Materials Science Forum Vols. 730-732 (2013) pp 445-449
© (2013) Trans Tech Publications, Switzerland
doi:10.4028/www.scientific.net/MSF.730-732.445

Fracture Toughness of Dense Cordierite: Sintering Cycle Effect

F. A. Costa Oliveira[1,a*], J. Cruz Fernandes[2,b], J. Schmitt[3,c], L. Guerra Rosa[2,d], D. Dias[4,e]

[1] LNEG - Laboratório Nacional de Energia e Geologia, LEN - Laboratório de Energia, Estrada do Paço do Lumiar, 1649-038 Lisboa, Portugal

[2] IST - Instituto Superior Técnico, T.U. Lisbon, Av. Rovisco Pais, 1049-001 Lisboa, Portugal

[3] IUT du Limousin, Allée André Maurois, 87065 Limoges cedex, France

[4] Rauschert Portuguesa SA, Estrada Nacional 249-4, Trajouce, 2785-653 São Domingos de Rana, Portugal

[a]fernando.oliveira@lneg.pt (corresponding author), [b]cruz.fernandes@ist.utl.pt, [c]julien.schmitt.js@gmail.com, [d]luisguerra@ist.utl.pt, [e]diamantinodias@rauschert.pt

Keywords: Cordierite; Fracture Toughness; Sintering; Strength.

Abstract. The aim of this work was to analyse the fracture behaviour of commercial dense cordierite bodies sintered in an electrical furnace in static air at 1250°C, 1275°C and 1300°C for 30 min using different cycling schedules in order to obtain tougher materials at minimum energy costs. Using a stereomicroscope and a scanning electron microscope, fracture surfaces of as-sintered bars tested under four-point bending at room temperature were examined at different magnification levels in order to determine the origin of fracture in each sintered bar.
Once the fracture origin was identified, it was possible to measure its size, and based on ASTM C1322-96a standard, we were able to estimate the fracture toughness of the sintered parts.
Fracture toughness was found to increase with increasing of sintering temperature from 1.8 MPa·m½ to 3.1 MPa·m½ by rising the temperature from 1250°C to 1300°C as the fracture process is strongly influenced by the microstructure of the material.

Introduction

Cordierite ceramics are particularly useful owing to their very low thermal expansion coefficient and consequently good resistance to thermal shock [1] and are often used as honeycomb-shaped catalyst carriers in automobile exhaust systems [2]. Due to its lower processing costs and its relatively lower dielectric constant at high frequencies, cordierite is an alternative material to be used as substrate in replacement of alumina for integrated circuit boards in electronic industry [3].
Since cordierite occurs in Nature as a rather rare mineral (orthorhombic form), most cordierite is of synthetic origin (actually the term "indialite" would be more properly used to designate the hexagonal form present in cordierite bodies but for sake of simplification the crystalline phase $2MgO.2Al_2O_3.5SiO_2$ will be referred to by the term "cordierite"). The development of cordierite bodies is not merely achieved by mixing raw materials whose composition sums up to that of cordierite (theoretically 51.4% SiO_2, 34.9% Al_2O_3 and 13.7% MgO). Indeed, two conflicting factors are known to affect cordierite formation. One is the fact that equilibrium is rarely reached during sintering. The other is the proximity of various eutectic reactions so that if equilibrium is approached, only small deviations from the stoichiometric composition will produce melting and/or unwanted phases. For this reason, bodies of high cordierite content inevitably have a very narrow sintering temperature range.