Module 12: Functional Effects & Characterization

- Is human skin more impervious to radio-active dust, or to nerve gases? What is the primary reason?
- Define the characteristic property of an aerosol that is used to determine the mist formation/ explosion potential of a heat-transfer fluid. Identify two dimensionless numbers that this property depends on. How is this property used in conjunction with cost to select an optimal heat-transfer fluid?
- Derive an expression for steady-state particle concentration a well-mixed, re-circulated & filtered clean room, considering all internal sources. Use to optimize the design of the cleanroom for minimum CCR.
- Relate the filtration efficiency of a fibrous filter to that of a single fiber. How is single fiber filtration efficiency dependent on particle size? Use the relationship to find an expression for MPPD (Most Penetrating Particle Diameter) as a function of fiber diameter.

- In a semiconductor wafer manufacturing facility, airborne particles in the vicinity of the wafer have been characterized as follows:

Average Size (μm)	**Mass Fraction**	**Mass-Transfer Nusselt Number**	**Diffusivity (cm^2/s)**
0.5 (sub-micron)	0.0001	1000	$1 X 10^{-5}$
10.0 (super-micron)	0.001	1500	$1 X 10^{-8}$

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  - Identify the two dominant deposition mechanisms in these size ranges and estimate the associated deposition rates. State any assumptions made.
  - How would the thermophoretic augmentation factor depend on air and wafer temperatures? Would the effect be greater for sub-micron or for super-micron particles?
  - Assume there is a thin film of a wetting liquid on the surface of the wafer. Name two forces of adhesion that would be weakened by this film, and one that would be strengthened. In each case, state the dependence of adhesion force on particle diameter.

- If the wafer were to be cleaned in a spin-rinse-dryer, how would be the applied centrifugal force scale with particle size? What procedure would you recommend in order to remove sub-micron particles more effectively? Describe the predominant particle removal mechanisms associated with that procedure.

- 10 % (by mass) of airborne particles sampled inside a clean room are in the size range 0.1 – 1 μm, another 20 % are between 1 and 5 μm in size, and the remainder are in the > 5 μm size range.
    - Supposing the airborne particles were a mix of organic and inorganic materials, how would you collect and analyze the particles to obtain their chemical composition? (10 Marks)
    - Describe the predominant transport mechanisms in the three different size ranges. How would you minimize the transportation flux in each range? (5 Marks)

- Describe the relevant deposition mechanisms and associated dimensionless numbers in each size range. (5 Marks)
- For an exposed dry wafer surface, what would be the predominant adhesion mechanisms in each size range? (5 Marks)
- Given that an exposed silicon wafer has a trace of moisture on it, how would the adhesion forces be altered? Consider 2 cases: (i) Wafer will be dried before next process step, (ii) Wafer will retain moisture until next process step. (5 Marks)
- What would be effective particle removal procedures in each size range? Describe the relevant mechanism for each procedure. (5 Marks)

- Describe any 3 industrial applications where particles play a beneficial role, and any two where they have a detrimental effect on product quality. In each case, identify particle characteristics of critical relevance.