DocMASE Project Proposal 2013-08

Project Title	3D damage characterization of surface modifications of ceramics
Main University and Advisor	Technical University of Catalonia (Spain) / Dr. Emilio Jiménez Piqué
Second University and Advisor	Saarland University (Germany) / Prof. Frank Mücklich and Prof. Matthias Hannig
Project Description (with **image**, if applicable)	Hard ceramics are being increasingly used in different applications in order to increase productivity and life-time, as in tooling, wear parts or mining, as well as in biomedical implants. Whereas in the last years much effort has been done in modifying the microstructure, nowadays there is a tendency to improve the performance by modifying the surface, especially by introducing controlled roughness or porosity. For example, it has been shown that a controlled roughness on zirconia dental implants produce better cell adhesion. However, zirconia components are susceptible to brittle catastrophic failure due to both the demanding loading conditions during use (wear, scratch, contact fatigue or impact) and especially to the introduction of surface features that can act as initial flaws for premature failure. Because of the complex surface geometry it is not easy to correctly characterize the flaws and damage produced during use in order to estimate the fracture probability and to increase the reliability of the component [1]. Normally, damage has been observed from surface inspection. However, these damage and surface modifications is three-dimensional and propagate in depth [2], and a realistic characterization should be done in 3D. Therefore, the objectives of this project is to: 1) Modify the surface of hard ceramics, focusing in ceramics for biomedical applications (YTZP, Al2O3/ZrO2) by laser interference patterning, grinding, chemical attack and/or by direct introduction of porosity during the processing. 2) Characterize the mechanical properties by nanoindentation techniques and other contact loading techniques and mechanical tests. 3) Characterize the produced damage by tomography techniques, especially by focused ion beam tomography. Atomic Probe Tomography and micro-CT will be also used in selected cases. 4) Estimate the fracture probability and propose changes in the materials and surface in order to enhance the structural integrity and reliability of these components. 5) Characterize the adherence of bacteria and cells at the modified surface in order to assess the formation of bacterial biofilms as well as mucosal attachment.
Previous Publications	[1] C.A. Botero, E. Jimenez-Pique, J. Seuba, T. Kulkarni, V.K. Sarin, L. Llanes "Mechanical behavior of 3Al2O3-2SiO2 films under nanoindentation" Acta Materialia 60 (2012) 5889–5899 [2] E. Jiménez-Piqué, A. Ramos, J.A. Muñoz-Tabares, A. Hatton, F. Soldera, F. Mücklich, M. Anglada "Focused ion beam tomography of zirconia degraded under hydrothermal conditions" Journal of the European Ceramic Society 32 (2012) 2129–2136 [3] Hannig, C., Hannig, M.,The oral cavity - a key system to understand substratum-dependent bioadhesion on solid surfaces in man. Clin Oral Invest 13 (2009) 123-139 (IF 2.233) [4] Rupf, S., Balkenhol, M., Sahrhage, T.O., Baum, A., Chromik, J.N., Ruppert, K., Wissenbach, D.K., Maurer, H., Hannig, M., Biofilm inhibition by an experimental dental resin composite containing octenidine dihydrochloride. Dental Mater 28 (2012) 974-984.
References	
Requirements of the candidates / Requirements during the doctoral programme (courses, seminars, etc.)	Very good English command. Bachelor in Materials Science, Chemistry, Physics or related disciplines. Master in Materials Science or related disciplines. 30 ECTS must been acquired during the program according to the minimum requirements of DocMASE.