Effect of SiC on the Mullite-Cordierite Composite Properties

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Abstract

Experimental samples were produced with mullite and cordierite powders with SiC. Effects of temperature, atmosphere and additive on the composite properties were investigated by XRD, STA and PSA methods. Results show that samples containing calcinate cordierite and calcinate mullite with SiC baked in air atmosphere have not suitable properties at the temperature range of 1380-1450 ˚C due to SiC intensive oxidation, while argon atmosphere decrease SiC oxidation. Using Bi_2O_3 *as the additive, cordierite phase formation and prevention from SiC oxidation at low temperatures were achieved, leading to the improvement of physical and mechanical properties*

Keywords : SiC, mullite, cordierite

1. Introduction

Fabrication of composites has been considered for many years and the applications of these composites are used for many different fields as below:

Shear stress, strength, strain field, amount of strain for fracture, type of fracture and toughness, therefore fabrication of different types of ceramic's composites to improve properties, have a special significances. It should be considered that for using composites, choosing ceramic's structures and phases that consolidated from the basic materials have more significance.

To improve the high temperature mechanical properties, SiC and C whiskers and particles are used as side phases [1], but it should be mentioned that the basic problem for using these materials are the oxidation in high temperatures. For choosing an appropriate oxide ceramic as basic phase, these properties should be considered as Refractory properties and thermal expansion coefficient.

Therefore, mullite as a material that has a low thermal conductivity, shock ability resistance, good de electric properties, high temperature mechanical properties as instance creep resistance, is an appropriate chosen for composites with SiC side particles. It should be noted, entrance of SiC particles to Mullite bodies and cordierite parts have been caused to improve mechanical properties [2, 3, 4, 5], therefore investigating of SiC effect on Mullite-Cordierite composites seem essential, so in this article have been tried to investigate SiC effect on Mullite-Cordierite composites properties.

2. Experiments

Specimens with different ratios of mullite and cordierite with different amounts of SiC(10%wt, 20%wt and 30%wt) were prepared, then different temperatures, combinations and atmospheres effects were investigated on the nominated samples.

3. Preparation of Mullite and Cordierite

Primary materials were weighed with stoichiometric ratio with 0.01 precision.

Materials were mixed in the planet mill with alcohol medium for 15 min and then mixed together again with magnetic stirrer in 70ºc for 2 hours and simultaneously alcohol evaporation occurs.

Prepared mixture completely dried in100ºc for 2 hours.

For preparing mullite, mixture was put in the furnace at 1700ºc for 3 hours.

For preparing cordierite, mixture was heated at 1450ºc for 2 hours.

Synthesized powder milled in planet mill device for 20 min.

Milling the powder was done in water medium and aluminum balls were used for fining the powder particles.

Finally, mixture was dried at 120ºc in the drier.

4. Results

Bodies baked in the range between 1380°C to 1450°C with different amount of mullite-cordierite and Sic. Porosity variation via temperature with ratio 1:1 of mullite to cordierite and 10wt% and 30wt% of SiC is shown in figure 1.

