A Novel Method of Applying UVC to Eliminate the 'Canyon Wall Effect' of Textured Surfaces in Healthcare Environments

Maya Jaffe

Georgia Institute of Technology

Biomedical Engineering Undergraduate

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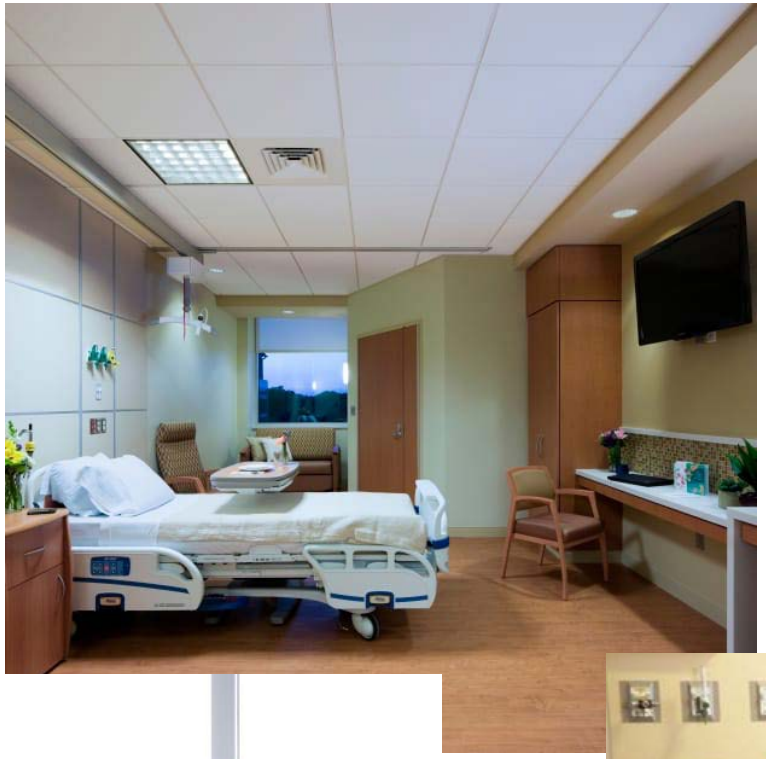
Dimer UVC INNOVATIONS

