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Education and Culture
Erasmus Mundus

DocMASE Project Proposal 2011-07

Project Title	***Spark plasma sintered nanocomposites based on zirconia doped with yttria***
Main University and Advisor	**Universitat Politècnica de Catalunya (UPC)** (Barcelona, SPAIN) Dr. Marc ANGLADA
Second Univ. and Advisor	**Lulea University of Technology (LTU)** (Luleå, SWEDEN) Dr. Marta-Lena ANTTI
Associated Partner(s)	**Nanoforce Technology** (London, ENGLAND) Dr. Michael REECE
Project Description	Tetragonal zirconia polycrystals stabilised with 3% molar yttria (3Y-TZP) have been widely used in the past in femoral heads of hip-joint replacements and now in dental restorations because of their high mechanical strength and fracture toughness, wear resistance and excellent biocompatibility. However, when exposed to aqueous environments, tetragonal to monoclinic transformation may take place at the surface even at the human body corporal temperature. This phenomenon is referred to as hydrothermal ageing or low temperature degradation (LTD) and its presence has dramatic effects on the performance of implants subjected to contact loading. 3Y-TZP is therefore no more used in orthopaedics and major companies have switched to alumina and zirconia composites. However, monolithic 3Y-TZP is increasingly used in dental applications, but it is now a subject under hot investigation weather LTD is also a serious limitation for the use of 3Y-TZP in dental implants [1]. One method to reduce LTD in 3Y-TZP is to refine the grain size by increasing the energy barrier for t-m transformation in humid environments. The effectiveness of this approach in reducing the amount of t-m transformation has been clearly demonstrated by reducing the grain size from several micrometers to the scale of a few hundred nanometres, but LTD is still operative for the smallest grain size achieved by conventional sintering. Recently, Chintapalli et al have shown that the novel technique of Spark Plasma Sintering (SPS) is able to produce dense materials with nanometric grain size which are resistant to LTD. However, a penalty is paid for this since the t-m transformation activated by stress is also nearly absent so that fracture toughness decreases in nanometric 3Y-TZP fabricated by SPS. The PhD thesis work proposed here aims to study the change in the yttria content and the incorporation of other ions in solution in order to produce Y-TZP by SPS which is of nanometric grain size, resistance to LTD and with fracture toughness at least as high as that sintered by conventional methods. Several approaches will be studied, but most of the effort will be addressed to study the design on 3Y-TZP nanocomposites produced by SPS which are resistant to LTD and with higher mechanical properties than monolithic 3Y-TZP. Most of the work will be carried out at UPC in Barcelona, but it will involve a stage of at least six months at LTU for specimen preparation and characterisation, and at least two stages of about 3 weeks each in London at Nanoforce for training in SPS and for preparing specimens by this technique. Also short stages are planned in other main partners of DocMASE, as well as in other associated partners.
References	[1] Chevalier J, Gremillard L, Deville S., “Low-Temperature Degradation of Zirconia and Implications for Biomedical Implants”, *Annu Rev Mater Res* **37** (2007) 1–32.
Previous Publications	1. J.A.Muñoz-Tabares, E. Jiménez-Piqué and M. Anglada, “Subsurface evaluation of hydrothermal degradation of Zirconia”, *Acta Materialia* **59** [2] (2011)473-484. 2. Y. Gaillard, E. Jiménez-Piqué, F. Soldera, F. Mücklich and M. Anglada, ”Quantification of hydrothermal degradation in zirconia by nanoindentation”, *Acta Materialia* **56** [16] (2008) 4206 – 4216. 3. R. Chintapalli, A. Mestra, F.Garcia, H. Yan, H., M. Reece, and M. Anglada, “Stability of nanocrystalline spark plasma sintered 3Y-TZP”. *Materials* **3**[2] (2010) 800-814