

Dr. Kai-tak Wan

UMR – Mechanical Engineering

Multi-scale Mechanical Modeling from a Single Cell to a Multi-cell Aggregate

University of Missouri-Rolla Ceramic Engineering Seminar Series Speaker
Thursday March 25, 2004

McNutt Hall, Room 204
3:30pm

Biography:

Dr. Kai-tak Wan graduated in Chemical Physics from University of Maryland at College Park in 1993. After a 2-year post-doctoral research at University of Sydney (Australia) and Hong Kong University of Science and Technology, he joined Nanyang Technological University in Singapore as Associate Professor of Mechanical Engineering. He was a visiting professor at Virginia Tech from 2001 to 2002, before joining the mechanical engineering department at University of Missouri-Rolla.

Abstract:

We measured in-situ the elastic modulus and piercing strength of the Zona Pallucida (cell membrane) of a mouse egg before and after in-vitro-fertilization (IVF) using a bio-MEMs device and an atomic force microscope (AFM), and reported the first time in literature the drastic change of mechanical behavior as a result of embryonic activities. A new solid mechanics model was constructed to include both bending and stretching of the ultra-thin membrane and residual stresses based on classical linear elasticity and viscoelastic rubber elasticity. The theory superceded the existing models of pure film bending and pure membrane stretching in the literature.

The new cellular biomechanics model was further extended to include cell-cell and cell-substrate adhesion. A series of experiments were conducted using liposomes of various phospholipid bilayers and treated glass surfaces as model cells and substrates respectively. Using our newly developed HR-RICM method (high resolution reflection interference contrast microscopy), the interfacial adhesion was measured to increase drastically by 2 orders of magnitude at a transition temperature of 37°C. The new adhesion model is currently used to investigate cell aggregation and thus the formation of 2-dimensional tissues / 3-D organs, aiming to establish the transition of the hierarchical mechanical behavior from micro- to macro scale and their inter-relationships. A new axisymmetric punch method and the related force sensing equipment were recently built to measure simultaneously the mechanical and adhesion parameters of an ultra-thin bio-membrane. The related mechanical model was constructed and experimentally verified. The new methods and theories will enhance the understanding of embryonic activities, morphogenesis, specific and non-specific adhesion of cells, stem cell condensation, and cancer research. There are also significant implications in the mechanical and adhesion behaviors of nano-structures (e.g. bucky balls and graphene sheets).

A meeting of the UMR Chapter of the American Ceramic Society and the Missouri Chapter of Keramos will follow the Seminar in McNutt 211.

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