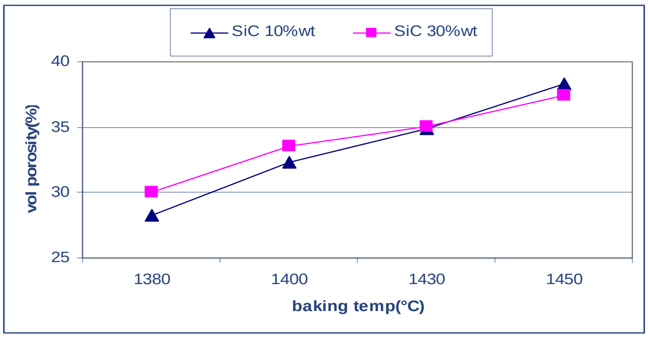

Fig. 1. Porosity variation via temperature with M/C=1:1 in argon atmosphere

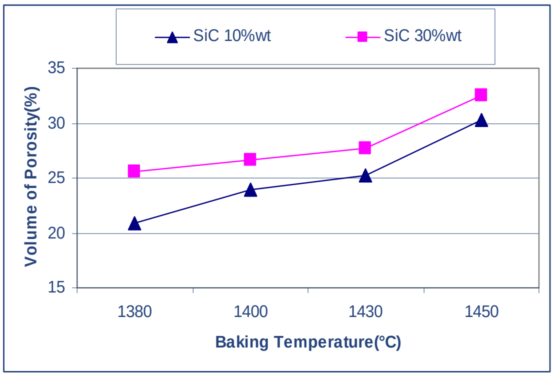

Fig. 2. Porosity variation via temperature with M/C=3:7 in argon atmosphere

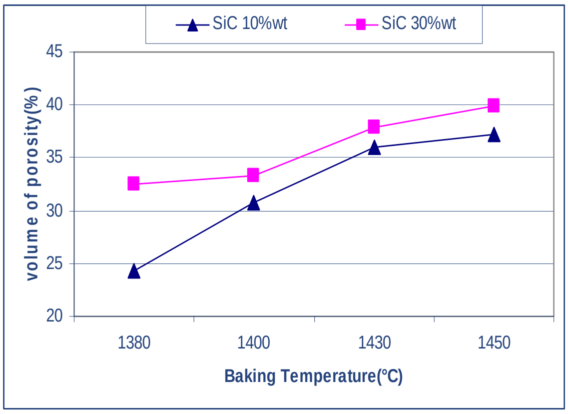

Fig. 3. Porosity variation via temperature with M/C=7:3 in argon atmosphere

Figure 2 and 3 shows the porosity variation with temperature in samples with ratio 7:3 and 3:7 of mullite to cordierite and with 10%wt and 30%wt of SiC. As it can be seen in Fig .2 and Fig. 3, by increasing the baking temperature, porosity increases. If these figures are compared with figure 1, it is clear that all the samples with different ratio of mullite to cordierite have the same treatment. It means that the oxidation of SiC is independent of ratio of mullite and cordierite and just depends on the amount of SiC which exist. Fig 4 shows the variation of strength in room temperature with increasing of baking temperature.

With increasing of baking temperature, strength improves, but in comparing with increasing of porosity, we expected the strength becomes worse. It can be explained when temperature rises, probably occurred a local sintering between mullite, cordierite and SiC and it cusses homogeneity gets better. Therefore it could recover not only the bad effects of increasing the porosity, but increased the whole strength.

Figures 5, 6 and 7 show the XRD pattern of body in temperatures in order 1380°C, 1430°C and 1450°C.

