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Nano-reinforced Quartz Composites

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We have studied the process of interaction between the components in the system «β-SiO_2–Fe_3O_4–Na_2O» in the temperature range from 20 to 1100 °C. Nano-reinforced composite building materials were developed on the base of quartz raw material. Developed materials are produced by low-temperature calcining technology.

Keywords: Building quartz composites materials, Roentgen-phase analysis of the technological process from 20 to 1050 °C.

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1. INTRODUCTION

By high-temperature X-ray diffraction analysis of the kinetics of polymorphic transformations SiO_2 and installed R_2O impact on the effects of these transitions. Scientifically based and experimentally developed technological parameters for obtaining the roasting building materials based on quartz sand.

The **purpose** of this study is to establish the possibility of forecasting the main physical and mechanical properties of the quartz-bearing roasting building materials, using different combinations of the main component and industrial iron supplement.

2. EXPERIMENTAL

For research using X-ray diffractometer with a high-top temperature box, with a horizontal plane of the sample, which allows you directly during the temperature rise recorded phase formation [1].

Studies have been conducted to determine the phase and structure formation in samples consisting of quartz rocks in the form of quartz sand and waste crushing quartzitic sandstone (80 %) as an iron supplement used waste wet magnetic separation (WMS) and dust electric steel-smelting plants (ESSP) of Oskol electric steel plant (OESP) (20 %), as well as additional input sintered additive in aqueous solution NaOH (2 %).

Waste WMC and dust of ESSP OESP are finely dispersed technological educational content of about 13 and 70 % iron oxide, respectively [2, 3]. Based on the above, we consider the processes of phase formation in the system «β-SiO_2–Fe_3O_4–R_2O» in the temperature range from 20 to 1100 °C.

3. RESULTS AND DISCUSSION

Established the following phase transformations in the system "SiO_2–NaOH–Fe_3O_4" from the treatment received by the diffraction patterns:

– polymorphic transformations $\beta \leftrightarrow \alpha$-$SiO_2$ modifications occur at much lower temperatures. Beginning of a transition in the α-modification recorded at 300 °C, and the full completion of the formation of α-SiO_2 – at 450 °C.

– marked the start crystallization of semi-amorphous magnetite (Fe_3O_4) at 200 °C and near 500 °C process is almost over – the main reflection peaks of Fe_3O_4 "semi-diffuse" became clear peaked, although the background in the diffraction increased even up to 700 °C, which indirectly indicates the increasing the iron-phase mixture, the gas phase due to sublimation. In the temperature range 300 – 500 °C and recorded the presence of hematite phase (α-Fe_2O_3). At higher temperatures the intensity of diffraction Fe_3O_4 decreased – oxide began to interact with the components of the mixture;

– calcite, which is present in the iron-departure OESP completes dissociation to 600 °C, and the resulting calcium oxide reacts with the components of the mixture in the temperature range from 650 to 900 °C;

– andradite ($Ca_3Fe_2Si_3O_{12}$) starts to form at 750 °C; its quantity increases with increasing temperature;

– klinoferrosilit ($FeSiO_3$) during isothermal begins to form at 1000 °C;

– a significant X-ray amorphous formation of glass phase, which is clearly seen in the diffraction pattern and the cooled sample, there are only 950 °C.

Conducted studies to determine the influence of iron supplements dust ESSP OESP revealed the following sequence of phase formation, shown in Fig. 1.

The mineral composition of the synthesized products in the mix "SiO_2–NaOH–Fe_3O_4", in an open system includes:

β-quartz, Fe_3O_4, $FeSiO_3$, $Ca_3Fe_2Si_3O_{12}$ and glass phase.

Thus, the introduction of alkali- and iron-containing component can reduce the temperature of polymorphic

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transformations β ↔ α modifications SiO_2; beginning of a transition in α-modification recorded at 300 °C, and the full completion of the formation of α-SiO_2 – at 450 °C. In this system showed a 750 °C the formation of andradite ($Ca_3Fe_2Si_3O_{12}$), and from 1000 °C and $FeSiO_3$, very low temperature (300–450 °C) the completion of the polymorphic transition β ↔ α-SiO_2 and not fixed to a temperature of 1100 °C even started α-education cristobalite.

