SUBR

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Mechanical Engineering Dept.

Main areas of Activity

- Wind Tunnel Experiments
- Molecular Dynamics Simulation

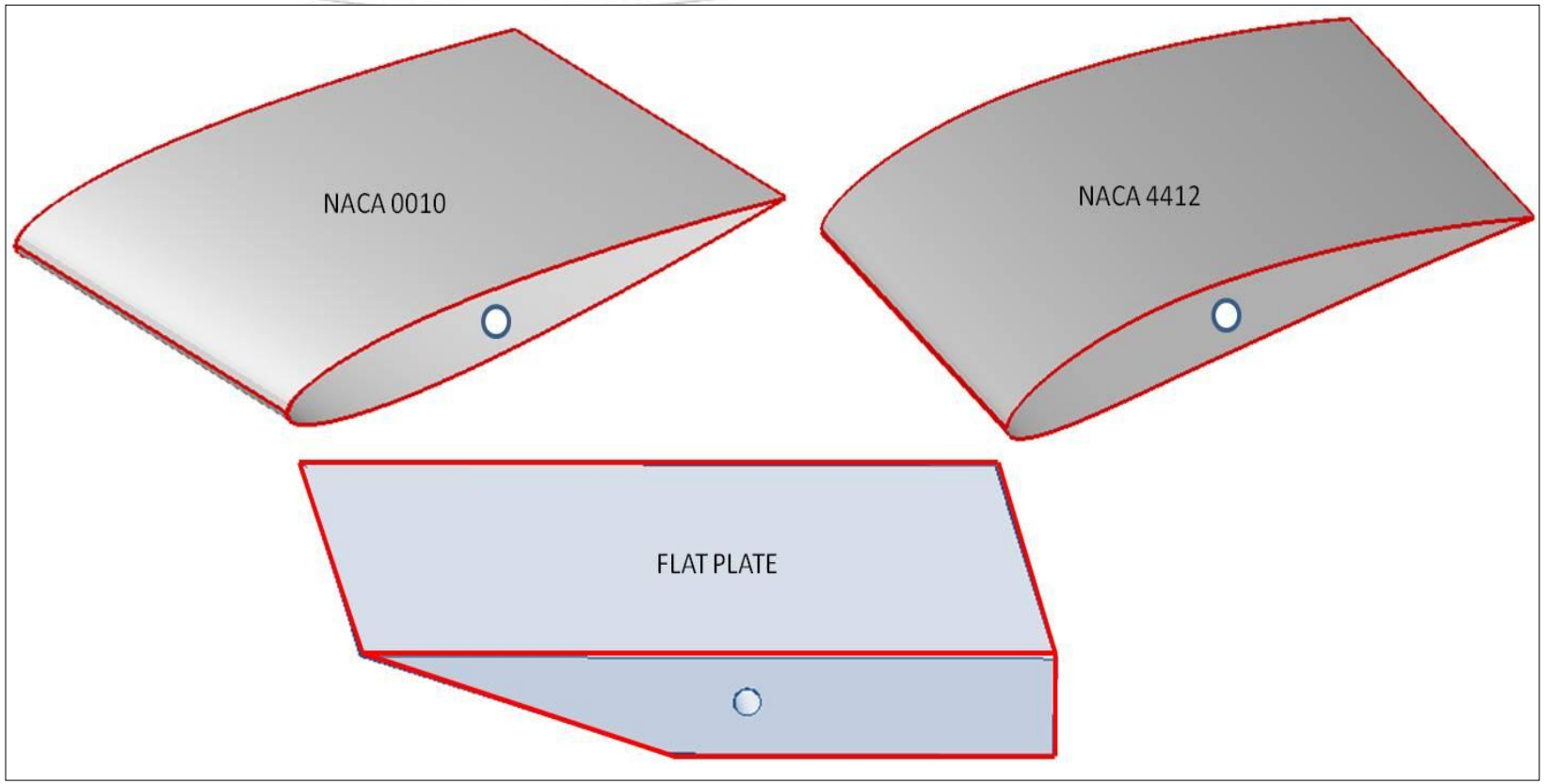
Wind Tunnel Experiments

- Aim is to study the aerodynamic performance of selected airfoils
- Principal Investigator: Dr. Patrick Mensah (ME Dept. SUBR)
- Post Doc Research Associate: Dr. Stephen Akwaboa (ME Dept. SUBR)
- Graduate Students: Michael Benissan, Derrick Goss