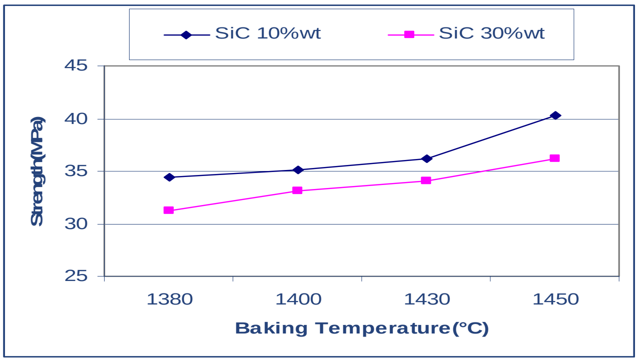

Fig. 4. Strength variation via temperature with M/C=1:1 in argon atmosphere

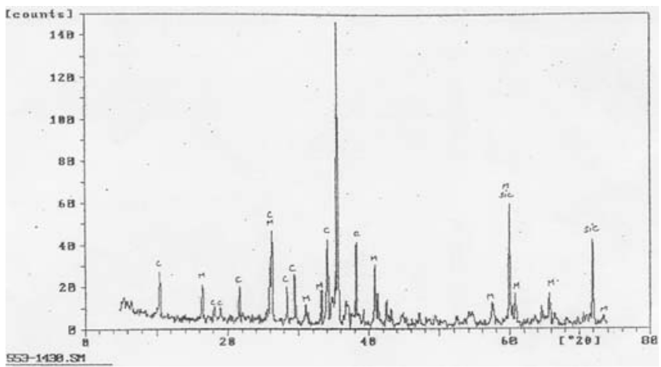

Fig. 5. XRD pattern, M/C=1:1, SiC=30%, Baking Temperature 1430°C

Figure 8 shows the effect of combination on strength. It can be seen when amount of SiC increases, the strength decreases. Because of more SiC, the porosity increases, so the probability of critical cracks to fracture becomes more and in fixed amount of SiC, it is observed that with increasing of cordierite phase, the strength increases and it's because of more sinter ability of body with cordierite.

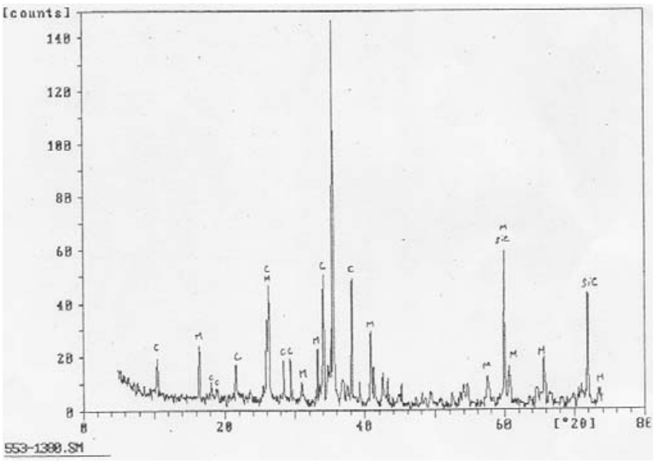

Fig. 6. XRD pattern, M/C=1:1, SiC=30%, Baking Temperature, 1380°C

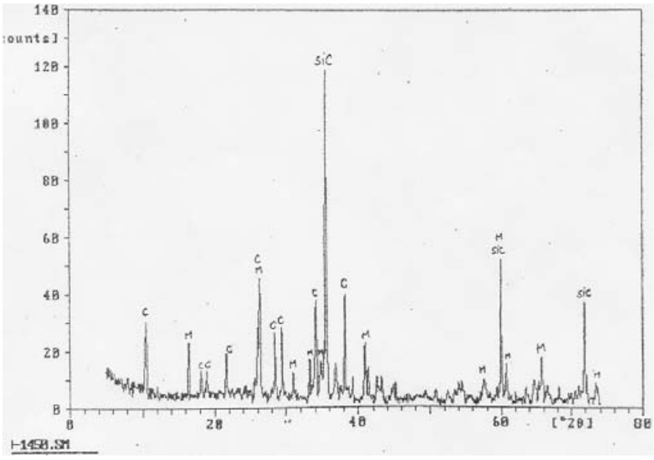

Fig. 7. XRD pattern, M/C=1:1, SiC=30%, Baking Temperature, 1450°C

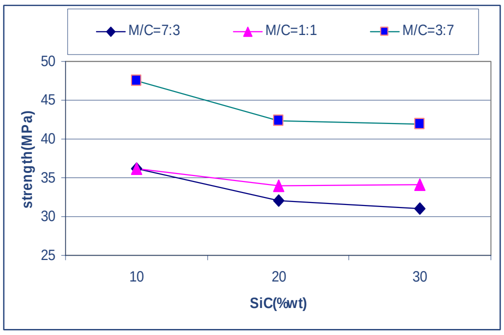

Fig. 8. Strength variation via combination (baking temp: 1430°C in argon atmosphere)

At first, the bodies were baked in air; but in high temperatures (T>1400°C), a lot of rashes were observed on samples' surfaces and they have been deformed. Its reason was oxidation of SiC and at last, amorphous SiO_2 was formed. For more inspection, bodies were baked in argon atmosphere with flow $2m^3$/min and after that, the visible state of samples were in good mood but with inspection of thermal analyze, it was observed that just the oxidation mechanism has been changed and last products were SiO and CO which had been left the samples. Therefore the surfaces looked perfect. Figures 9, 10 and 11 show the thermal treatment of different bodies in air.

