kinetics in mode of films of Gd_2Fe_{17} alloy, precipitations on heated substrate. In the range from room temperature to the T_s=400 K the amorphous films are observed. At T_s=500 K these films become amorphous-crystalline. At the further increase of the substrate temperature the fraction of a polycrystal phase increases. The interpretation of electron diffraction patterns has shown, that the polycrystalline films consists of three phases: Gd_2Fe_{17} (60 %) with Th_2Ni_{17} structural type (φ_1-phase), Gd_2Fe_{17} (30 %) of Th_2Zn_{17} structural type (φ_2-phase) and some (about. 10 %) $GdFe_5$ of $CaCu_5$ structural type (fig.3).



a)



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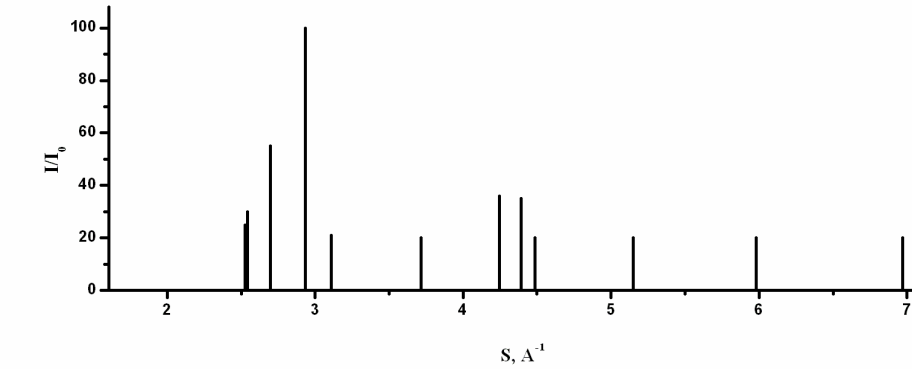
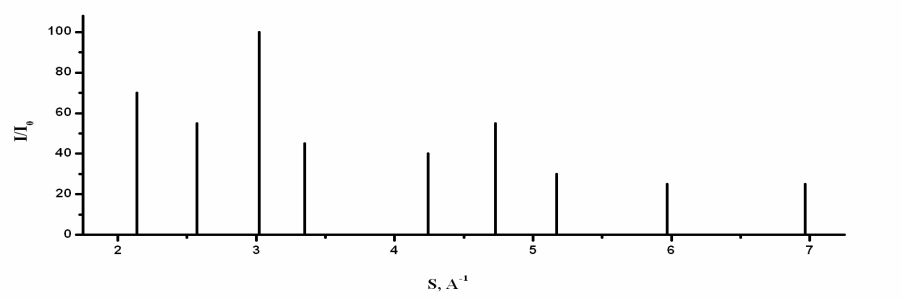
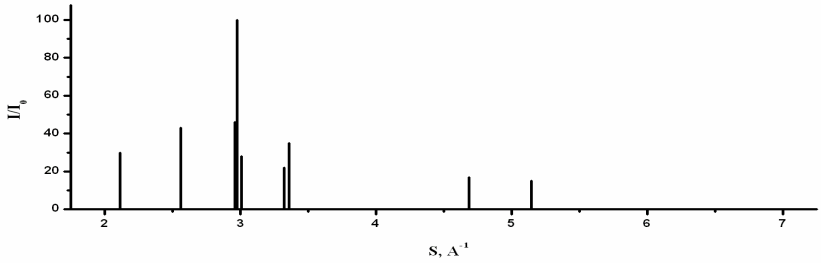


c)

Figure 2. X-ray Diagrams *a)* – amorphous Gd_2Fe_{17} films (T_s=300K); *b)* – *a*-Fe phase; *c)* – Gd_6Fe_{23} phase.



a)



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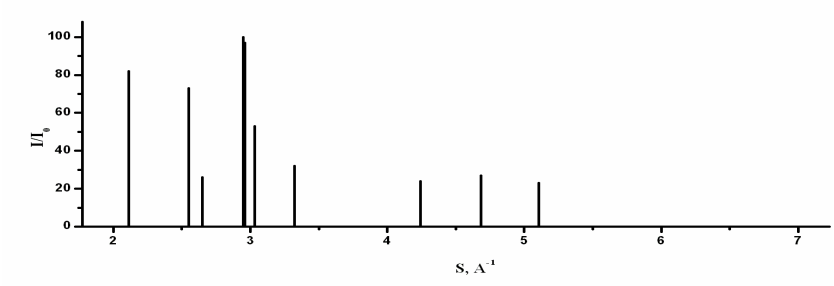