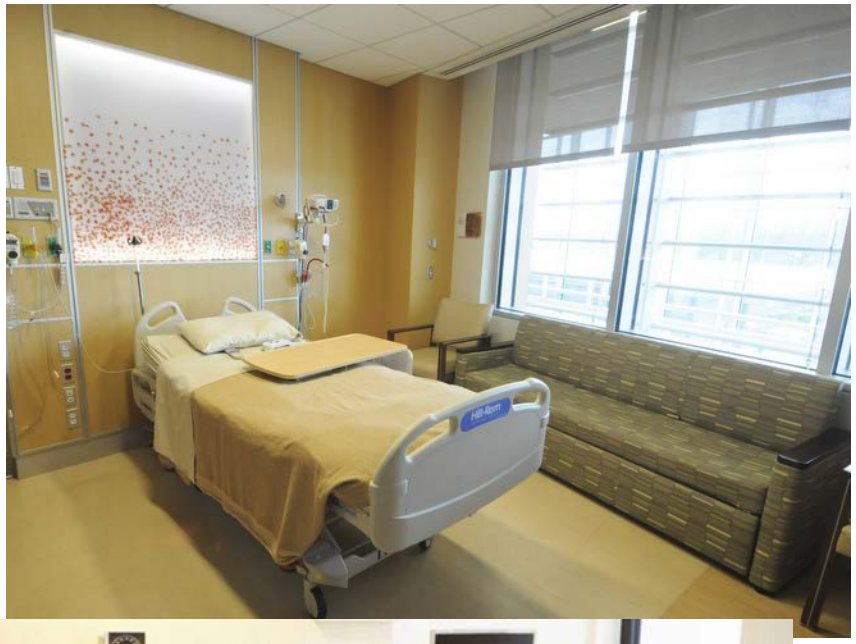
Georgia Institute of Technology

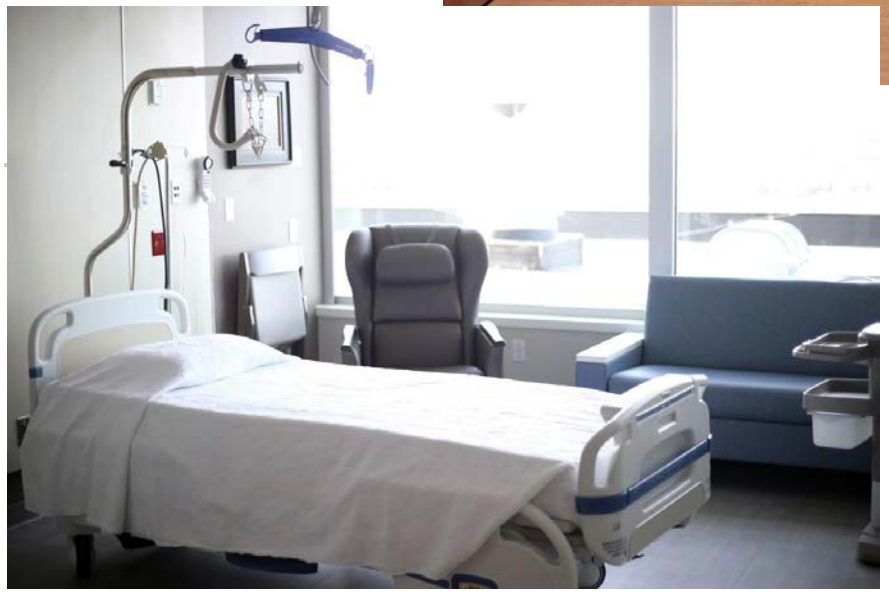
Outline

1. Textured Surfaces in Healthcare
2. The ‘Canyon Wall Effect’
3. Experimental Design and Results
4. Recommendations

Characterizing Hospital Environments/ Surfaces







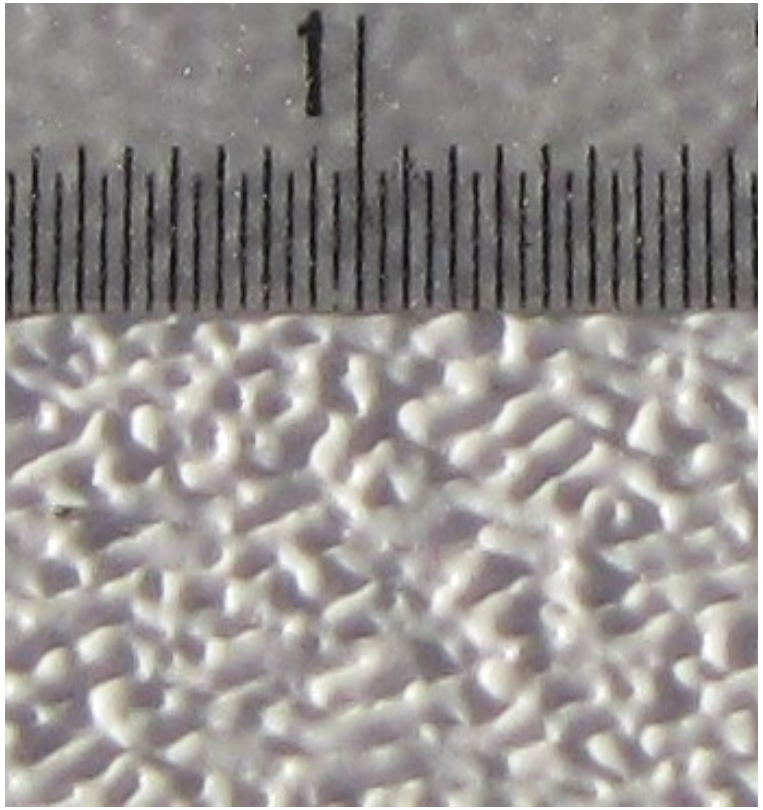
Hospital Room Disinfection

- Hospital Acquired Infections (HAIs)
  - Clostridium difficile (C. diff)
  - Staphylococcus aureus (MRSA)
- Chemical and UVC
- UV Advantages
  - Efficiency
  - Safety
  - Effectiveness

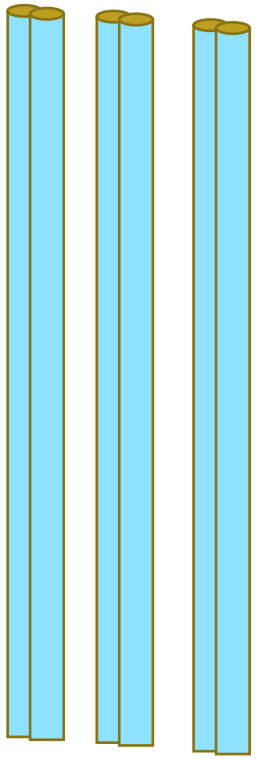
UV Disinfection Considerations

3 aspects to consider when placing lamp:

