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The Property Characterization of α-Sialon/Ni Composites Synthesized by Spark Plasma Sintering

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Abstract: This study investigates the effect of micron-sized nickel particle additions on the microstructural, thermal, and mechanical property changes of α-sialon ceramic composites. The α-sialon/Ni composites were synthesized with an increasing amount of Ni (10–40 wt.%) using the spark plasma sintering technique and nanosized alpha precursors at a relatively low synthesis temperature of 1500 °C with a holding time of 30 min in each case. The density of the samples increased with the increase in Ni content of up to 15 wt.% and, with the further increase in Ni content, it became almost constant with a slight decrease. Furthermore, thermal conductivity and thermal expansion properties of Ni-sialon composites improved slightly with the inclusion of 10 wt.% Ni. The addition of Ni to α-sialon matrix resulted in a decrease in the hardness of the composites from HV_{10} 21.6 to H_{V10} 16.3, however the presence of Ni as a softer interfacial phase resulted in a substantial increase in the fracture toughness of these composites. Fracture toughness was found to increase by approximately 91% at 40 wt.% Ni addition.

Keywords: α-sialon; sialon–nickel composite; spark plasma sintering; microstructure; densification; mechanical properties; thermal properties

1. Introduction

Engineering applications (such as turbine components, ball bearings, and hard cutting tools) require the use of materials that exhibit high strength, toughness and hardness, exceptional thermal performance, high resistance to oxidation, wear, and corrosion. Silicon nitride (Si_3N_4) is a ceramic material that has been extensively used in areas requiring exceptional mechanical properties at elevated temperature, such as gas turbine engine parts [1]. Difficulty in sintering silicon nitride material led to the development of sialon materials, where Si_3N_4 structure is modified by replacing a fraction of the silicon (Si) and nitrogen (N) with aluminum (Al) and oxygen (O) [1,2]. Sialon is a solid solution of Si_3N_4 and Al_2O_3 [1,3,4]. Sialons could primarily exist in two major phases: alpha or