Flotation Height In "Air Hockey" Spatial Atomic Layer Deposition

J. Grasso, B. Willis

Department of Chemical and Biomolecular Engineering, University of Connecticut, Storrs, CT, USA

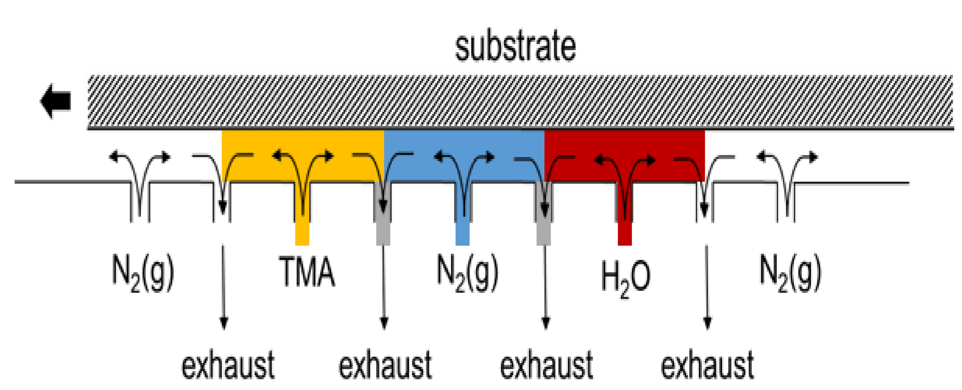
Background on Atomic Layer Deposition

What is atomic layer deposition (ALD)?

- ALD is a subclass of CVD that deposits thin films on substrates through sequential exposure of reactant gases
- Known for highly conformal films with atomic level thickness control for a wide variety of materials
- Applications include: solar cell passivation, optical films, Plasmonics, etc.

System of Interest: "Air Hockey" Reactor

- Spatial ALD system that operates analogous to an "air hockey" table
- Substrate floats on a bed of gas and travels across a deposition zone
- A nitrogen curtain separates the continuously fed precursors allowing for true ALD operation
- Spatial ALD has potential for high-throughput processing

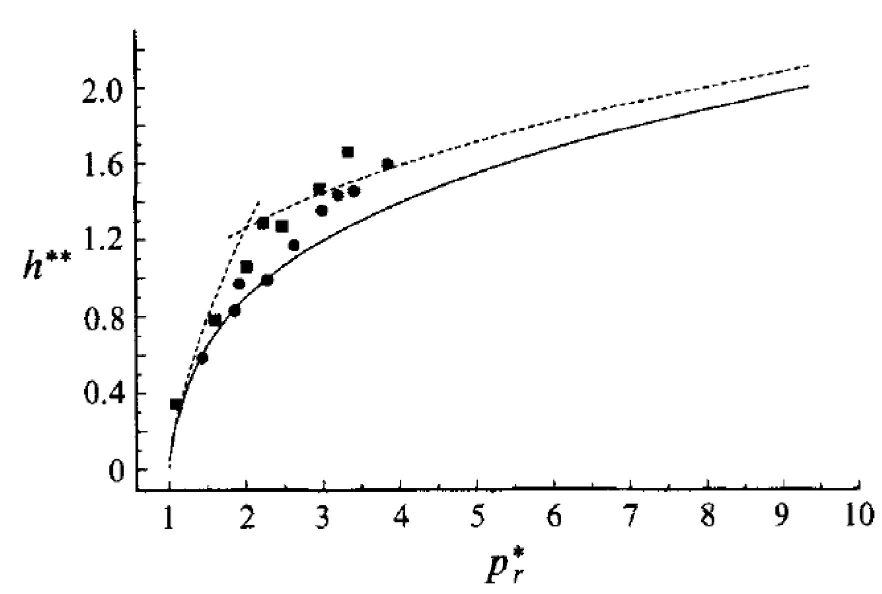


Goal of Simulation

- To gain a greater insight to the underlying fluid mechanics of the spatial ALD system to aid in improved design and performance
- In this study, a relationship between the inlet conditions and flotation height will be determined