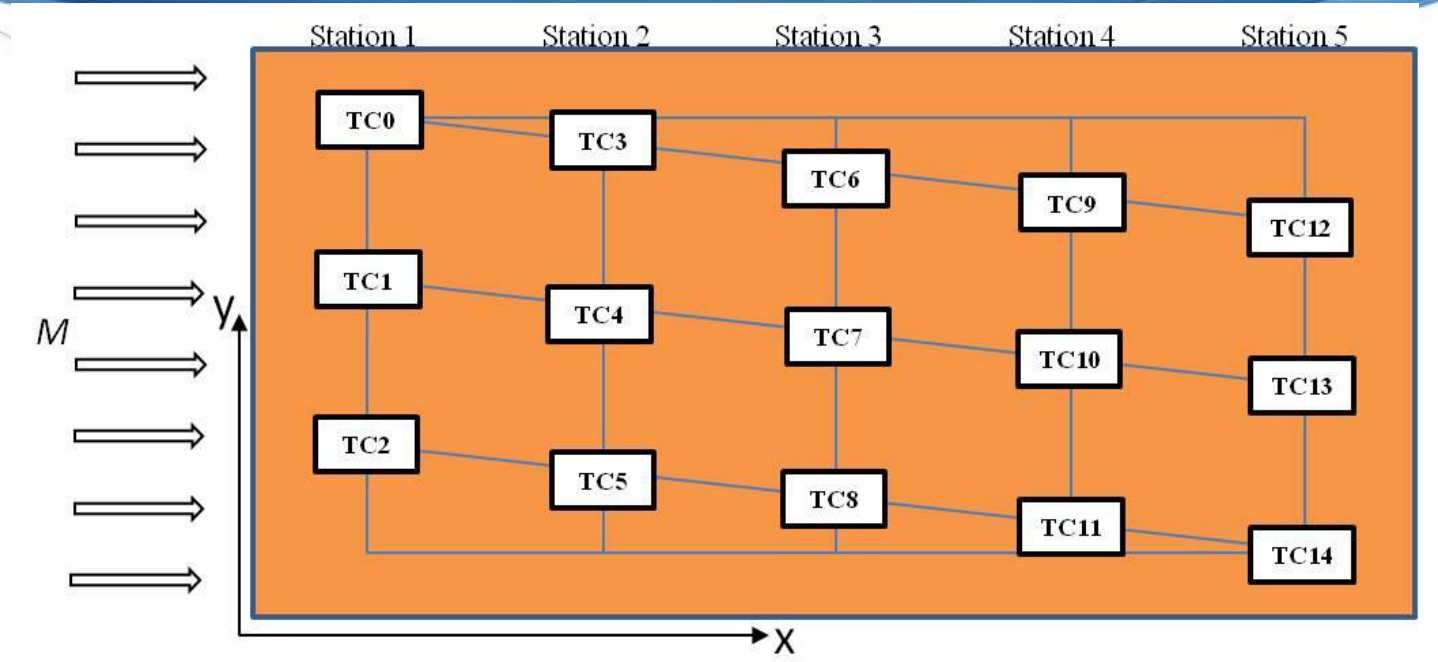
Wind Tunnel @ SUBR

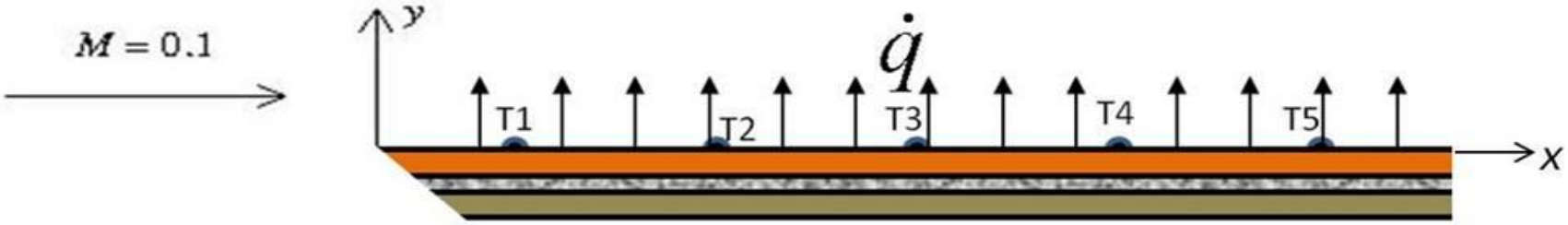
Close-up of test Section

Experimentally study forced convection heat transfer with constant surface heat flux over the following surfaces