1. UV Lamp Strength

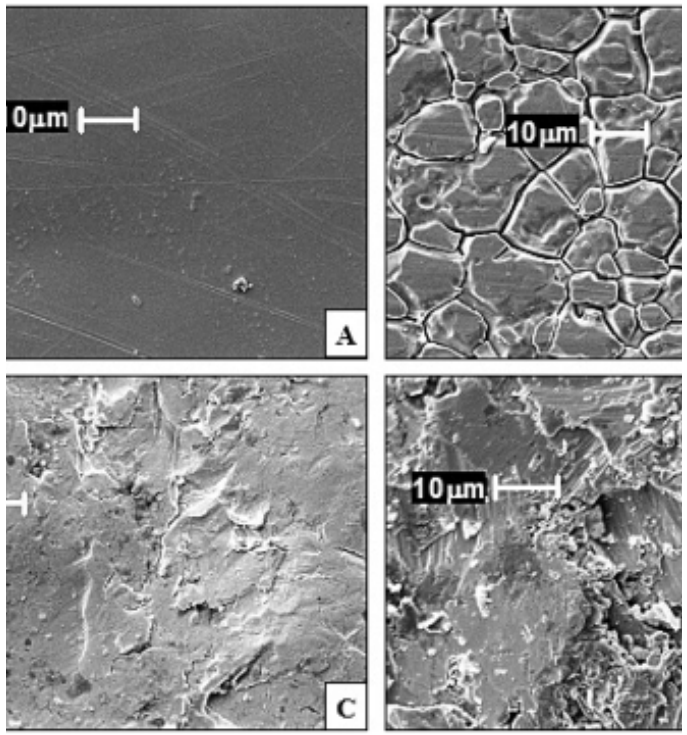


2. Surface Roughness (Texture)

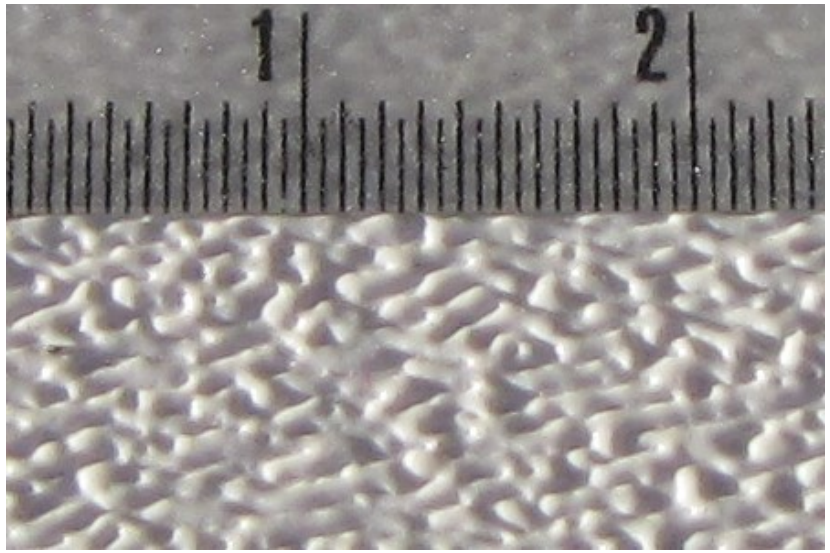


3. Incident Angle

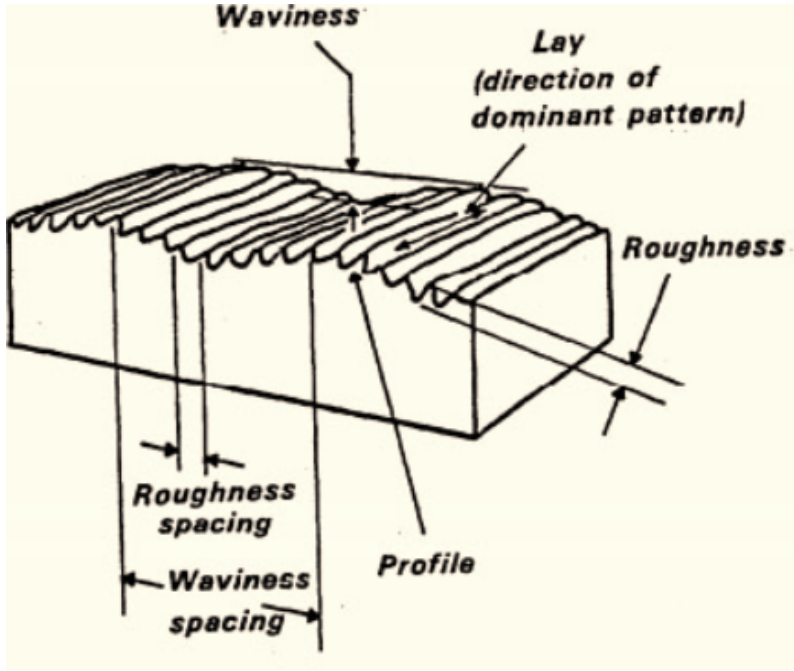
Quantifying Surface Texture



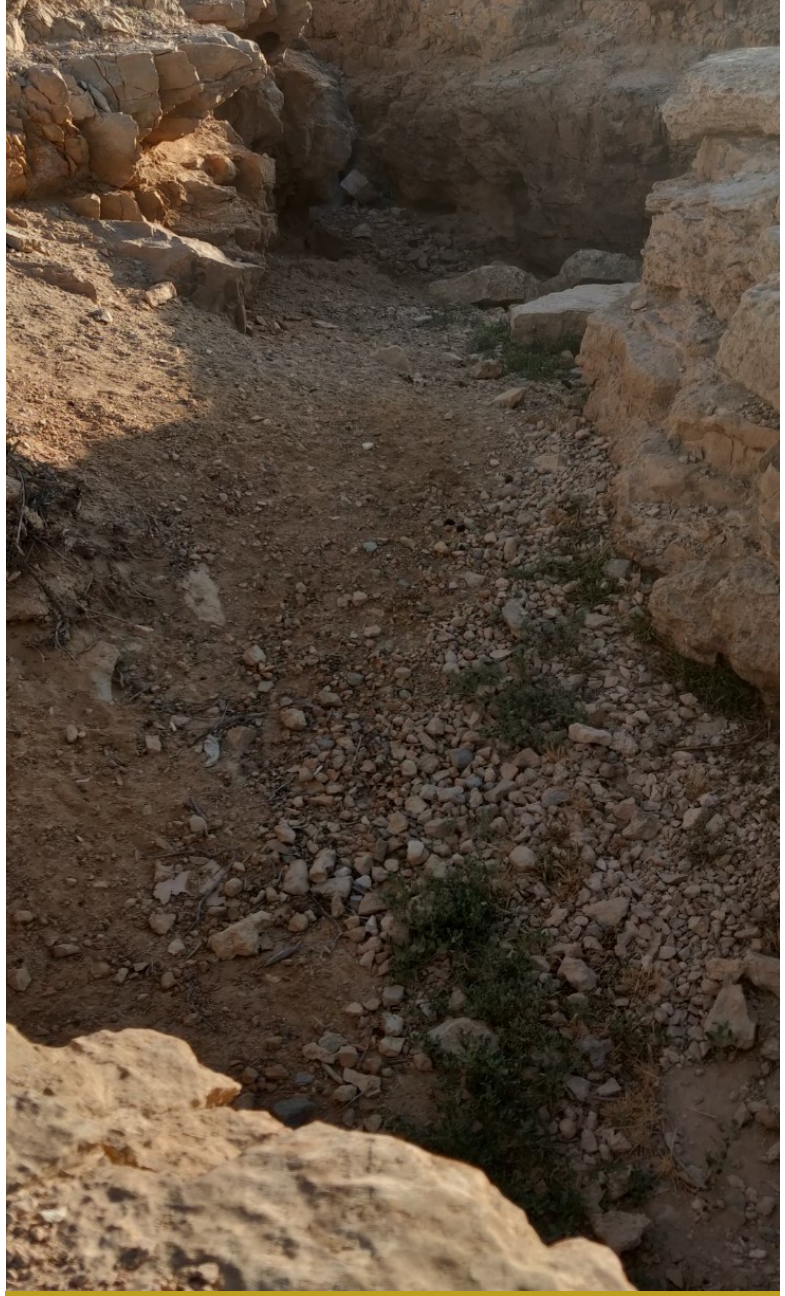
Stainless steel under microscope with different finishes.



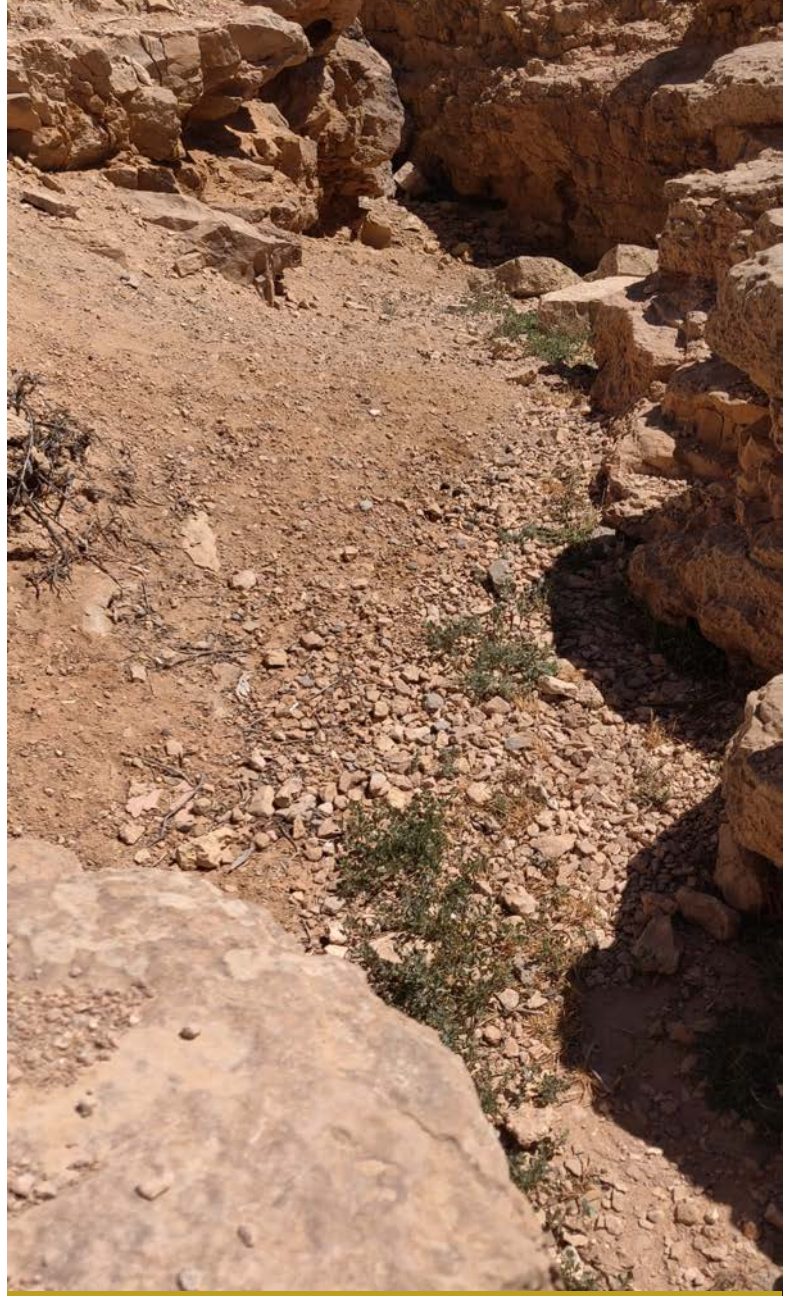
Enlarged view of typical textured surface found in healthcare settings.