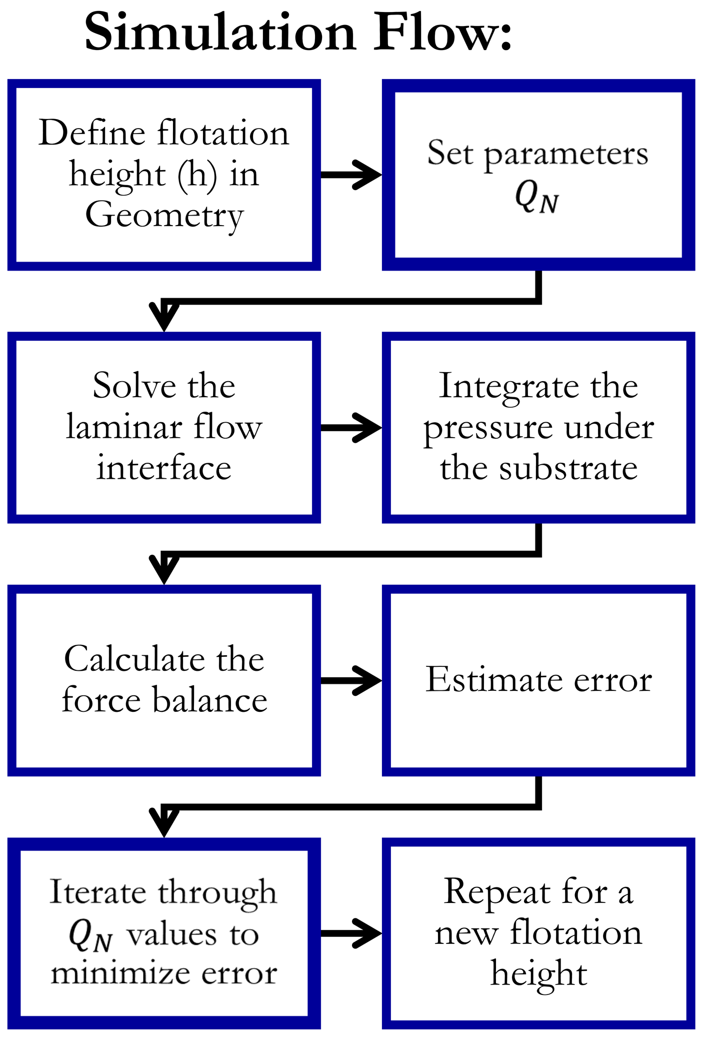
Previous Work:

- A flotation height study using a porous air table was studied
- Logarithmic relationship between flotation height and reservoir pressure



Computational Method

Simulation Flow:



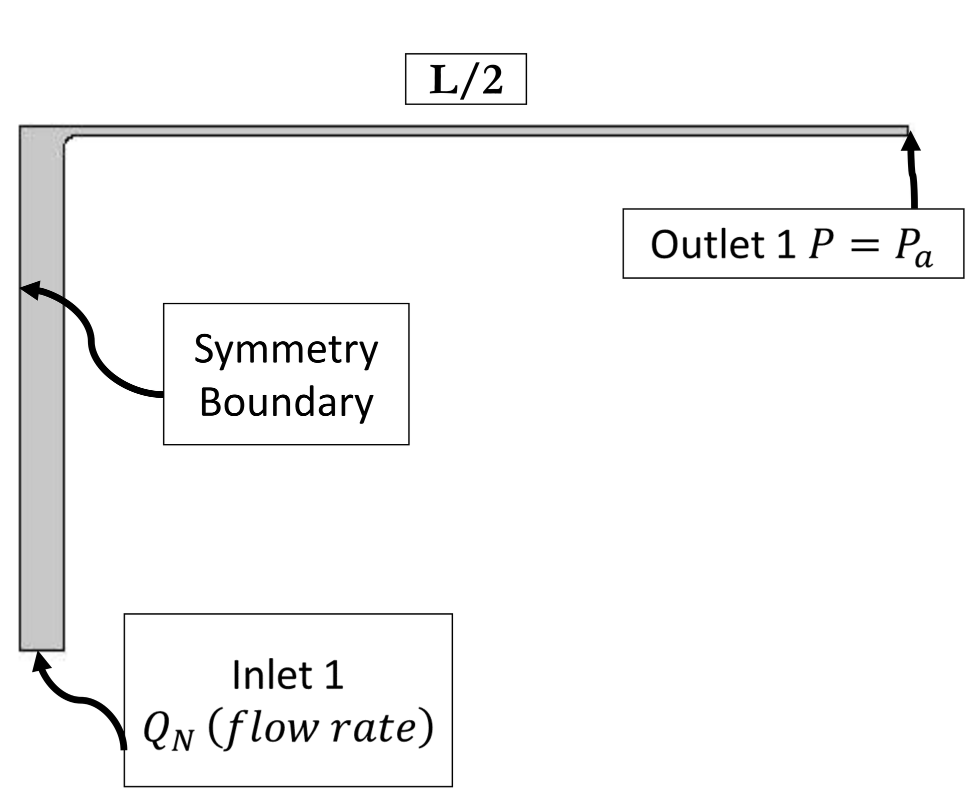
Inverse Modeling:

