

00A_Global Views

Topics

- What is Nanoscience and Engineering? Your opinion, my opinion

- Some examples

- Fundamental building blocks

- This course is about building models that link performance to nanostructure; what are the guidelines?

- What is Nanoscience and Engineering? Your opinion, my opinion.

- Mechanical strength of fibers

- tiny robots

- composite and medical

- MEMS connecting humans to the internet

- atomic level interactions like diffusion

- giving instructions to tiny robots

- semiconductors- thin film structures

- atomic interactions- quantum computing

- high surface area like in catalyst, surface science-thin films

- wetting of surfaces

- materials science on a small scale mechanical strength

- high surface area - medical uses-tissue growth

- food color

- Some examples

Cloud Seeding

Small crystals of potassium iodide are sprayed in the clouds which cause the clouds (water vapor) to condense into rain droplets.

Energy of formation = heat of evaporation of water = 286 kJ/mol at 25 °C.

Graphene Supercapacitors

Graphene sheets can store vast amounts of charge which can be delivered in a short time.

Mechanical Deformation at Nano-Microscale

The reliability and high strength of optical fibers and thin films in microelectronics is related to small dimensions.

Color of nanoparticle changes with size

Nanoparticles of CdS for example change their color towards the blue in the spectrum (known as the blue shift) as the particles become smaller.

High rate lithium ion batteries

The small length scale of the electrolytes, the anodes and the cathodes in lithium ion batteries has an influence on the of charging.

Doping Silicon

Silicon is doped with p-type (e.g. P) or n-type (e.g. Al) dopants, but to small depths to make p-n junctions for example.

And more...

- This course is about building models that link performance to nanostructure; what are the guidelines?

Data Science

Those that are based entirely on data. The recent machine-learning and AI approaches have given more "punch" to these models. But they are based upon statistics; they require massive amounts of data. Cloud computing is mainly based on this approach.

Weather prediction (partially), and prediction of the COVID path are good examples.

Analytical

These models are entirely analytical, and derive from fundamental concept in physics, mechanics and materials science; for example, a model that predicts the energy stored in a diving board as a function of its geometry. These models yield closed form predictions. They always depend on fundamental properties of the materials. For example, in the case of the diving board the elastic or the Youngs modulus of the material is needed.

A sterling example of such models lies in mechanics where prediction such as buckling of a cylinder under compression can be made with precision with mathematical models and solid-geometry.

Hybrid

More recently a hybrid approach where machine-learning is combined with analytical models to zero-in quickly, that is with less computation, on the key variables, is being developed.

For example in weather prediction data science is combined with computational fluid mechanics to make the computations more efficient and precise.

Our Approach

We shall follow the analytical approach. We shall seek to build models that link laboratory measurements with the structure, bonding, etc. at the atomic length scale: for example, relating the strength of the bonds to surface energy.