The 'Canyon Wall Effect'



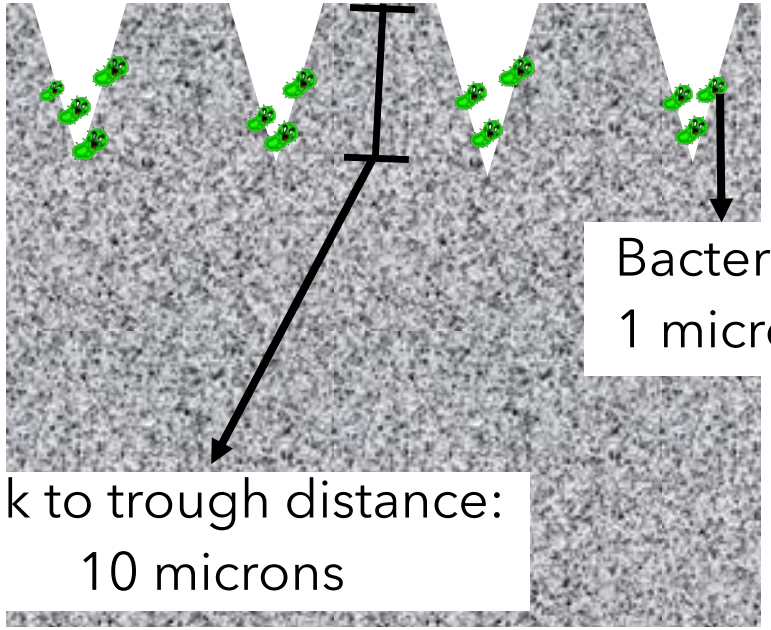
9am canyon – 2m deep



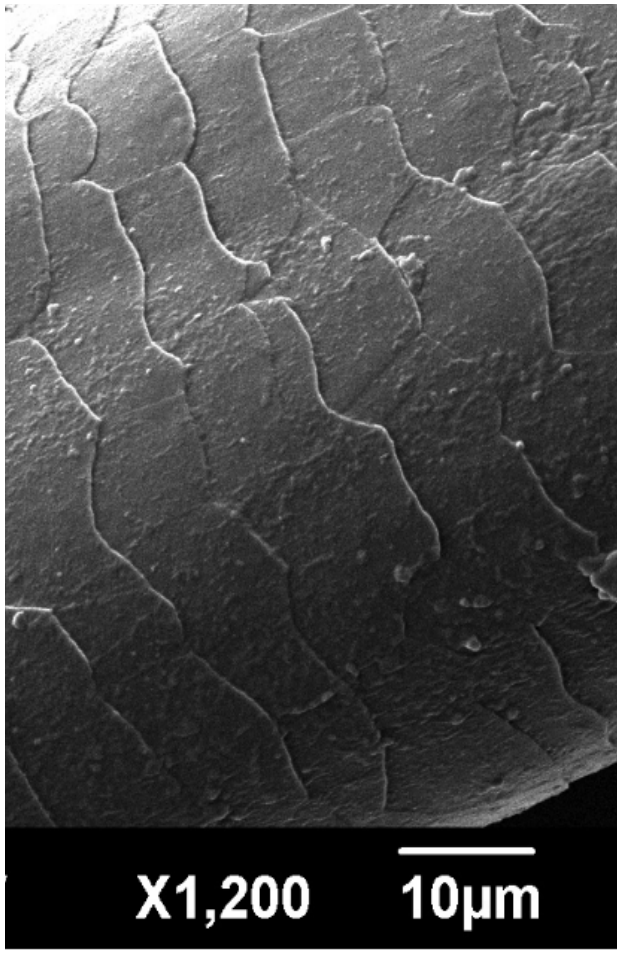
12pm canyon – 2m deep

The ‘Canyon Wall Effect’ on a Submillimeter Scale

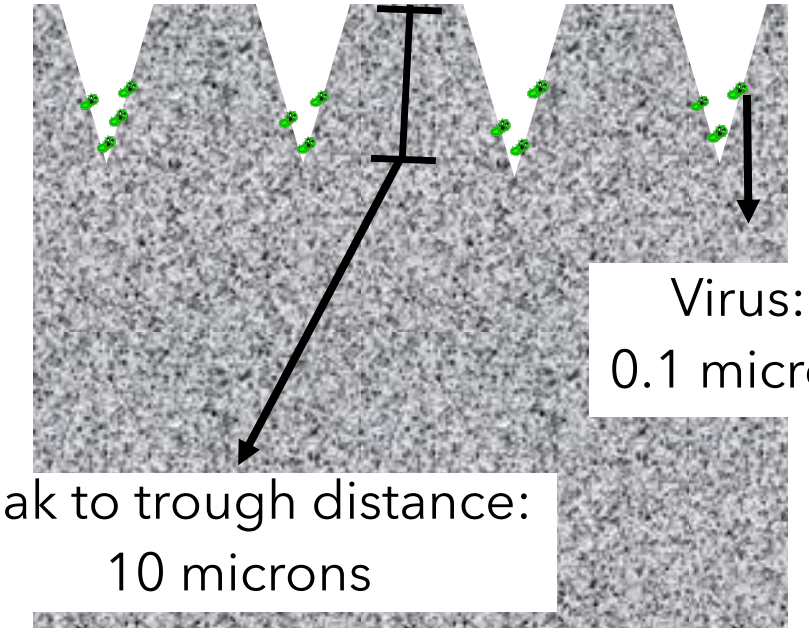
Bacteria



Equivalent to hiker in
100m deep canyon



Viruses



Equivalent to hiker in
1000m deep canyon

Is the ‘Canyon Wall Effect’ real?