- The unknown variable (h) must be specified in the geometry so the parameters must be adjusted to solve for the specified flotation height, h
- Force balance on rectangular glass substrate:

$$Mg = 2W\int_0^{L/2} (P - P_a)dx$$

where:

P = pressure under substrate



Assumptions:

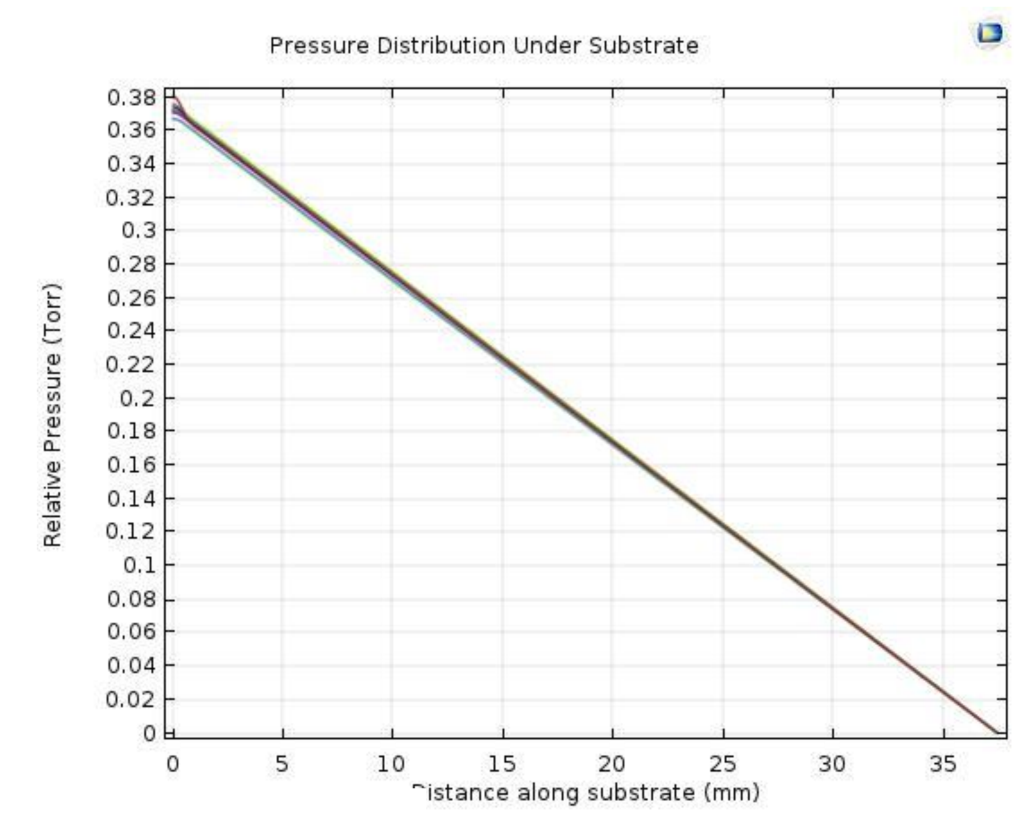
- Compressible flow
- Laminar flow
- $P = P(x)$

