

**INVESTIGATION ON THE EFFECT OF
SINTERING TEMPERATURE AND
COMPOSITION OF TITANIUM (Ti) ON
ELECTRICAL CONDUCTIVITY OF
 $\text{Al}_2\text{O}_3/\text{ZrO}_2/\text{Ti}$ CERAMIC COMPOSITES**

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SUPERVISOR'S DECLARATION

I hereby declare that I have checked this thesis, and, in my opinion, this thesis is adequate in terms of scope and quality for the award of the degree of Master of Science.

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I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

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ABSTRAK

Seramik telah dianggap sebagai salah satu bahan penting kerana ketahanan terhadap suhu tinggi dan kekerasan tinggi. Walau bagaimanapun, kerapuhan dan sifat kekonduksian elektrik yang rendah mempengaruhi penggunaannya secara meluas dalam aplikasi yang berbeza. Bilangan elektron yang dikongsi menunjukkan daya tarikan yang berkaitan dengan kekuatan ikatan kovalen. Sebaliknya, ikatan ionik dan kovalen tidak membentuk elektron bebas seperti ikatan logam. Oleh itu, bahan seramik mempunyai kekonduksian elektrik dan termal yang rendah. Sebagai contoh, sifat seramik penebat, dielektrik atau konduktif rendah menjadikannya sukar untuk dimesin mengikut bentuk dan kerumitan yang diperlukan dengan menggunakan mesin pelepasan elektrik bukan konvensional (EDM). Kekonduksian elektrik seramik dapat diperbaiki dengan penambahan zarah logam konduktif sehingga sifat mikrostrukturnya dapat diubah. Oleh itu, kekonduksian elektrik komposit matriks seramik Alumina diperkuat dengan Titanium ($\text{Al}_2\text{O}_3 / \text{Ti}$) dengan berat (w) peratusan (%) berbeza, serbuk dipadatkan dan disinter, menggunakan teknik sinter tanpa tekanan pada suhu 1600°C , 1650°C dan 1700°C dan dikaji untuk kemungkinan peningkatan kekonduksian elektrik. Wawasan baru mengenai interaksi proses mikro untuk peningkatan kekonduksian telah dibuat. Seramik $\text{Al}_2\text{O}_3/\text{Ti}$ diperhatikan meningkatkan kekonduksian elektriknya apabila peratusan berat (%) berat Ti meningkat. Pembentukan fasa TiO_2 membantu dalam meningkatkan konduksi elektrik. Dengan penambahan Ti secara berterusan, TiO_2 bereaksi sepenuhnya dan menghasilkan lebihan yang membantu mengalirkkan elektrik. Peningkatan kekonduksian elektrik disebabkan terutamanya oleh pembentukan fasa Ti yang saling berkaitan dalam matriks alumina selepas pensinteran. Kekonduksian elektrik disinter pada 1600°C dengan 5WT% menunjukkan peningkatan tertinggi dalam kekonduksian elektrik $78.795 \times 10^3 \text{ S/cm}$ berbanding dengan Al_2O_3 tulen.

ABSTRACT

Ceramic has remained one of the significant materials owing to its resistance to elevated temperature and hardness. Nevertheless, ceramics exhibit low electrical conductivity, and it is very brittle. These properties influenced the broad utilization of it in various functions. Most ceramics usually have combination of both covalent and ionic bond. The number of electrons shared indicates the force of attractions related to strength of covalent bond. In contrast, neither ionic nor covalent bonding forms free electrons like in metallic bonding. Thus, ceramic material has low electrical and thermal conductivity. For instance, the properties of low conductivity of ceramics creates difficulty in terms of machining to the obligatory form and complexity utilizing the non-conventional electrical discharge machining (EDM). The property of electrical conductivity in the ceramics can be enhanced by the accumulation of conductive metallic particles so that its microstructural property would be altered. Consequently, the electrical conductivity of ceramic matrix composite of alumina reinforced with titanium ($\text{Al}_2\text{O}_3/\text{Ti}$) with different weight (w) percentage (%) is manufactured. Pressureless sintering was utilized with temperature of 1600°C, 1650°C and 1700°C to investigate for potential progress in electrical conductivity. A new-found notion on the microstructural-process interaction for the better electrical conductivity was recognized. The $\text{Al}_2\text{O}_3/\text{Ti}$ ceramics was noticed in enhancing its electrical conductivity as the weight percentage (wt%) of Ti increases. Based on the Scanning Electron Microscopy (SEM) and observation of EDX, rise in the electrical conductivity is primarily attributed to the formation of interconnected Ti phases inside the alumina matrix after sintering. The formation of TiO_2 after sintering additionally promotes the progress in electrical conductivity. With the constant increased of Ti content, TiO_2 reacted entirely and the volumes of Ti residual also increased. The new phases are likely to be a contributing factor for the enhanced conductivity of the alumina matrix. The electrical conductivity sintered at 1600°C with 20 wt% Ti display greatest improvement in electrical conductivity of 78.795×10^3 S/cm related to pure of Al_2O_3 .

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