UNIVERSITY OF WOLLONGONG AUSTRALIA

Thesis writing

Conclusion

ENGINEERING EXAMPLE

Example: conclusion of a thesis	
The aims of this project were to develop a simple technique for microwave sintering of yttria zirconia, and to compare the resultant properties and microstructure with material sintered by conventional constant heating rate processes. As a result of this research, a simple technique which enables controlled microwave heating of yttria zirconia ceramics has been developed. Using this technique during constant rate heating it was found that there was an enhancement of densification during microwave sintering in comparison to conventional heating.	*reviews aim of research* *reminds reader of main results*
A small but significant shift in the density - grain size relationship occurred during microwave sintering of 3 mol% yttria zirconia for densities below 96% TD, indicating that microwave sintering accelerates lattice diffusion more than surface and grain boundary diffusion during the initial and intermediate stages of sintering. However, the difference in this relationship disappeared at higher densities once grain growth began to dominate. No shift was found in the density - grain size relationship during any stage of the sintering process when constant rate sintering of 8 mol% yttria zirconia in the microwave field was compared to conventional heating. Heating rate was not found to have a significant effect on the grain size / density relationship.	*reiterates secondary results* *details results*
Whether there is a change in the grain size/ density relationship during microwave sintering when compared to conventional sintering is dependent on a number of other factors which affect the kinetics of diffusion and grain growth. A change in this relationship was identified for 3 mol% yttria zirconia, which has a relatively high activation energy and low driving force for grain growth, as compared to 8 mol% yttria zirconia, in which grain growth proceeds much more quickly due to low activation energy, high driving force and high grain boundary mobility.	*explains & interprets results*
...	
Results of isothermal densification experiments at 1300^{0}C also evidenced the enhancement of densification when microwave heating is used. Microwave heated samples had a significantly higher density after brief dwell times at this temperature than did conventionally heated samples subjected to the same thermal schedule. Grain size/ density relationships were similar to those found during constant rate heating. However, the low temperature enabled the microwave samples to retain a smaller grain size once densification had ceased, due to the slower rate of grain growth.	*further explains & interprets results*

Example: conclusion of a thesis	
Ageing experiments conducted at 1500^{0}C showed that once densification was near completion, grain growth in 3 mol% yttria zirconia was accelerated in the microwave field, and exaggerated grain growth occurred. This resulted in a greater apparent transformability of the tetragonal phase. No significant differences in grain growth were observed between conventional and microwave heated 8 mol% yttria zirconia during ageing. The higher oxygen vacancy concentration of 8 mol% yttria zirconia does not appear to have increased the magnitude of the enhancement to densification by the microwave field.	*further explains & interprets results*
It would appear that the effects of microwave sintering may not necessarily be the same for all ceramic materials. If the activation energy for grain growth is similar to or higher than the activation energy for densification, then it does appear to be possible for a change in the balance between densification and grain growth during sintering to occur which favours densification. Low grain boundary mobility is also advantageous in restricting grain growth during densification. However, dwell times need to be selected to avoid exaggerated grain growth. The optimal way to take advantage of the benefits of microwave sintering for yttria zirconia ceramics would appear to be incorporation of dwell periods at temperatures in the 1200 - 1350^{0}C range in the sintering program. This would allow high densities to be achieved, while restricting grain growth. Sintering at lower temperatures would also provide some energy savings.	*main conclusions and implications of research*

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