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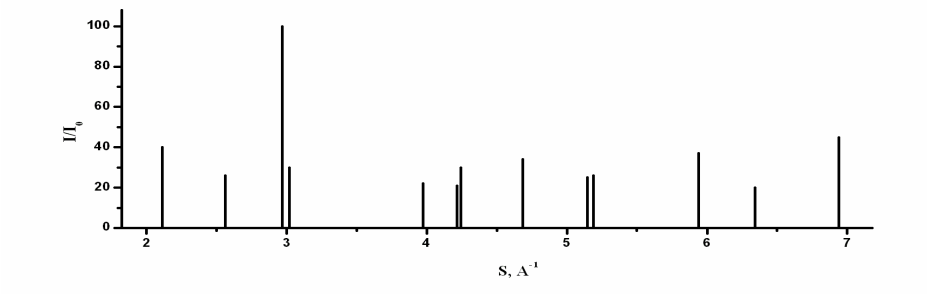

d)

Figure 3. X-ray Diagrams *a)* – amorphous Gd_2Fe_{17} films (T_s=400K); *b)* – φ_1 phase (Th_2Ni_{17}); *c)* – φ_2 phase (Th_2Zn_{17}); *a)* – $GdFe_5$ phase

The unit cell of hexagonal modification of Gd_2Fe_{17} compound is presented (fig.4) constructed on the basis of the diffraction data using of computer code PowderCell (a = 8.50 And, c =8.35 A).

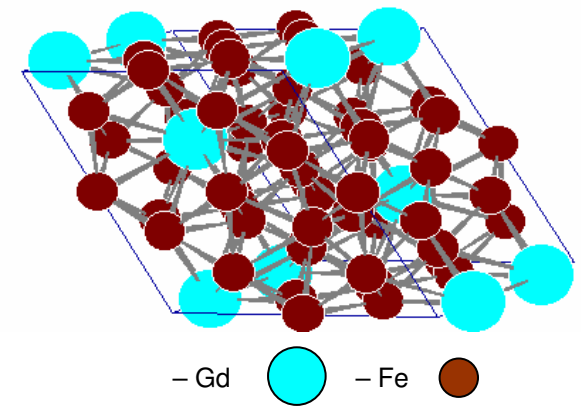

Figure 4. The unit cell of hexagonal modification of Gd_2Fe_{17}.

The apperance of these phases in Gd_2Fe_{17} films indicates on possibility of origination in a precipitation process of microareas enriched and depleted of iron. Such mechanism of formation of films leads to the mutual blocking of growing of crystallites of φ_1- and φ_2 phases. This predetermines a possibility amorphous state of the formation in intermetallic Gd_2Fe_{17} compound and predetermines high thermal resistance of amorphous state in films precipitated on substrates at ambient temperature. At the precipitation of films on heated substrates the diffusive length of adsorbed atoms increases and decreases the density of seeds in which formation of the long-range order, and crystalline structure of phases φ_1 and φ_2 is possible[4].

LITERATURE

1. П.І. Крип'якевич, Д.П. Франкевич, О.С. Заречнюк Багаті на Fe сполуки в системах рідкісноземельниї метал – залізо та їх кристалічні структури. // Вісник львіського ун-ту, сер.хім. Вип.8, С.61-74 (1965)
2. Е.И. Гладышевский, О.И. Бодак Кристаллохимия интерметаллических соединений редкоземельных металлов. // Львов: "Вища школа" 250с. (1982)
3. П.И. Крипякевич, Д.П. Франкевич, Ю.В. Ворошилов Соединения со структурами типа Th_6Mn_{23} в сплавах редкоземельных металлов с марганцем и железом. // Порошковая металургия. №11 (35), С55-61 (1965)
4. Шпак А.П., Куницкий Ю.А., Карбовский В.Л. Кластерные и наноструктурные материалы. К.:Академпериодика, 587с. (2001)