

## Size Ranges of Suspended Particles

- Macro Particle Range
  - > 25  $\mu\text{m}$ , visible to the naked eye
- Micro Particle Range
  - 1 - 15  $\mu\text{m}$ , visible with an optical microscope
- Macro Molecular Range
  - 0.1 - 1  $\mu\text{m}$ , visible with a high power optical microscope
- Molecular Range
  - 1 - 100 nm, visible with a scanning electron microscope
- Ionic Range
  - 0.1 - 1 nm, not visible with current technology

## Fundamentals of Micromachining

De-Ionized Water

## Size Range of Common Particles

Atomic Radii	1-6 Angstroms
Metal Ions	2-7 Angstroms
Aqueous Salts	2-20 Angstroms
Sugars	7-25 Angstroms
Pyrogens	20-250 Angstroms
Colloidal Silica	6-250 nm
Albumin Protein	8-100 nm
Viruses	9-100 nm
Carbon Black	12-100 nm
Tobacco Smoke	20-1000 nm
Paint Pigment	0.1-5 $\mu\text{m}$
Bacteria	0.25-30 $\mu\text{m}$
Lung Damaging Dust	0.5-35 $\mu\text{m}$
Coal Dust	1.0-100 $\mu\text{m}$
Milled Flour	1.0-100 $\mu\text{m}$
Yeast Cells	2.0-50 $\mu\text{m}$
Red Blood Cells	5.0-9.0 $\mu\text{m}$
Pollens	10-100 $\mu\text{m}$
Human Hair (Diameter)	25-200 $\mu\text{m}$
Mist	70-200 $\mu\text{m}$
Beach Sand	100-10,000 $\mu\text{m}$

## Clean Water as a Processing Chemical

- Water ( $\text{H}_2\text{O}$ ) is the most prevalently used material in microfabrication processes, and is used mainly for rinsing and cleaning of wafers.
- Approximately 6000 gallons of de-ionized (DI) water are required for each 6" CMOS wafer.
- DI water must be manufactured on site to achieve the quality and purity levels required by modern microfabrication.
- Each gallon of DI water may require as much as 4-6 gallons of raw city grade water to manufacture.
- DI water must be continuously recirculated in order to achieve the quality and purity levels.

## Types of Water Filtration

- Particle Filtration
  - 1-75  $\mu\text{m}$  cartridge filters: cellulose, fiberglass, or polypropylene fibers
- Microfiltration
  - 0.1-1.0  $\mu\text{m}$  cartridge filters: ceramic or polymer membranes
- Ultrafiltration
  - 20-2000 Angstroms: chemically based
- Reverse Osmosis (Hyperfiltration)
  - 1-200 Angstroms: uses special membrane and high pressure to overcome osmotic pressure