

Multi-resolution Simulation Based Engineering and Science

review of presentation given by Dr. Wing Kam Liu of Northwestern University

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Dr. Liu's program is the study of engineering simulations that span many orders of scale. The purpose of this is to investigate and anticipate the effects of inclusions in materials and how they impact the performance of materials on a structural rather than (but not excluding) a chemical basis.

This study is largely direct numerical operations employing immersed finite limit methods also known as mesh or nodal analysis. This method of modeling structures is well known and is developed in any particular specialty through concurrent testing on physical models or specimens.

Dr. Liu's group has developed their models through successively slicing specimens to test their ability to model and predict material behavior. At the gross scale, the lab technician may recall the operation and purpose of a microtome that can prepare thin slivers of a specimen isolated and immobilized in a small cylinder of wax. Through successive slices, the entire specimen is dissected into a substantial number of thin disks that allow viewing sections of the specimen under an optical microscope.

Mimicking that operation and using a microscope as the tool of dissection, Dr. Liu's group has used a focused Ion Beam and Scanning Electron Microscope to produce successive dissection layers 50 nm thick from their test materials.

The challenge at this fine scale is to not introduce specimen distortions to slices that are only 1400 molecules deep. To do this, they seek to peel away at natural interfaces so as to not introduce behavioral changes into the material. Otherwise the study of foreign inclusions would be overwhelmed with new artifacts.

One application of Dr. Liu's group is to be able to model and engineer materials whose performance under operational stress can insure operating lifetimes of decades of use in high stress environments. An application in a space craft can expect to endure considerable temperature variations or differentials. Also to be expected are radiation along with the erosion from the wear and tear of typical use. It is expected that such devices will occupy roughly a volume of one cubic centimeter.