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Editorial Board Address:

Faculty of Material Science and Applied Chemistry
Riga Technical University
Azenes Str. 14/24
LV-1048, Riga, Latvia
Phone: +371 7089249
Fax: +371 7615756
E-mail: ilze@ktf.rtu.lv

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Contents

Porous Mullite Ceramics Doped with ZrO_2

Ludmila Mahnicka[1], Ruta Svinka[1], Visvaldis Svinka[1]
[1]*Riga Technical University*

Keywords **– mullite-corundum, zirconia, alumina, kaolin, porous refractory ceramics.**

INTRODUCTION

Mullite ($3Al_2O_3 \cdot 2SiO_2$) phase is an important stabile crystalline phase in the alumosilicate system. Mullite ceramics with high porosity serves as a heat insulator and filter, as well as it can be used in construction and thermal engineering [1]. Zirconia ceramics is also an excellent candidate for high temperature applications, because of high melting point (2715 °C), good corrosion resistance and high mechanical properties. The glass phase of Al_2O_3-SiO_2-ZrO_2 system begins to form only from 1750 to 1850 °C, which is higher than, for example, that of Li_2O, Na_2O and MgO [2]. Therefore, ZrO_2 is used as a modifying additive and influences the properties of mullite ceramics.

EXPERIMENTAL PROCEDURE

A. Raw Materials and Characterisation

As mullite stoichiometric composition is $3Al_2O_3 \cdot 2SiO_2$, the ratio of Al_2O_3 (*Nabalox, Germany*) and pure SiO_2 (d_{50}=6.94 μm) was 2.57:1. The α-Al_2O_3 (d_{50}=4 μm) and γ-Al_2O_3 (d_{50}=80 μm) were used in the ratio 1:3. The amount of kaolin was 30 wt%, (*MEKA, Germany* with SiO_2 – 56.2 wt%, Al_2O_3 – 31.0 wt %). The weight percentage of used ZrO_2 stabilized with MgO additive was 5% of dry raw material mass. Distilled water content in the suspensions was 38–40 wt%, aluminium paste (*Aquapor 9008*) was 0.18 wt% and it was used as the pore former.

B. Preparation of the Samples and Testing Method

The porous mullite ceramics was prepared by direct foaming, when the formation of pores occurred as a result of hydrogen formation in a chemical reaction between aluminium paste and suspension of raw materials with pH>7 [1]. The preparation of the samples included three main processes: 1) the preparation of suspension of raw materials with the addition of Al paste suspension; 2) slip casting of final suspension in the mould, pore formation and solidification of the suspension; 3) drying of the samples (for 24 h at 50 °C) and sintering at the necessary temperatures (1650 °C, 1700 °C and 1750 °C, holding time – 1 hour).

The phase compositions of samples and such parameters as shrinkage, bulk density, porosity, thermal and mechanical properties of ceramics were analysed in our research. To assess the above-mentioned parameters, we used the XRD analysis, differential thermal analysis, pore size distribution by Hg porosimetry, hydrostatic weighting and three-point bending test. The ten cycles of thermal shock test were implemented by rapidly changing temperatures (from 1000 °C to 20°C). The elastic modulus of the samples after each cycle of thermal shock was measured with the *Buzz-o-sonic* non-destructive acoustic method called the impulse excitation technique. Advantage of this method is that the same sample is measured after all cycles, which reduces the probability of occurrence of the error.

RESULTS AND DISCUSSION

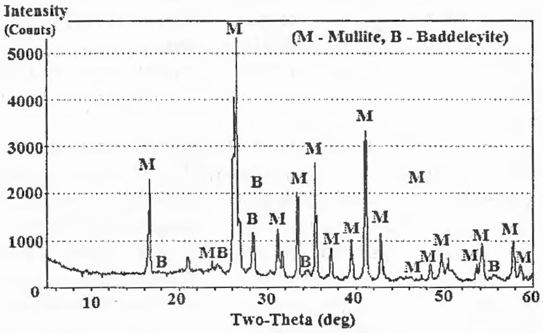

Figure 1. XRD patterns: phases of ZrO_2 (5 wt%) doped samples

Mullite is the dominant phase of samples with 5 wt% of ZrO_2 additive (Figure 1). The baddeleyite phase is from ZrO_2 and it is not so intensively expressed as mullite. The corundum phase is not observed. Phase of mullite is more intensive in the samples with ZrO_2 after sintering at 1650 °C than in the samples without ZrO_2 additive that were sintered at 1750 °C. The bulk density of doped samples is 1.68 g/cm^3. ZrO_2 additive decreases the porosity of samples.

CONCLUSIONS

ZrO_2 additive influences mullite formation and its intensity, as well as properties of samples, decreases the sintering temperature and increases the sintering ability of samples.

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