1. **Cleanliness in Microfabrication**

   → A requirement for success

   a) **Particles in the environment**

   → dust, pollen, mold, dead skin cells, hair, etc.

   → consider that the average human hair is 100μm in diameter → imagine the result of 1 hair landing on a wafer of MEMS devices with 2μm features, during microfabrication

   → Many dust particles are electrically conductive

   → can short out electrical MEMS structures

   → Cleanroom suits are worn by microlab workers to minimize contamination from workers

   → hairnet

   → face mask

   → low dust cleanroom suit

   → booties

   → low dust gloves

b) **Cleanliness Definition**

Class X Cleanroom → less than X of 0.5μm or larger particles per ft$^3$

Ex: Class 1000 cleanroom: <1000 0.5μm+ particles per ft$^3$
Typical outdoor environment: ~ 400,000 particles per ft$^3$

<table>
<thead>
<tr>
<th>Class</th>
<th>Fabrication Limit (feature size)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1000</td>
<td>4 μm</td>
</tr>
<tr>
<td>100</td>
<td>1.25 μm</td>
</tr>
<tr>
<td>10</td>
<td>0.7 μm</td>
</tr>
<tr>
<td>1</td>
<td>0.3 μm</td>
</tr>
<tr>
<td>0.1</td>
<td>&lt;0.1 μm</td>
</tr>
</tbody>
</table>

→ Imagine the cleanliness required for sub-10nm devices

(show paper)
→ Most likely fabrication is 100% robotic → no people in the cleanroom

C) Besides Clean Air
→ High purity chemicals must also be used in microfabrication → expensive

A. Water
→ Water for use in microfabrication must be "deionized"
→ Ions in water (particularly Na) can migrate into Si and other materials, contaminating them
→ Deionized water is called "DI water"
→ Tap water resistivity ~ 50 kΩ-cm
→ DI water resistivity ~ 18 MΩ-cm

² Note: textbook has error in units, p. 34