Forming Nanostructured Ceramics: The Art of the Possible

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Abstract

There is considerable talk in the literature of the benefits to be gained from producing nanostructured ceramic materials however much is speculation based on the properties of the precursor powders and then assuming that these can be retained in the final, sintered component. The present work therefore has two main aims:

i) to investigate the science underpinning the production of nanostructured ceramics, and

ii) to determine what can be achieved NOW based on existing forming processes.

Both dry and wet routes to the production of green nanoparticle compacts are currently being investigated since the homogeneity of particle packing has an enormous impact on the quality of the sintered component produced. Whilst wet routes are expected to lead to superior green nanostructures, industry is largely tooled up to use dry forming routes. With respect to the latter, the flow and compaction properties of a range of nanopowders and nanometre /micrometre combinations are being investigated as a function of particle size, size distribution (including the affect of agglomeration) for several different ceramic nanopowders. For wet forming routes, powder dispersion is a common problem in most industrial sectors that becomes more acute when nanoparticles are used. The work is therefore intended to provide a clearer understanding of nanoparticle dispersion with adsorbed polyelectrolytes and to relate the rheological property of the suspensions to the chemistries of the suspended particle surfaces, polyelectrolytes, solids loadings and interparticle forces. The resulting suspensions are being used to produce compacts with as high green densities as possible. For both dry and wet forming routes, the resultant compacts results are being characterised using a range of techniques.

Once formed, there is a need to convert the green compacts into (usually dense) sintered forms whilst retaining the nanostructure. This is extremely difficult, especially when using (low cost) pressureless sintering techniques, because the driving forces for densification and grain coarsening are comparable in magnitude, both being proportional to the reciprocal grain size. Success is dependent on close control of the competition between them. A number of options exist, these include the use of:

- *Additions that reduce grain boundary mobilities,* however, this approach can only be used where the additions do not affect the desired properties of the final product.
- *Very rapid firing technologies,* which requires extremely homogeneous green compacts of limited size.
- *A two-step sintering method* in which suppression of the final stage grain growth can be achieved by exploiting the difference in kinetics between grain boundary diffusion and grain boundary migration[1].

The research is currently examining the potential that is offered by the latter approach for a range of different ceramic systems; with full microstructural characterisation and property measurement after sintering. All the above work is being performed for monolithic ceramics and multilayer electroceramic components.

1. Wei Chen I & Wang X-H, Nature **404** 168-171 2000.