Problem Statement

Problem statement: Most healthcare surfaces are horizontal and textured. Most UV emitters use only vertical UVC sources, meaning that bacteria on surfaces experience the ‘canyon wall effect.’

Hypothesis

Hypothesis 1: UV lamps positioned parallel to the surface will have greater germicidal effectiveness than UV lamps placed perpendicular to the surface.

Hypothesis 2: This importance of where you place the UV lamp is more pronounced with textured surfaces than a smooth surface.

Testing the ‘Canyon Wall Effect’

- 2 independent variables:
  - UV orientation relative to surface (parallel vs. perpendicular)
  - Surface texture (smooth vs. textured)

<u>Experimental conditions</u>

Parallel:

- UV applied parallel to *smooth* surfaces
- UV applied parallel to *textured* surfaces

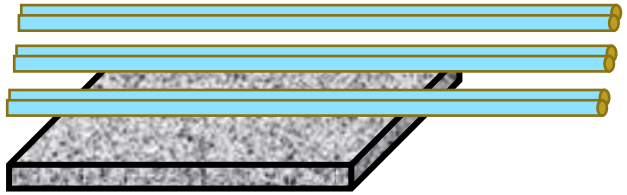
Perpendicular:

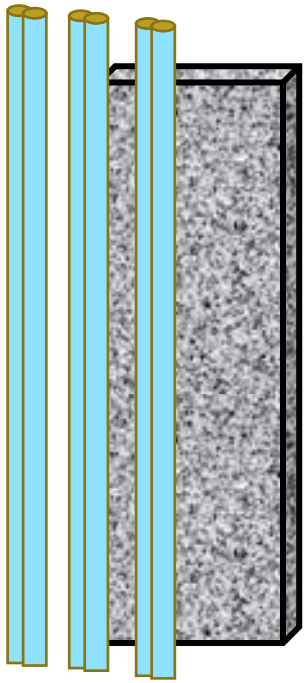
- UV applied perpendicularly to *smooth* surfaces
- UV applied perpendicularly to *texture* surfaces

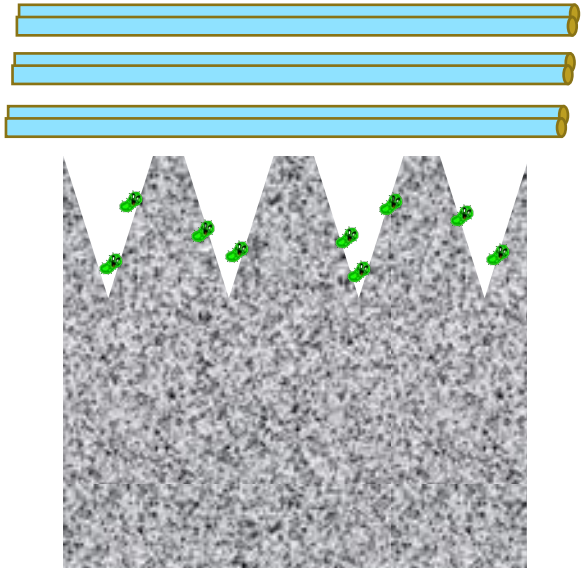
Definitions

Parallel:

UVC lamp (light source) placed parallel to surface being disinfected.

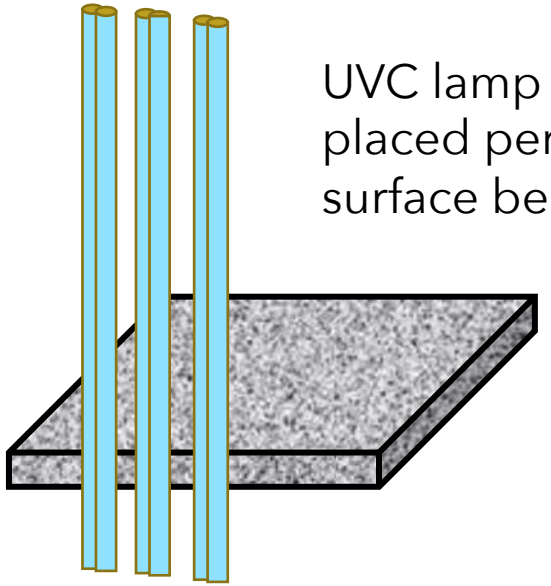


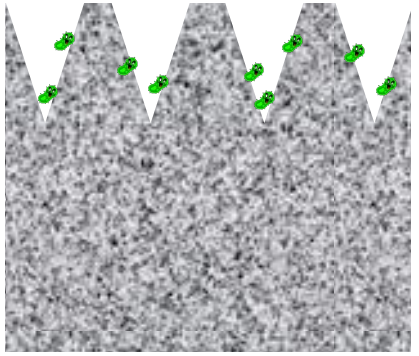


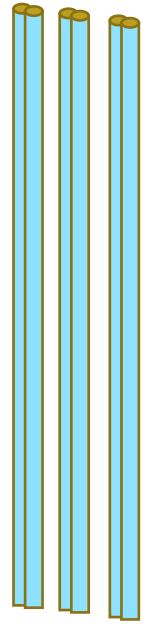


Perpendicular:

UVC lamp (light source) placed perpendicular to surface being disinfected.

