INTERACTION OF EUROPIUM OXIDE WITH IRON OXIDE AT 1300°C

OLGA CHUDINOVYCH, DMYTRO VEDEL, SERHII KORICHEV, MARYNA ZAMULA

I. M. Frantsevich Institute for Problems in Materials Science of NAS of Ukraine

The phase relations in the Eu_2O_3–Fe_2O_3 system at 1300 °C were studied in the whole concentration range by X-ray diffraction (XRD) and scanning electron microscopy (SEM). The samples were prepared with a concentration step of 1–5 mol %. The isothermal cross-sections of the Eu_2O_3–Fe_2O_3 phase diagram at 1300 °C are characterized by the presence of four single-phase (B–Eu_2O_3, $EuFeO_3$(R), $Eu_3Fe_5O_{12}$, Fe_2O_3), three two-phase (B–Eu_2O_3+$EuFeO_3$, $EuFeO_3$+ $Eu_3Fe_5O_{12}$, $Eu_3Fe_5O_{12}$+Fe_2O_3) regions.

Keywords: phase equilibria, iron oxide, europium oxide, perovskite-type, solid solutions, lattice parameters

Introduction. Today it is important to create new materials with high magnetic properties. Chemical compounds of iron oxide Fe_2O_3 with rare earth oxides Ln_2O_3 have special magnetic (ferromagnetic) properties that combine high magnetisation with semiconducting or dielectric properties, thanks to which they have been widely used as magnetic materials in radio engineering, radio electronics, computer technology, catalysis, gas separation fuel cells, magneto-optical devices. In recent years, rare earth orthoferrites $RFeO_3$ have become the focus of research for the development of multiferroics [1–4].

In the Fe_2O_3–Eu_2O_3 oxide system, complex oxide phases such as $EuFeO_3$ and $Eu_3Fe_5O_{12}$ are formed. These compounds have significant potential for applications in spintronics, magneto-optics, and sensors.

The study of phase equilibria in systems based on REE oxides will provide an opportunity to form a theoretical basis for creating new materials, which allows for determining the optimal compositions of materials, technological parameters of their production, and conditions of operation.

Experimental methodology. Eu_2O_3 with a content of the main component of 99.99 %, $Fe(NO_3)_3 \cdot 9H_2O$ and nitric acid were used as starting materials. The specimens with different concentrations of Fe_2O_3 were prepared from Eu^{3+}/Fe^{3+} nitrate solutions with their subsequent evaporation and decomposition at 800 °C for 2 h. Solutions of Eu^{3+} nitrates were obtained by dissolving europium oxide in nitric acid. Powders were pressed at 10 MPa into pellets of 5 mm in diameter and 4 mm in height. To study phase relationships at 1300 °C thermal treatment of as-prepared samples was carried out in two stages: at 1100°C (for 100 h in air) and then at 1300 °C (for 300 h in air) in the furnaces with heating elements based on Fecral (H23U5T) and Superkanthal ($MoSi_2$), respectively. The heating rate was 3°C/min^{-1}.

The determination of the characteristics of the samples was carried out using physicochemical methods X-ray diffraction (XRD) and scanning electron microscopy (SEM).

For phase composition analysis, X-ray patterns were obtained on an X-ray diffractometer DRON-3M (CuKα-radiation with a nickel filter). The scan angle was 0.05–0.1° in the range 2θ = 15–80°. SEM was used to assess the homogeneity of the powders. Elemental analysis of the samples was performed by X-ray spectral microanalysis (XMR) using an energy dispersive spectrometer (EDS) INCA 450 (OXFORD Instruments).

Discussion of results. According to SEM and XRD analyses, there are Eu_2O_3, Fe_2O_3, $Eu_3Fe_5O_{12}$ and $EuFeO_3$ (R) phases in the Eu_2O_3–Fe_2O_3 system at 1300 °C. The boundaries of the homogeneity field of the ordered phase $EuFeO_3$ (R) at 1300 °C have an extension (49–52 mol% Eu_2O_3). The lattice parameters of the unit cell R phase varies from a = 0.536 nm, b = 0.561 nm, c = 0.768 nm in two-phase sample (B + R), containing 70 mol % Eu_2O_3-30 mol % Fe_2O_3 to a = 0.538 nm, b = 0.559 nm, c = 0.769 nm for the solid solution of boundary composition, containing 49 mol % Eu_2O_3-51 mol % Fe_2O_3. The boundaries of the homogeneity field of the ordered phase $Eu_3Fe_5O_{12}$ at 1300 ºC have an extension (61–63 mol% Fe_2O_3). Europium oxide forms solid solutions based on the monoclinic modification. Using the concentration dependences of the unit cell parameters, it was established that the range of homogeneity of solid solutions based on the B-phase extends from 99 to 100 mol% Eu_2O_3 at 1300 °C. The Fe_2O_3 does not form regions of homogeneity.

Conclusions. Phase equilibria have been studied in the Eu_2O_3–Fe_2O_3 system at 1300 °C. It has been established that solid state interactions between two oxides resulted in the formation of phases (B-Eu_2O_3, $EuFeO_3$, $Eu_3Fe_5O_{12}$, Fe_2O_3).

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