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Caries of Human Dental Tissues Studied Using X-Ray and Electron Correlative Microscopy

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Hydrated biological mineral composites of hydroxyapatite crystallites within organic matrix form the hardest tissue in the human body, the dental enamel, as well as other parts of the tooth (dentine, cementum, etc.). These tissues possess a hierarchical structure that delivers their versatile mechanical properties. These composites have excellent thermo-mechanical stability under severe exposure conditions in the oral cavity, but are subject to biological and chemical degradation (decay) due to human dental caries, a disease that affects a vast proportion of the world's population as a consequence of the modern sugar-rich diet, causing dental erosion due to the activity of acid-producing bacteria residing in the biofilm (plaque).

A strong and durable bond between dentine and enamel is formed by the dentine enamel junction (DEJ), an important biological interface that resists failure under long-term harsh thermal and mechanical conditions in the mouth. Understanding the underlying reasons for this remarkable combination of strength and toughness remains an important challenge, both in the context of dentistry, and from the point of view of pursuing biomimetic advanced materials engineering. Residual strain develops in the vicinity of the DEJ during Odontogenesis (tooth formation). The experimental and interpretational challenges that could not be overcome until recently presented an obstacle to the evaluation of residual stress in the vicinity of the DEJ at the appropriate spatial resolution. The recently developed FIB-DIC micro-ring-core method was used to determine the residual elastic strain at micron resolution. The residual strain profiling across the transition from dentine to enamel was correlated with the study of internal architecture using X-ray scattering (SAXS/WAXS), providing insight into the origins of the remarkable performance of the DEJ, and also the degradation of enamel during early caries.

Biography:

Professor Alexander M. Korsunsky (AMK) is a world-leader in engineering microscopy of materials systems and structures for optimization of design, durability and performance. He leads MBLEM lab at the University of Oxford, and the Centre for In situ Processing Science (CIPS) at Research Complex at Harwell. He consults Rolls-Royce plc on matters of residual stress and structural integrity, and is Editor-in-Chief of Materials & Design, a major Elsevier journal (2017 impact factor 4.364). AMK leads a major EPSRC research project on nanoscale analysis and modelling of human dental caries.