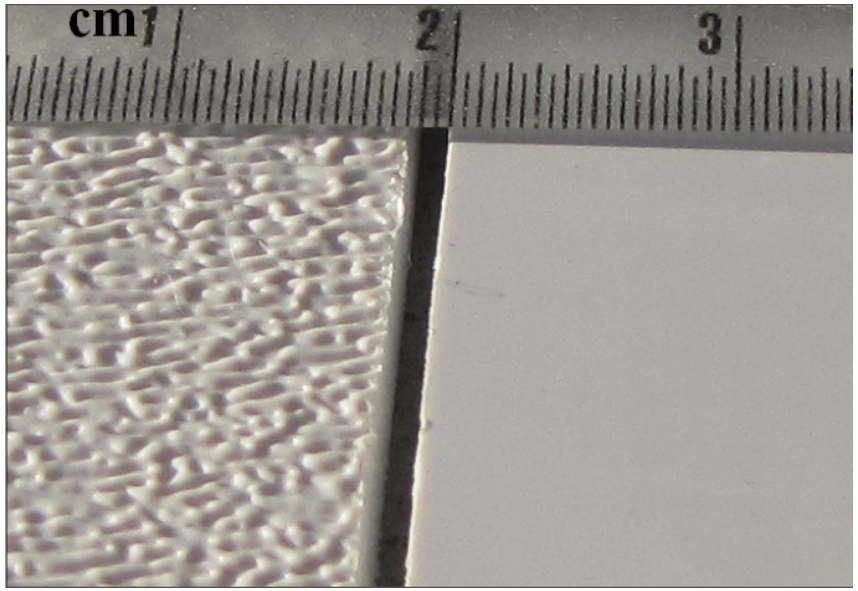






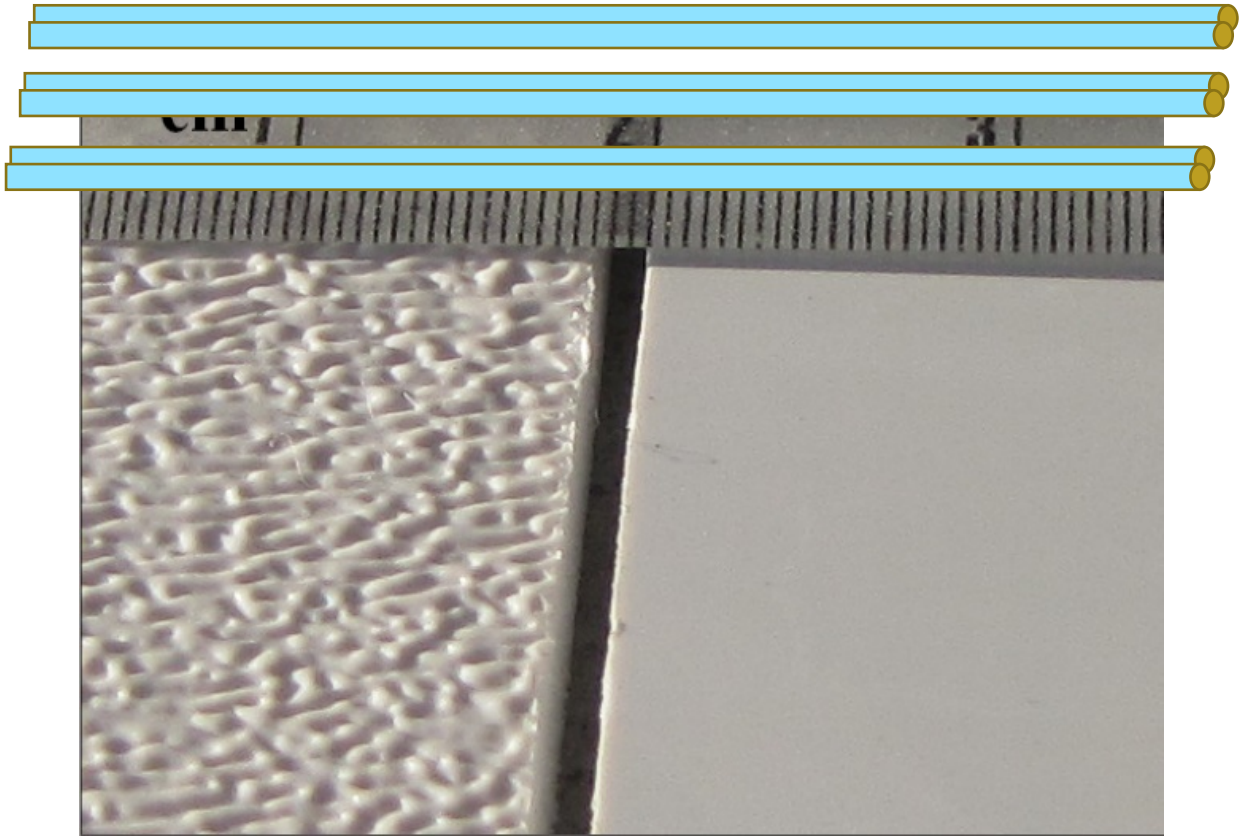
Materials for the Experiments

- 8cm by 8cm disinfected ABS plastic tiles
  - Common in hospital rooms
  - Smooth and textured (shown to the left)
  - Low UVC reflection
  - Uniform and random texturing
    - 1mm peak-valley height
- *S. aureus* solution
- UVC meter
- UVC light → UV Hammer Device
- Baird Parker contact plates



Methods: **Parallel** Lamps on Smooth vs. Textured Surface

UVC applied parallel to smooth and textured tiles.



