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NEUTRON DIFFRACTION STUDY OF THE HARD MAGNETIC MATERIALS $Nd_2Fe_{14}B$ DOPED BY Dy

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Paper deals with Nd-Fe-B magnets. Main task is to study the crystal structure and magnetic properties of Nd-Fe-B magnet system containing rare earth elements by neutron diffraction method.
***Keywords*:** magnet, diffraction, structure, properties, rare earth elements.

I. Introduction

The Nd-Fe-B system permanent magnet is the strongest magnet in the world There are many applications in the various field. The main purpose of our work is to study the crystal structure and magnetic properties of Nd-Fe-B magnet system containing rare earth elements by neutron diffraction method. In order to study microstructure of substance in solid state, it requires determination of the parts of the microstructures in the material. Especially, coercivityHc is an important magnetic property for operating at hugh temperature [1].

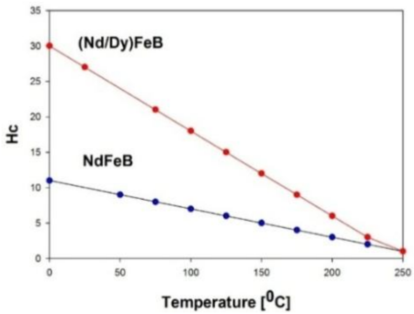

Fig. 1. Effect of temperature on Hc of Nd-Fe-B and (Nd,Dy)-Fe-B magnet

II. Experiment

This study were performed on the time-of-flight (TOF-method) measurement (Fig2) in Frank Laboratory of Neutron Physics, JINR, Dubna, Russia [2]. The bulk sample neither with or without Ni-plating is heated at 100, 150, 200 and 250 °C (with 25°C) under an atomospheric condition, because the neutron diffraction patterns will be used for investigating the effect of temperature.

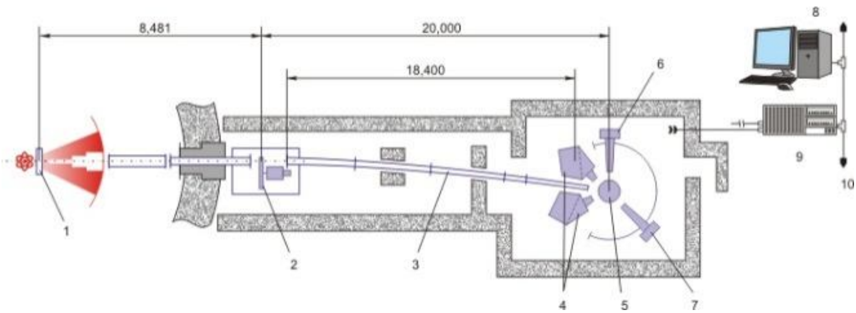

Fig. 2.Scheme of High Resolution Furrier Diffractometer (HRFD)

The space group is P42/mn, structure No. 136, and there are fourNd2Fe14B units 68 atoms per unit cell [3].

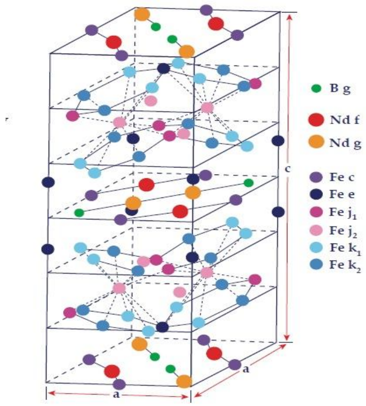

Fig. 3. Unit cell of Nd2Fe14B (P42/mnm space group)

III. Results

1. Figure 4 shows the Neutron diffraction pattern of the room temperature of sintered $Nd_2Fe_{14}B$magnet . Horizontal axis is a atomic d-spacing perpendicular axis shows intensity.
2. Figure 5 show the neutron diffraction pattern of the sintered $Nd_2Fe_{14}B$doped Dy.
3. Figure 6 shows the relationship of d-spacing and intensity at 1.39Å of the sintered $Nd_2Fe_{14}B$magnet. The trend of peaks of intensity decreases depending on heating temperature.
4. Figure 7 shows the relationship of d-spacing and intensity at 1.39Å of the sintered $(Dy/Nd)_2Fe_{14}B$magnet. The trend of peaks of intensity increases