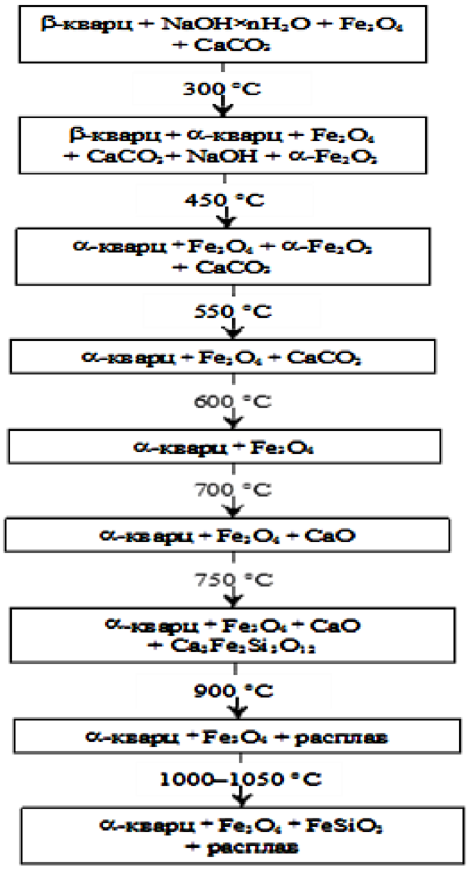

Fig. 1 – The sequence of phase formation in the system "SiO_2-NaOH-Fe_3O_4" in the temperature range 20 – 1200 °C

The results obtained allow a more targeted control of modification of silica transformations and reactions in the system "SiO_2–NaOH–Fe_3O_4" in obtaining roasting nano-reinforced silica composites based on natural and man-made silica-materials and additives, as well as effective use of iron-containing waste dumps OESP. Large specific surface iron supplements dust ESSP and a number of fine particles of quartz, which are inevitably present in natural quartz sand, at the temperature rise promote intensive education fusible silicates and iron $Sa_3Fe_2Si_3O_{12}$ $FeSiO_3$.

Glass phase, which envelops the pores and cracks and reinforcing at cooling nano-crystallites tumors (Fig. 2), is self-reinforced matrix in the resulting composite and creates a monolithic body with high consumer properties. The optimum sintering temperature of the components developed is in the temperature range 950 – 1000 °C. At these temperatures, to obtain the most robust products with the most dense structures.

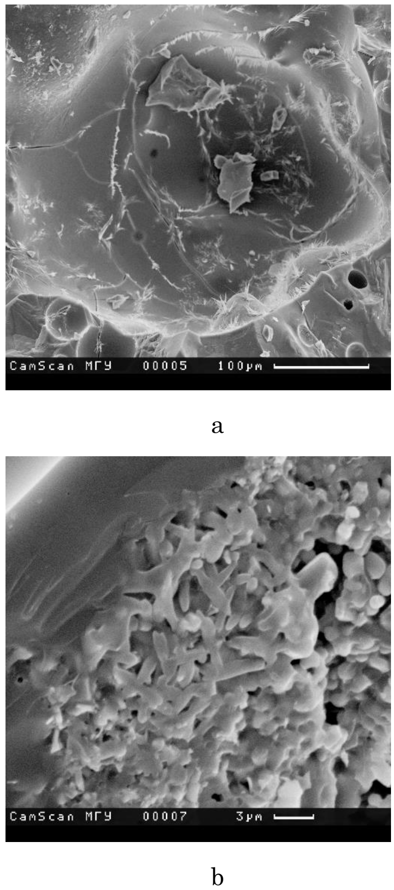

Fig. 2 – The microstructure of the samples: a) 950 °C, b) 1000 °C

4. CONCLUSIONS

The found of phase and structure formation during the heat treatment of multicomponent systems provide the ability to manage the process of obtaining nano-reinforced during firing quartz composites based on quartz-bearing rocks, and predict the fundamental physical and mechanical properties of these materials, using different combinations of the main component and industrial iron supplements, as waste MWC and dust ESSP OESP.

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