Methods: **Parallel** Lamps on Smooth vs. Textured Surfaces

S. aureus prepared through culture and incubation.

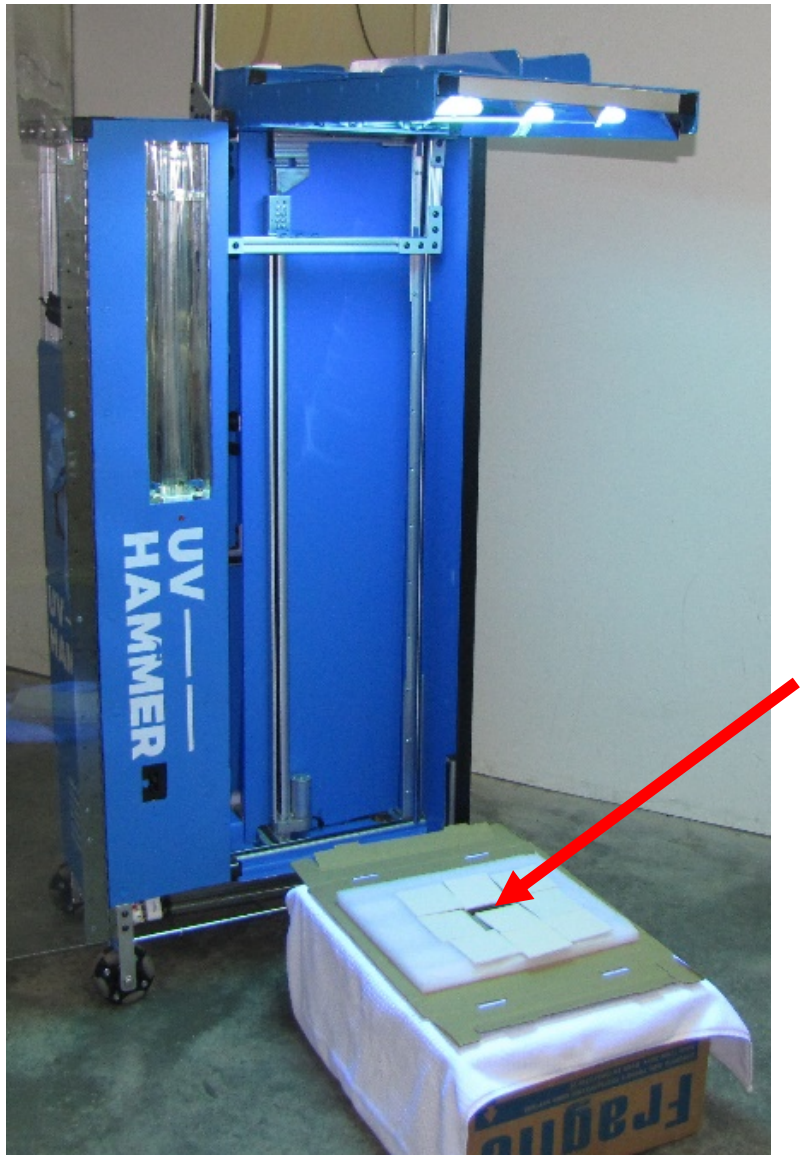
1.1 m from light source

Lamp length: 505 mm

Smooth tiles and textured tiles.

Lamps powered until meter read 5, 10, 20 mJ/cm^2

Stationary



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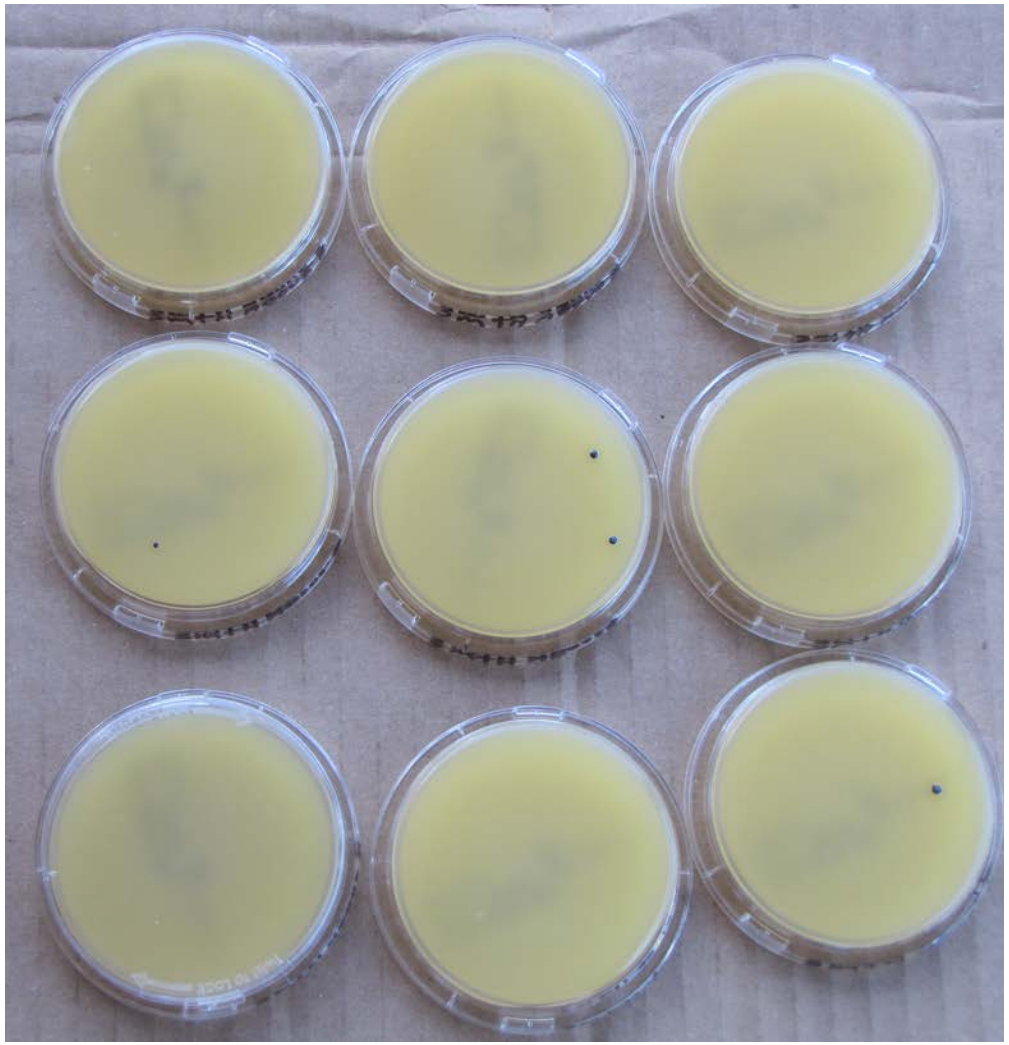


Quantitative Baird Parker contact plates contacted to the tiles.

Incubated at 35-39 C for 36 hours.

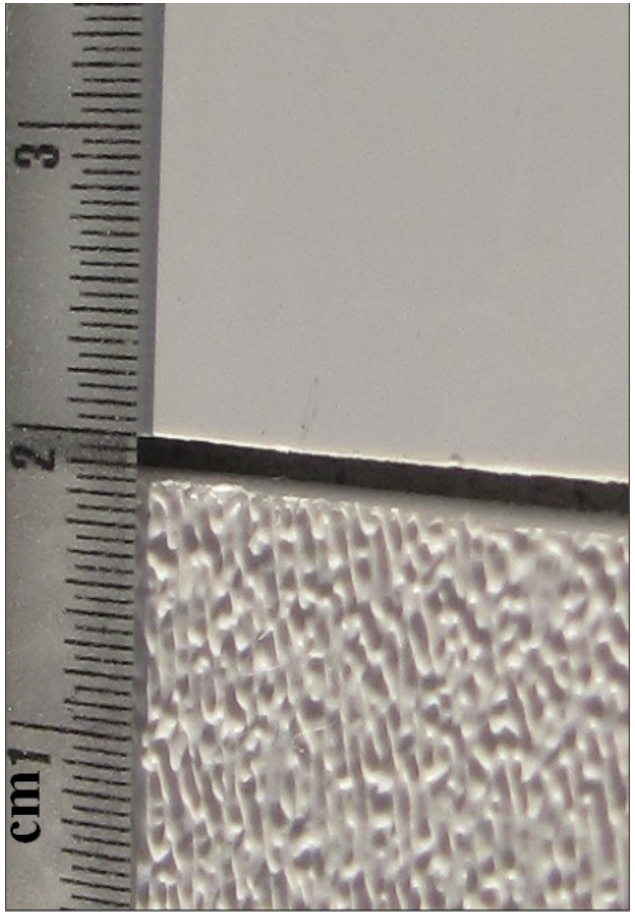
Photographs taken of plates.