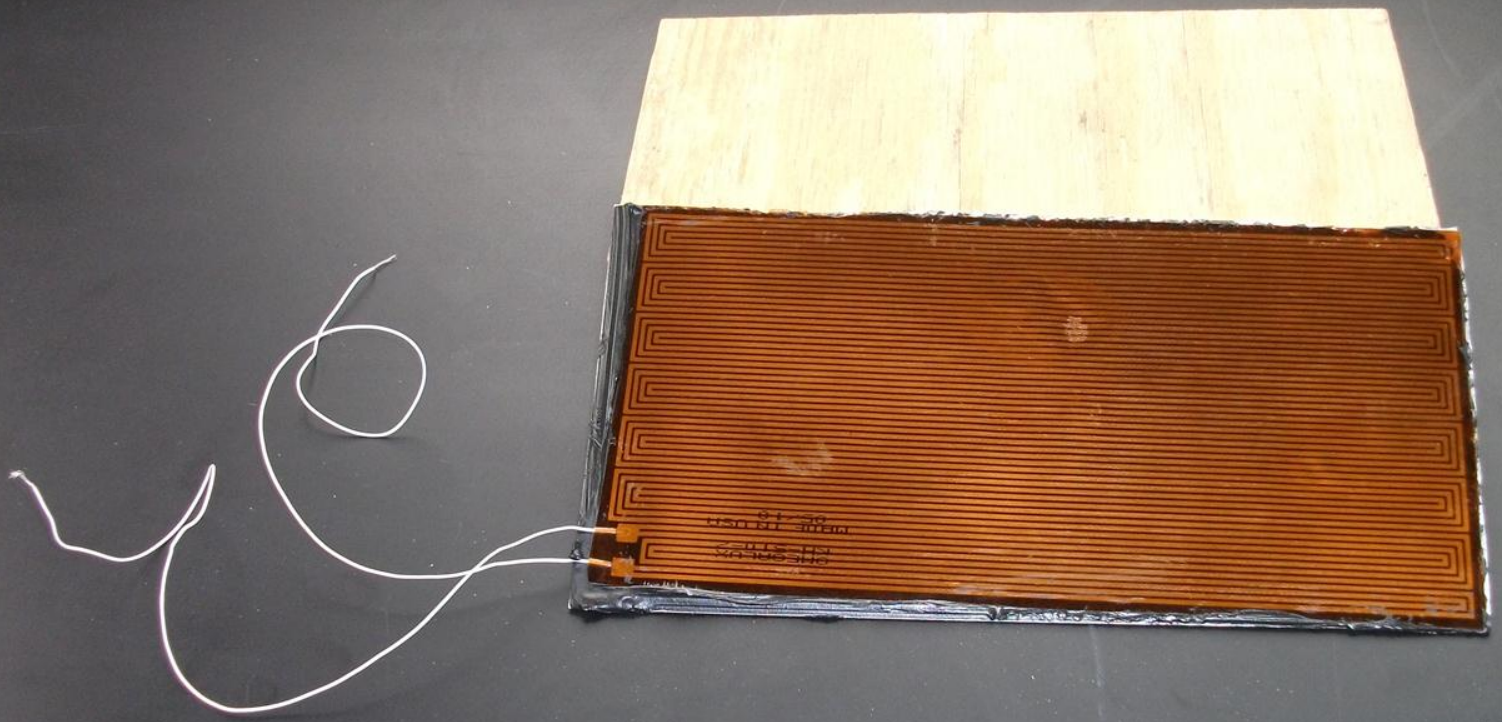


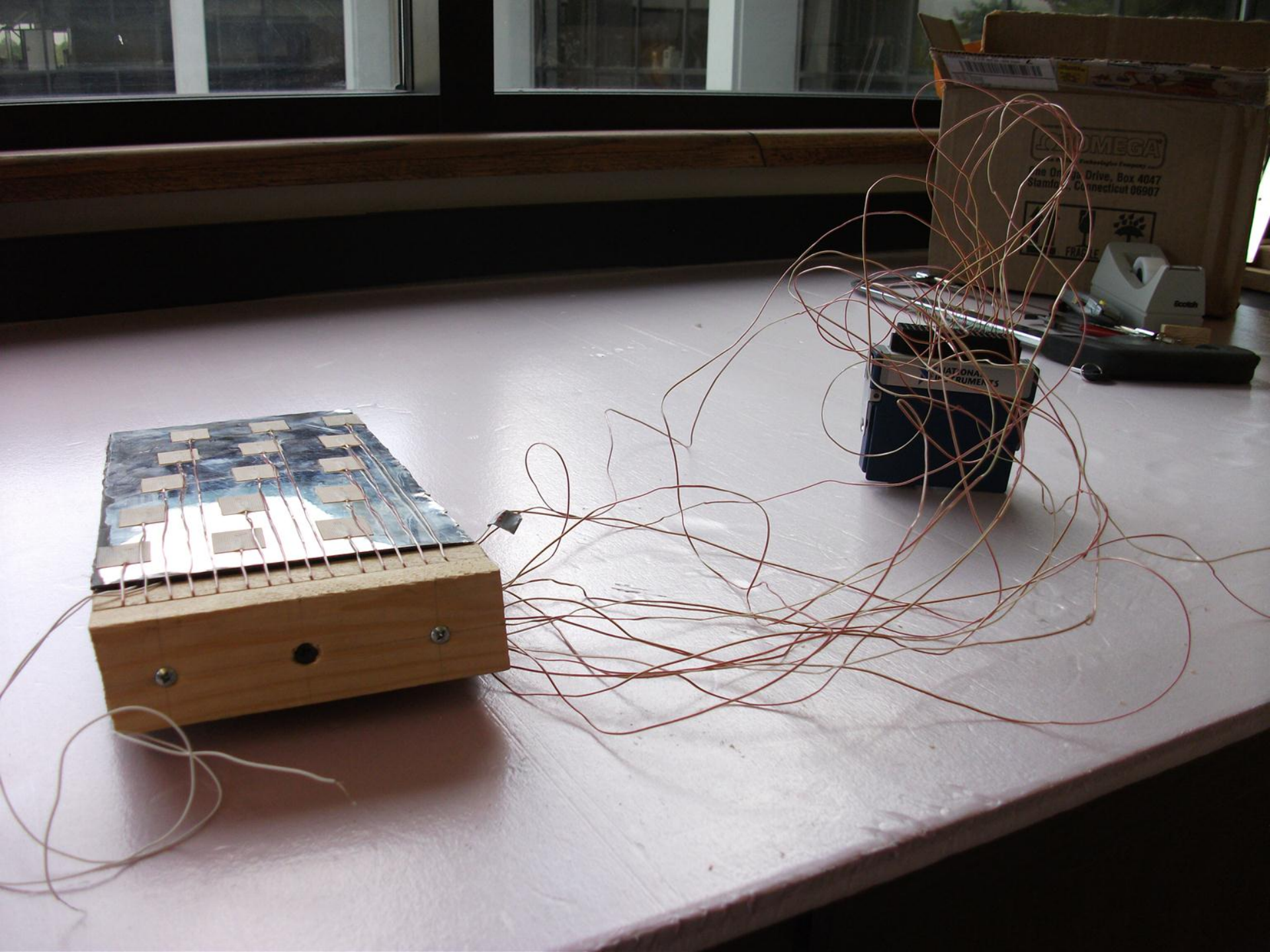
Grid Set for Thermocouples





Flexible heater attached to metal plate




OMEGA
Drive, Box 4047
Connecticut 06907
FRAGILE
Scotch

Mounted in the test section

Theory

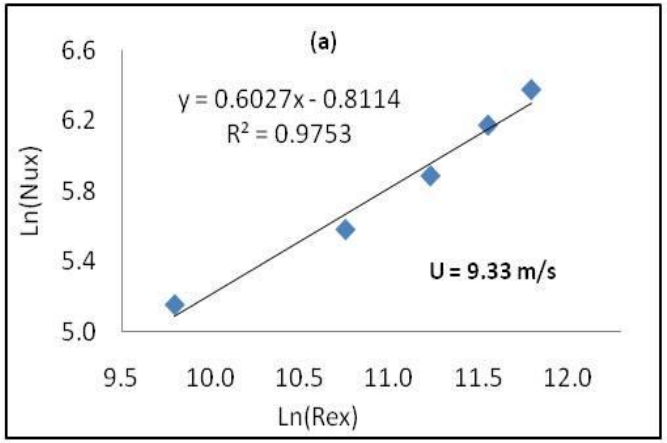
- Thermal boundary layer develops when free stream and surface temperatures are different