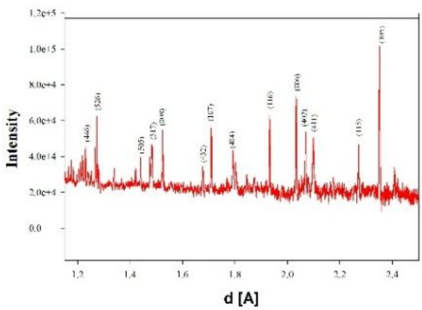

Fig. 4. Neutron diffraction pattern of the room temperature of sintered $Nd_2Fe_{14}B$ magnet

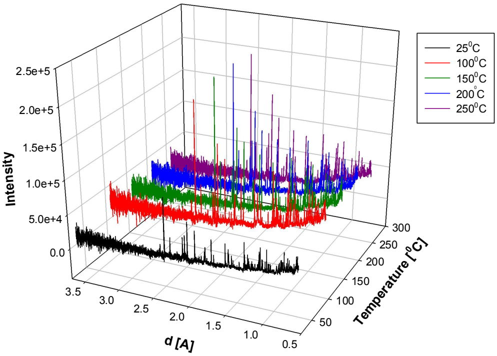

Fig. 5. Neutron diffraction pattern of the sintered $(Dy/Nd)_2Fe_{14}B$ magnet

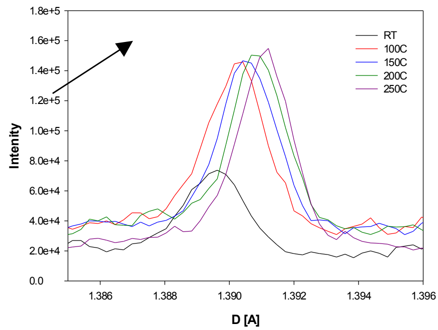

Fig. 6. Relationship of d-spacing and intensity at 1.39Å of the sintered $Nd_2Fe_{14}B$

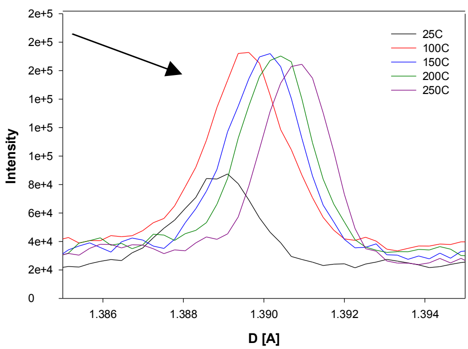

Fig. 7. Relationship of d-spacing and intensity at 1.39Å of the sintered $(Dy/Nd)_2Fe_{14}B$

IV. Discussion

Comparing of Figure 6 and Figure 7, the trend of peaks of intensity is that the former decreases and the latter increases and the values of peaks of d increase depending on heating temperature. It means that the neutron diffraction method is useful for analysis of magnet. Figure 8 shows the conceptual micro-structure of the sintered Nd-Fe-B system magnet. The micro-structure consisits of $Nd_2Fe_{14}B$ as a main phase, grain boundary and triple point. Grain boundary consists of Nd-rich-pahse and B-rich phase. And the grain boundary contains some Nd oxides as Nd_2O_3 or NdO and B oxide as B_2O_3[4].

If behavior of oxygen and boron could be clarified with neutron diffraction, we might understand the mechanism of coercivity of Nd-Fe-B magnets.

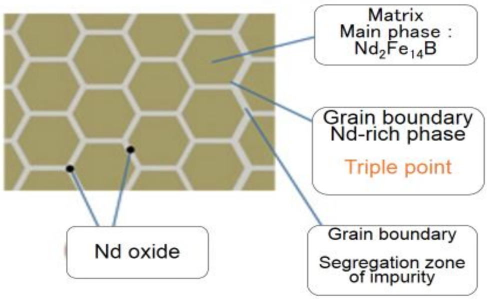

Fig. 8. Conceptual micro-structure
of the sintered Nd-Fe-B system magnet

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ИССЛЕДОВАНИЕ МАГНИТНЫХ МАТЕРИАЛОВ $Nd_2Fe_{14}B$ С ПОМОЩЬЮ НЕЙТРОННОЙ ДИФРАКЦИИ

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Статья посвящена магнитам Nd-Fe-B. Главная задача состоит в том, чтобы изучить кристаллическую структуру и магнитные свойства системы магнитов Nd-Fe-B, содержащих редкоземельные элементы, методом нейтронной дифракции.
Ключевые слова: элементы магнит, дифракция, структура, свойства, редкоземельных металлов.