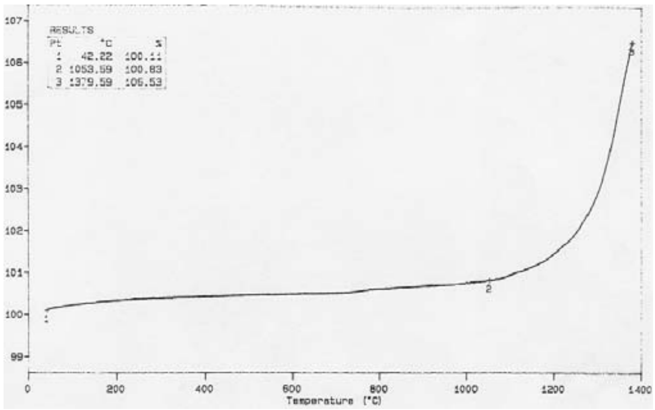

Fig. 9. Thermal treat of body, SiC=30%wt, M/C=1:1

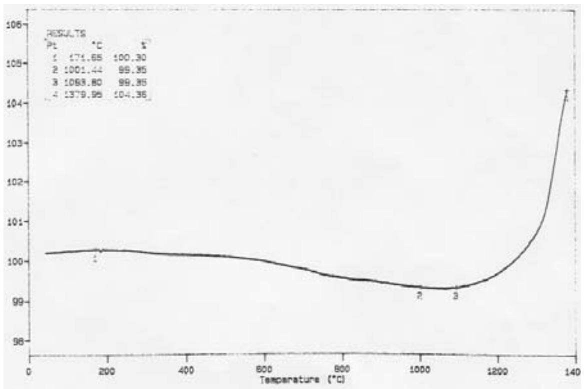

Fig. 10. Thermal treat of body, SiC=30%wt, M/C=7:3

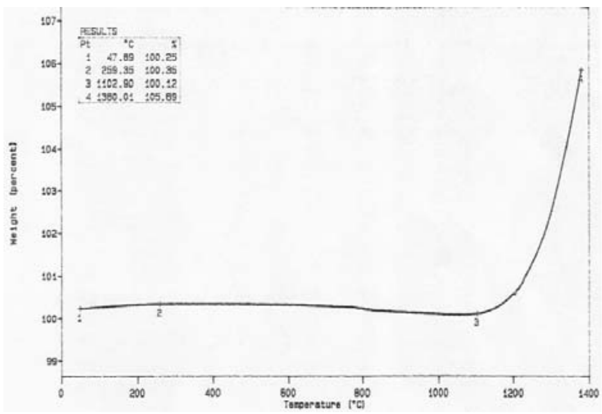

Fig. 11. Thermal treat of body, SiC=30%wt, M/C=3:7

Serious oxidation occurs in SiC at temperature above 1300ºc, therefore, baked specimens approximately dispersed in high temperature. Oxidation in SiC at atmospheric temperature is inactive.

Oxidation in SiC at argon environment is active. SiC gradually exits from specimens when oxidation occurs in high temperature (above 1300ºc). This phenomenon leads porosity to increase, thus strength decreases

5. Conclusion

1. Temperature effect: porosity increases with increasing bake temperature. This phenomenon is the result of reaching to cordierite catalysis temperature.
2. Composition effect: porosity increases with increasing in amount of SiC. Porosity of specimens decreases with increasing in amount of cordierite, that shows cordierite sintering ability is better than mullite and SiC in 1430ºc.
3. Atmospheric Effect: Deformation and Breaking Out of Specimens Occurs in Temperature above the 1400ºc. After Baking Specimens in Argon environment, Specimens Have Good Properties in Visual Check, But with Further Inspection by Thermal Analysis, it is understood that in practical field just Oxidation Method changes with changing Bake Atmosphere and This Is a Result of Exiting SiC and CO gases From the Specimens.

6. References

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