- Newton's law of cooling to evaluate convective heat transfer on the solid surface
- Correlations used: $q_s = h(T - T_\infty)_{y=0}$ $q_s = f\,\frac{E^2}{RA}$

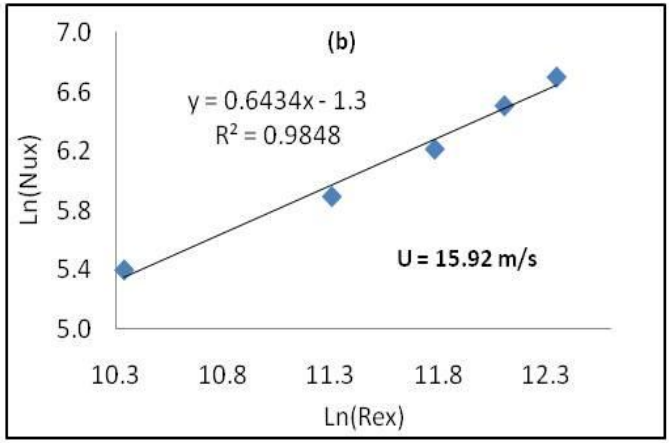
$$Nu_x = \frac{hx}{k} \qquad Re_x = \frac{\rho U x}{\mu} \qquad Nu_x = A Re_x^m Pr^n$$

$$Ln(Nu_x) = Ln(APr^n) + mLn(Re_x)$$

Readings taken and sample plot

Surface temperature (°C) of the plate					
x (m)	U = 9.33 m/s	U = 15.92 m/s	U = 22.5 m/s	U = 29.5 m/s	U = 35.6 m/s
0.03	28.5077	26.6166	26.1891	25.5368	26.6468
0.08	35.1786	31.0540	29.6260	28.3893	29.3319
0.13	38.2461	33.1068	31.1649	29.6000	30.3861
0.18	38.9660	33.5532	31.4690	29.8143	30.9923
0.23	39.8314	34.2930	32.0864	30.3602	30.8151





m values obtained 0.6 - 0.7 [Literature: m = 0.5 laminar; 0.8 turbulent]

- Study on airfoils scheduled to commence in the 3rd week of November, 2011.

