Chemical method for obtaining nanostructured Nd-Fe-B alloy

Abdurakhmonov Odiljon Eshmukhammad ugli

Abstract

Relevance of the research topic

To date, Nd-Fe-B permanent magnets have become indispensable components in many high-tech products, including high-capacity hard drives, magnetic resonance imaging devices, wind generators and motors for electric and hybrid vehicles. The magnetic fields created by rare-earth magnets are comparable to the magnetic fields of electromagnets, while rare-earth magnets do not require energy costs and are compact.

The magnetic characteristics of a permanent magnet Nd-Fe-B depend on the methods of their production. Nanostructuring of the Nd-Fe-B alloy makes it possible to obtain magnetic materials based on them with high magnetic characteristics.

It should be noted that to obtain a nanostructured Nd-Fe-B alloy, the development of new production methods is required. It is known that the main methods of obtaining nanostructured Nd-Fe-B alloys are physical, such as: arc melting, spinning from the melt, mechanical milling. However, physical methods have several disadvantages, such as: high energy consumption, the duration of the production process, the complexity of controlling the granulometric composition. Unlike physical methods, chemical methods make it possible to obtain materials with a controlled granulometric composition.

Currently known chemical methods for obtaining nanostructured Nd-Fe-B alloy include three main stages: synthesis of intermediates, reduction of intermediates to Nd-Fe-B, and production of the finished product. It should be noted that the works presented in the literature on the production of intermediates require the use of organic compounds, which leads to the formation of ash residue during heat treatment.

Therefore, an urgent task is to develop a new approach to the synthesis of nanostructured Nd-Fe-B alloy without the use of organic compounds at the stage of obtaining intermediates.

Purpose and main objectives of the study

Development of a chemical method for obtaining a nanostructured Nd-Fe-B alloy.

The goal identified the need to solve the following tasks:

1. Obtaining Nd_2O_3, Fe_2O_3 and Fe_3BO_6 nanoparticles by controlled precipitation from solutions. Determination of the influence of the main parameters on the size and shape of the resulting nanoparticles;
2. Preparation of nanostructured Nd-Fe-B alloys from Nd_2O_3, Fe_2O_3 and Fe_3BO_6 nanoparticles using a reduction diffusion process;
3. Investigation of physicochemical characteristics of nanoparticle powders and nanostructured Nd-Fe-B alloys of various stoichiometric composition;
4. Preparation and study of nanocomposites based on nanostructured Nd-Fe-B alloy and unsaturated polyester resin.

Scientific novelty

For the first time, nanostructured Nd-Fe-B alloy powders of Nd_2O_3, Fe_2O_3 and Fe_3BO_6 nanoparticles obtained by precipitation without the use of organic compounds were used. The developed method makes it possible to obtain a nanostructured Nd-Fe-B alloy that does not contain carbon compounds.

A possible mechanism for the formation of the $Nd_2Fe_{14}B$ magnetohard phase from powders of Nd_2O_3, Fe_2O_3 and Fe_3BO_6 nanoparticles in a two-stage reduction-diffusion process is proposed. At the first stage, $NdFeO_3$, $NdBO_3$, α-Fe_2O_3 nanoparticles are formed, at the second stage, particles consisting of $Nd_2Fe_{14}B$, α-Fe and CaO phases are formed.

A nanocomposite based on a nanostructured Nd-Fe-B alloy has been obtained, which has high magnetic characteristics comparable to those of a nanostructured Nd-Fe-B alloy doped with Dy and Co.

Theoretical and practical significance

The developed chemical method for obtaining nanostructured Nd-Fe-B alloy has practical recommendations for creating highly efficient Nd-Fe-B permanent magnets.

The prospects of using a composition consisting of 98 wt. are shown.% nanostructured alloy $Nd_{16}Fe_{76}B_8$ and 2 wt.% unsaturated polyester resin. The resulting nanocomposite is characterized by magnetohardness properties at room temperatures (H_c=7.7 kOe and M_r = 70 $A \cdot m^2/kg$) and can be used in areas that place high demands on the magnetic characteristics of the material.

The results of testing of Nd-Fe-B nanocomposites with electroplated and polymer coatings in salt mist showed high corrosion resistance corresponding to the international standard ISO 9227:2017(E).

Provisions for Defense

1. Results of the study of the stages of synthesis of nanostructured Nd-Fe-B alloy.
2. The results of the study of the possible mechanism of the reduction-diffusion process of the formation of the magnetic phase $Nd_2Fe_{14}B$.
3. The results of the study of the magnetic properties of the alloy Nd-Fe-B depending on the stoichiometric composition of the starting materials.