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Abstract

Full Text

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SOLID SOLUTIONS OF LANTHANUM AND YTTRIUM DIORTHOSILICATES

As a result of a series of studies ($^{1-7}$) carried out at the Institute of Silicate Chemistry, phase diagrams of systems containing rare-earth oxides were studied, a number of new silicates of rare-earth elements were obtained, and some of their physicochemical properties were investigated. The present work is devoted to the study of phase relations between the diorthosilicates of lanthanum and yttrium, which, according to spectroscopic investigations (^{8}), belong to different structural groups of compounds of this class. For preparing the alloys subsequently used for structural investigations, the starting materials employed were lanthanum oxide (La_2O_3—99.92%, total of other rare-earth-element oxides < 0.1) and yttrium oxide (total of other r.e.e. oxides $< 0.5\%$; Cu < 0.001, Fe—0.001%) and crystalline silica (99.90% SiO_2). The starting mixtures were prepared by prolonged mixing in an agate mortar of accurately weighed oxides. From the mixtures, small cylinders were pressed and subjected to preliminary fusion in an electric arc.

Fig. 1. Phase diagram of the system lanthanum diorthosilicate—yttrium diorthosilicate

The compositions for investigation were taken at every 10 wt.% of the diorthosilicates selected as components of the system. Subsequent heat treatments were carried out in a Galakhov-system electric microfurnace (^{9}). The furnace was calibrated by the melting temperatures of palladium, platinum, and corundum. The accuracy of temperature measurement was $±$20°.

In carrying out the experiments, after the samples had been loaded into the furnace, the temperature was gradually raised up to melting of the sample, which was placed in a loop of tungsten wire located at the center of the heating coil. After the sample had melted, the temperature was raised by another 150° and then lowered to the specified annealing temperature. Annealing was conducted

Fig. 2. Ionization X-ray diffraction patterns of alloys of the lanthanum diorthosilicate—yttrium diorthosilicate system. X-ray diffraction pattern of the solid solution: $Y_2O_3 \cdot 2SiO_2$ (a), $La_2O_3 \cdot 2SiO_2$ (b). 1—100 wt. % b, 2—10 a + 90 b, 3—20 a + 80 b, 4—30 a + 70 b, 5—40 a + 60 b, 6—50 a + 50 b, 7—60 a + 40 b, 8—70 a + 30 b, 9—80 a + 20 b, 10—90 a + 10 b, 11—100 a

Figure 2: Fig. 2. Ionization X-ray diffraction patterns of alloys of the lanthanum diorthosilicate—yttrium diorthosilicate system. X-ray diffraction pattern of the solid solution: $Y_2O_3 \cdot 2SiO_2$ (a), $La_2O_3 \cdot 2SiO_2$ (b). 1—100 wt. % b, 2—10 a + 90 b, 3—20 a + 80 b, 4—30 a + 70 b, 5—40 a + 60 b, 6—50 a + 50 b, 7—60 a + 40 b, 8—70 a + 30 b, 9—80 a + 20 b, 10—90 a + 10 b, 11—100 a

for short periods of time (1-10 min.), after which the sample was subjected to rapid cooling by being dropped, with the aid of an electromagnet, onto the water-cooled bottom of the furnace. Annealing at high temperature was carried out in an argon atmosphere in order to avoid oxidation and volatilization of tungsten, as well as volatilization of the components of the samples. In addition, in some cases the samples were annealed in a furnace with a Pt—Rh heater in an air atmosphere at 1400-1550° for a long time in order to study the kinetics of decomposition of solid solutions by means of X-ray and microscopic analysis. In those cases where it was not possible to obtain the initial samples in a glassy state by quenching, the solidus was determined by comparing the sizes and habit of the crystals present.

in samples quenched from different annealing temperatures. On the basis of the results obtained, a phase diagram of the system lanthanum diorthosilicate —yttrium diorthosilicate was constructed (Fig. 1). It belongs

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to a type characterized by the presence in the system of limited mutual solubility of the components in the solid phase. This circumstance is primarily due to the difference in the structures of the diorthosilicates studied. The region of coexistence of a mixture of two solid solutions of limited concentration occupies a significant part of the diagram.

To the article by N. A. Toropov, Gurudas Mandal, p. 1128

Fig. 3. *a* —Microstructure of an alloy with 45 wt.% $Y_2O_3 \cdot 2SiO_2$; *b* —microstructure of an alloy with 30 wt.% $La_2O_3 \cdot 2SiO_2$; *a*, *b* —decomposition of the solid solution. Reflected light, 240×

DAN, vol. 156, No. 5

Since both components of the system—diorthosilicates—melt congruently, regions for the orthosilicates stable here are correspondingly revealed on the liquidus and solidus curves. The phase fields in the diagram were constructed from the data of X-ray diffraction and crystal-optical investigation of samples of the system subjected to various heat treatments. The X-ray diffraction patterns are presented in Fig. 2. It should be noted that microscopic examination made it possible to determine the presence of a second phase when it was present in an amount not even exceeding 2-3%. Therefore, for example, sample 4 with 30% yttrium diorthosilicate, although it appeared single-phase by X-ray analysis, showed individual crystallites of the second phase under the microscope and was taken as close to the limiting composition for the region of homogeneous solid solution. Figure 3a shows the microstructure of a sample arising upon prolonged annealing of an alloy with 30 wt.% yttrium diorthosilicate in the two-phase region of coexistence of solid solutions; Fig. 3b shows a sample from the same region, but with a higher content of yttrium silicate.

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Note: Figure translations are in progress. See original paper for figures.