Development of a Thermal Model for a TBC System: A Molecular Dynamics Simulation Approach

Objectives

- Develop a thermal model to predict the temperature gradient within the substrate-TBC system

- Determine temperature drops at the interfaces associated with thermal boundary resistance

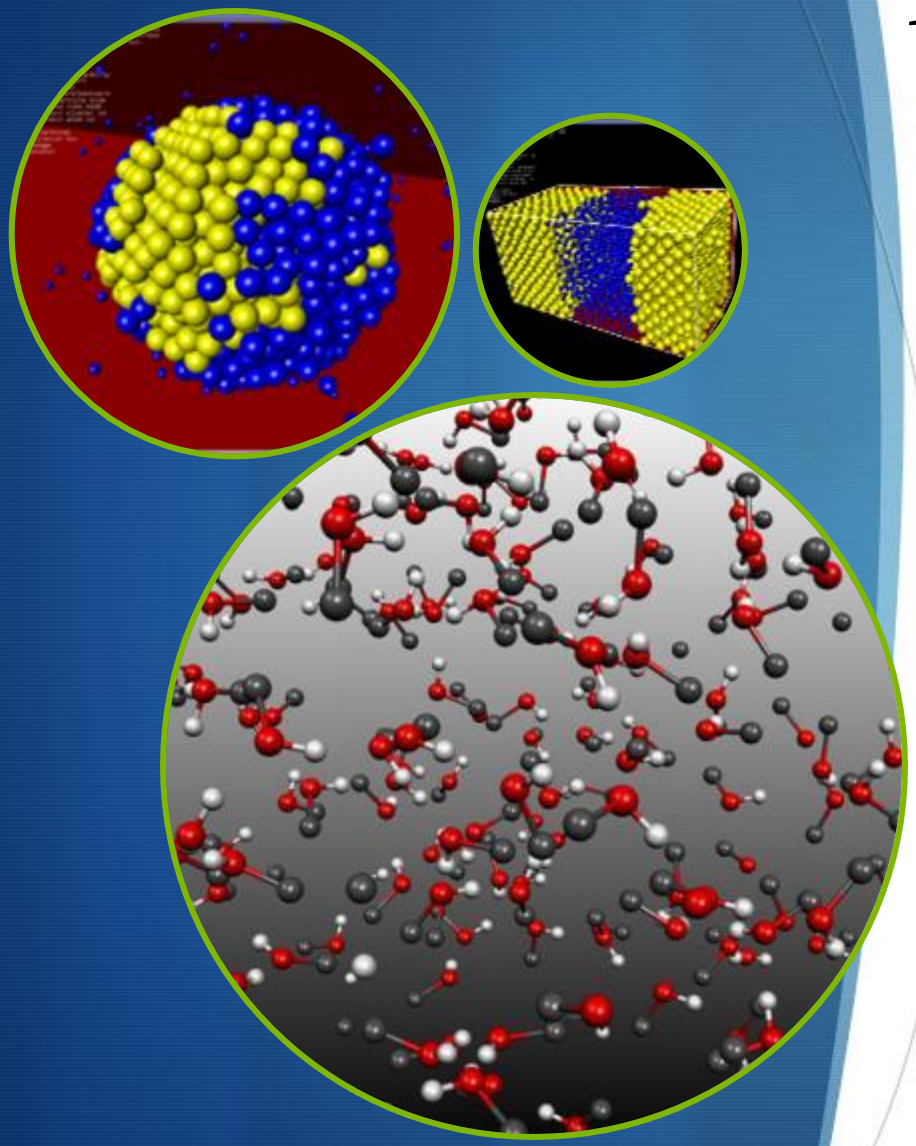
Motivation

- Components of TBC systems behave differently with increasing temperature
- Thermal residual stresses build up due to mismatch of material properties and high temperature oxidation
- Failure could be adhesive or cohesive
- Thermal gradient information has been used in models that study the evolution of residual stresses and hence prediction of TBC failure and durability

Why Molecular Dynamics Simulation?

- Explore macroscopic properties of a system through microscopic simulations.
- Generates information at the microscopic level – atomic positions and velocities.
- Increased importance to migrate from macroscopic thermal transport models to models and theories based on microscopic principles
- This has become necessary due to the proliferation of nano-scale devices and structures

The Way forward



- **Obtain information on the structures of materials in TBC system**
- **Their Elastic Properties**
- **Cohesive Energy**
- **Empirical Potentials**
- **Consider possible simplifications without affecting credibility of the model**

Acknowledgements

- LA-SiGMA
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- Southern University - College of Engineering

Thank You!