ADVANCING NANO-CERAMICS FROM LABORATORY TO MANUFACTURE

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Research in the Department of Materials at Loughborough University is working towards taking fundamental research into nanostructured ceramics through to industrial application; licensing agreements are currently being negotiated for the work based on zirconia and it is hoped that the technology will be launched during 2012.

The research team at Loughborough is working on producing and characterising a range of nanostructured ceramics, including alumina and zirconia toughened alumina, barium titanate, hafnium boride and carbide, yttrium aluminium garnet (YAG) and a range of yttria partially stabilised zirconias. Each material is at a different stage of progress, with zirconia being the most developed. It is now possible to produce fully dense, genuinely nanostructured yttria tetragonal zirconia polycrystal (YTZP) ceramic from powders as fine as 20 nm; this is smaller than the size of a typical virus. The YTZP ceramics have been found to display some extremely useful properties. For example, although zirconia is one of the strongest and toughest advanced ceramic materials, it is very vulnerable to attack by moisture, particularly at temperatures in the range ~100 – 300°C. The moisture causes a catastrophic phase change that can reduce conventional, submicron zirconia into a pile of damp powder in less than one hour at ~250°C. Whilst more resistant grades are being developed, the new nanoYTZP has been found to show no trace whatsoever of the phase change even beginning to occur after 3 weeks at 250°C. Combined with high strength and, for the right grades, high toughness or ionic conductivity, this has led to significant interest being shown in these materials for applications as diverse as hip replacement implants, dental ceramics, solid oxide fuel cell electrolyte and valves for the petrochemical industry.

The work has been able to progress thanks to a series of research grants from EPSRC and the TSB in particular, in combination with excellent industrial support. The Powders Sector of the Materials KTN (formerly PowdermatriX) also aided this process very much. Two EPSRC programmes and a DTI (now the TSB) project over the period 2002-07 got the work off to an excellent start and allowed the basic green forming and densification routes to be developed. The work then continued with an EPSRC Follow-on Fund project, which assessed the potential for commercial exploitation of the technology, before being developed further and broadened in terms of the range of ceramics being investigated via a TSB Collaborative Research project. The team were then able to capitalise on the developments and start to translate them into industry via support from the EPSRC Collaboration Fund. This current grant is allowing a nanozirconia engineering component prototype, the ceramic internals for a petrochemical valve, to be produced. Further support focused on scale up was received from the Royal Society Brian Mercer scheme, whilst additional TSB support is about to start for work in the area of bioceramics.

This sequence of research grants, and the wonderful technology transfer nature of the EPSRC Follow On Fund and Collaboration Fund, has really helped the team to accelerate the process of getting their ideas into industry. Unless something unforeseen happens, it should be possible for the technology to be commercialised within a decade of the start of the research; something that is really quite rare. The work on barium titanate should follow during 2013, with the other ceramics being commercialised over the ensuing years.

The team at Loughborough considers itself very lucky, however. Each time, just when it was needed, there was a Call for Proposals in just the right area and in just the right format. What they believe is needed is to remove some of the luck from this process. A small amount of funding needs to be reserved by both EPSRC (Follow On & Collaboration Funds) and the TSB that can only be applied for by researchers who have already been successful and are developing their ideas steadily closer towards commercialisation. The funding must certainly remain competitive, there must be no diminution of the principle of funding excellence, but such a fund would remove the element of chance that there is a Call in an appropriate area; something that is currently quite restrictive for the TSB in particular.

This development of nanostructured ceramics is an achievement that exemplifies how the availability of successive and appropriate public funding initiatives can lead to effective innovation. Removing the element of chance that has been involved can only improve this process further.