1.2 starts here (no 1.1)

The needs of scientists and engineers.
And Equipment and Instrumentation

needs: slide 1 Transfer of energy across multiple length scales
slide 2 Combining top-down with bottom-up approaches } inter disciplinary
3 - Interfacing biological and synthetic systems
4 - Observing reactions / processes in real time (pent. seconds) }
5 - Increased resolution
- and a long etc.

Requirements: All these needs require the combination of expertise in different disciplines and combined efforts to advance equipment and characterization techniques.

In addition, scientists and engineers require space which is properly designed to enable interaction btw different teams and allowing the sophistication required by advance characterization and fabrication techniques.

Specific characteristics of buildings / space dedicated to research and development of nanotechnology:

[1] INTERACTIVE SPACE   slide 6 and video on it.

A state-of-the-art research and manufacturing center should combine technical (imaging, clean room, characterization, manufacture) and non-technical (offices, meeting rooms, ...) spaces in an effective way, with the main goal to promote interaction btw different teams, as well as to facilitate transfer of systems btw different technical spaces.

Below there is a list of different spaces that need to be included in a successful nano-research/manufacturing facility:

- Dry and wet labs
- semiconductor and bio-chem rooms (different)
- Quiet labs
- Imaging labs (imaging)
- Optical labs (metrology)
- Shielded labs (electronics) accuracy)

In addition, such a facility should provide for external users and visitors from industry and academy, including government agencies, physics, chemistry, biology (and others) departments, etc.

Focusing on technical spaces, one needs to account for <u>environmental considerations</u>:

[2] TEMPERATURE AND HUMIDITY

Let's take the example of a TEM, the technique most demanding in terms of T stability. (show picture of UCF TEM) slide 7

$T = 20 \pm (0.01 \text{ to } 0.25)^\circ C$

Temperature drift $< 0.5^\circ C/h$ (fluctuation $< 0.05^\circ C/min$)

Heat generated by a 300 keV TEM column and support equipment are 500 W and 1000 W, respectively.

For this to be ~~controlled~~ achieved, one needs to control:

- lights
- heat transfer through walls
- high air exchange > 300 AC/h

Humidity is crucial for other instruments. $< \pm 1\%$ (good) $< \pm 5\%$ (ok)

3 ELECTRICITY AND EM NOISE

Many equipment units, and most importantly, measurement techniques, particularly regarding degree of sensitivity and accuracy, rely on a good control of the electrical power feeding the corresponding instrumentation.

Power disturbances occur from external and internal sources:
- External: lighting, faults, utility switch surges, ...
- Internal: Mechanical equipment, elevators, lab equipment...

Several ways to reduce power disturbances:

- power conditioners,
- dedicated circuits
- shielded-isolation transformers
- uninterruptible power suplies (UPS) show in utility corridor

In addition, there are other external/internal sources of electromagnetic disruptions, such as:

- ground currents
- line signals (60Hz)
- ELF (extra low freq.) and EMI (electromagnetic interference) sources
- sources of heat (which translate in electrical disruptions).

Especial care needs to be taken when dealing with some nanotechnology processes, since these disruptions can be very problematic. Show example of noise and its effect in a STM measurement - slide 2

Electromagnetic Shielding (Faraday cage, shielding rooms.) show shielding slide 3

~~For information on solving these issues go to www.HDRINC.com~~

4 VIBRATION AND ACOUSTICS

Many laboratory operations are sensitive to vibrations, and these are more important the higher the sensitivity or accuracy of the process is.

- Metrology
- TEM, SEM, STM (imaging)
- Lithographies (EBeam, photo...)

Other equipment are also affected by vibrations, although to a lesser extend.

Sources of external vibration are multiple:

- Machinery
- traffic
- human activity
- ....

The effect of mechanical vibrations depend on:

- amplitude
- duration
- frequency

Standards to describe recommende vibration criteria (VC)

Generic vibration criteria curves: Given to architects to deal with vibrations.

Show a VC curve (slide 4)

Specific VC curves: For different equipment and techniques

Show VC curves in slide 5

It represents the rms velocity (calculated from $V = 2\pi f \lambda$ [→ displacement wavelenght]) in sets of one-third octave band. It is calculated within proportional band widths

(Show curves in slides)

5 MECHANICAL NOISE

Noise is measured in bels, or decibels (dB)

$$1\,dB = 10 \log\left(\frac{I}{I_0}\right)$$

The sound-intensity-level dB(SIL) reference is standarized to the threshold intensity of hearing in humans in air,

i.e., 1kHz with $I_0 = 10^{-12}\,N/m^2$

the sound-pressure-level dB(SPL) relative to 20 μPa, is the minimum sound a human can hear in air (a mosquito 3m away)

→ Sound sources are primarily coming from A/C, ventilation, machinery...

→ solutions : - acoustic mitigation covering (tiles, curtains, etc.)
- silencers, narrow ducts channels, reducing air flow in A/C

6 CLEAN ROOMS

clean spaces where the number of particles over a certain size is limited.

Show tables in slide 6-8

TO FINISH, SUMMARIZE ALL SPECIFICATIONS WITH slide 9

CHAPTER 1 SUPPORT MATERIAL

slide 1 - TEM at UCF
video of TEM at work
show clean room and some support equipment in building (UPS)

slide 2 - STM image with EMI noise...
www.HDRIMC.com (info to eliminate power disruption)
slide 3 - EM shielding of a room
slide 4 - VC curve (generic)
slide 5 - VC curves (specific)
slides 6/8 - Clean rooms
slide 9 - all specifications together