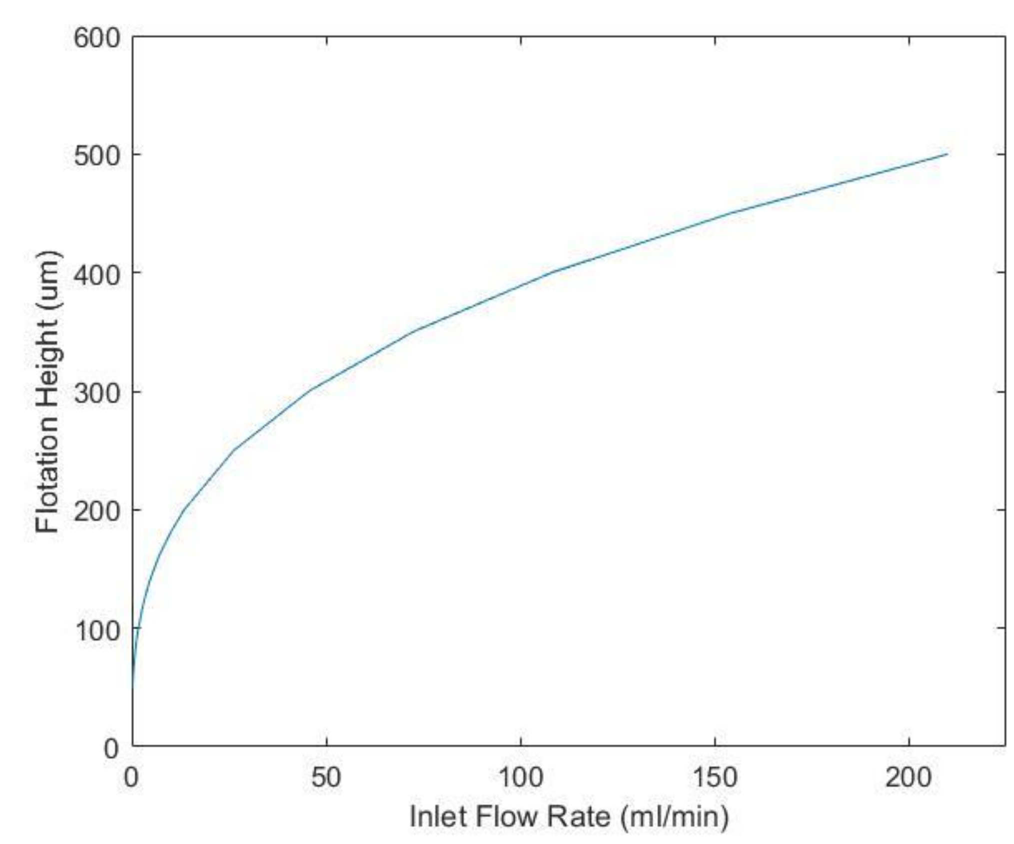
Constants:

- M(mass) = 9.53 g
- W(width) = 50 mm
- L(length) = 75 mm

Results

- The pressure distribution along the edge under the substrate offers validation of a successful force balance calculation
- Pressure distribution is unaffected by gap height
- Linear relationship is analogous with pressure drop in poiseuille flow





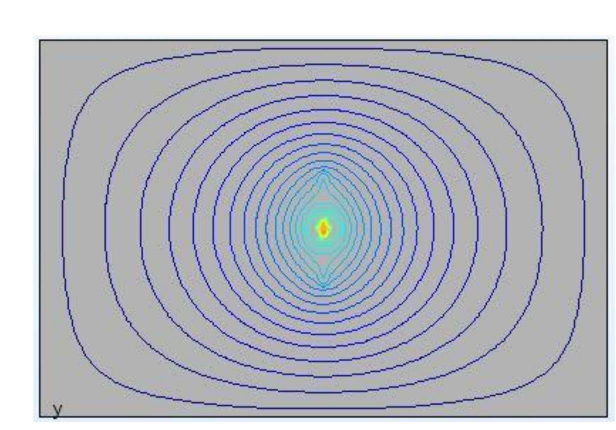
- The flow rate (Q_N) exhibits the same relationship with flotation height as reservoir pressure does for a porous air tables

Conclusions and Future Work

- The relationship developed is in agreement with previous work for porous air tables
- This study acts as a preliminary study of the spatial ALD system that will be the backbone of future work

Future Work

- Expand this model to be 3D to account for pressure variations in the y-direction



- Incorporate all inlet and exhaust vacuum vents. Using the optimization model to conduct a parameter estimation study to solve for each flow rate as well as the outlet pressures
- Collect experimental height measurements and compare with the constructed models
- Construct a model that utilizes the fluid-structure interaction physics to displace a rigid, solid substrate a distance that corresponds to the force balance
    - This could eliminate the need to perform inverse modeling
- Combine fluid flow with transport of dilute species to solve the diffusion problem to test the effectiveness of the nitrogen diffusional barrier.

References

1. E. J. Hinch and J. Lemaitre, "The effect of viscosity on the height of disks floating above an air table," Journal of Fluid Mechanics, vol. 273, pp. 313-322, 1994.
2. J. Lemaitre, A. Gervois, H. Peerhossaini, D. Bideau and J. P. Troadec, "An air table designed to study two-dimensional disc packings: preliminary tests and first results," Journal of Physics D: Applied Physics, pp. 1396-1404, 1990.