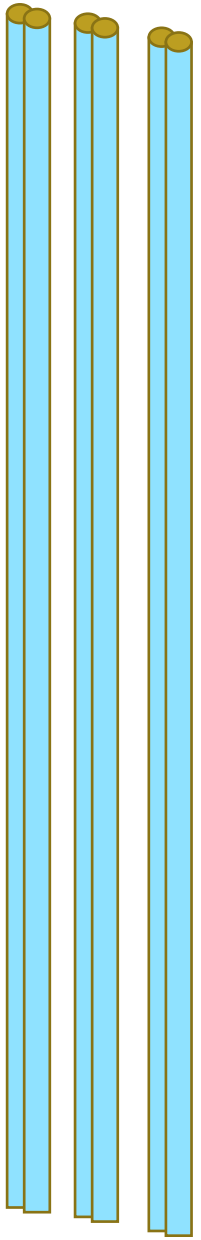
Bacteria on each plate counted.

Statistical and data analysis on plate counts.

Methods: **Perpendicular** Lamps on Smooth vs. Textured Surfaces

UVC applied perpendicularly or to the side of smooth and textured tiles.





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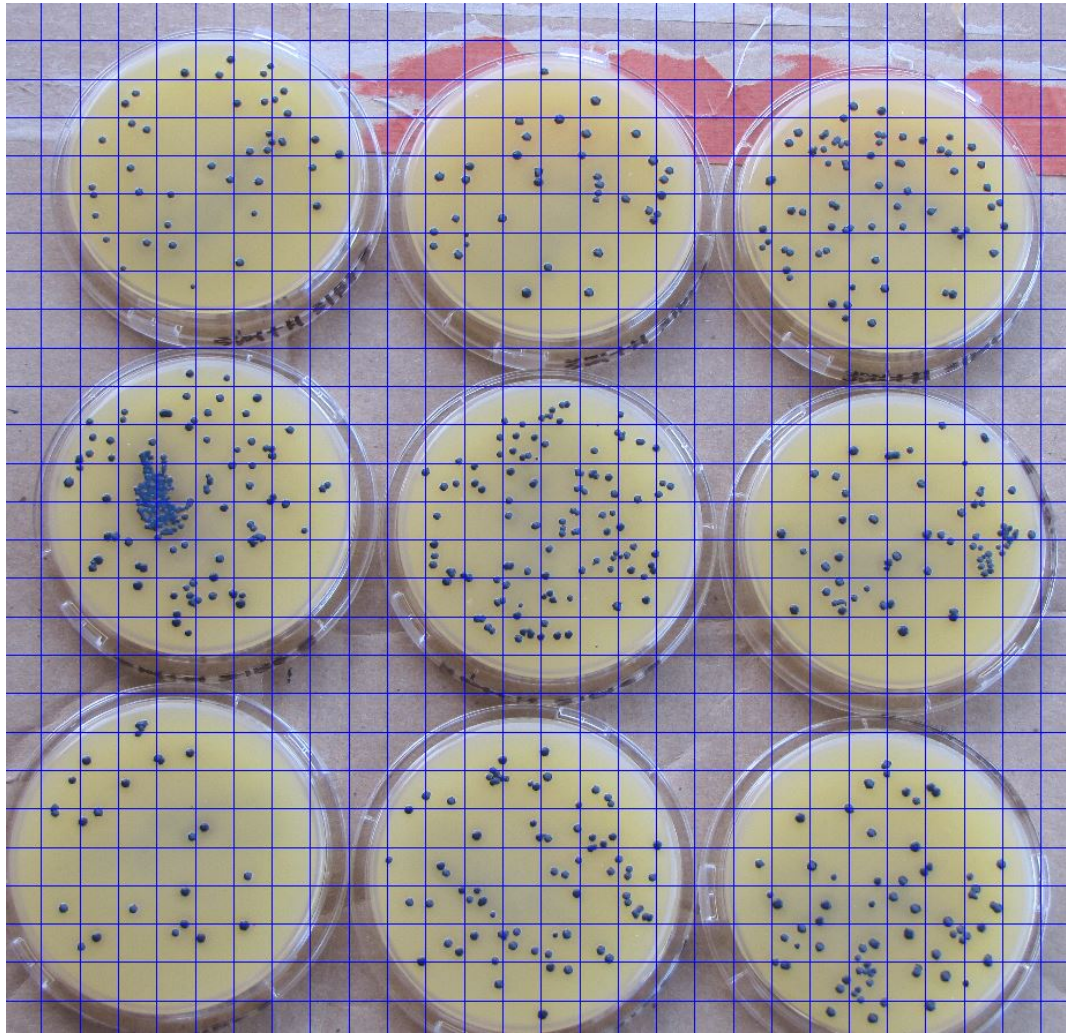
Methods: **Perpendicular** Lamps on Smooth vs. Textured Surfaces



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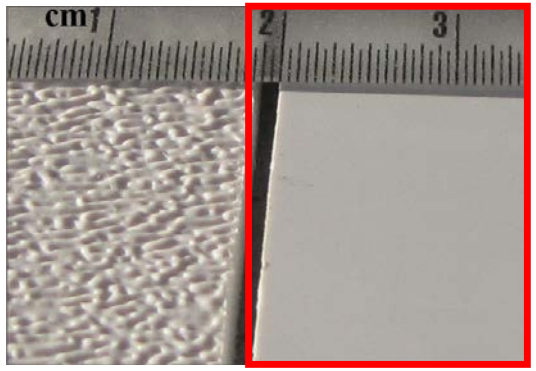
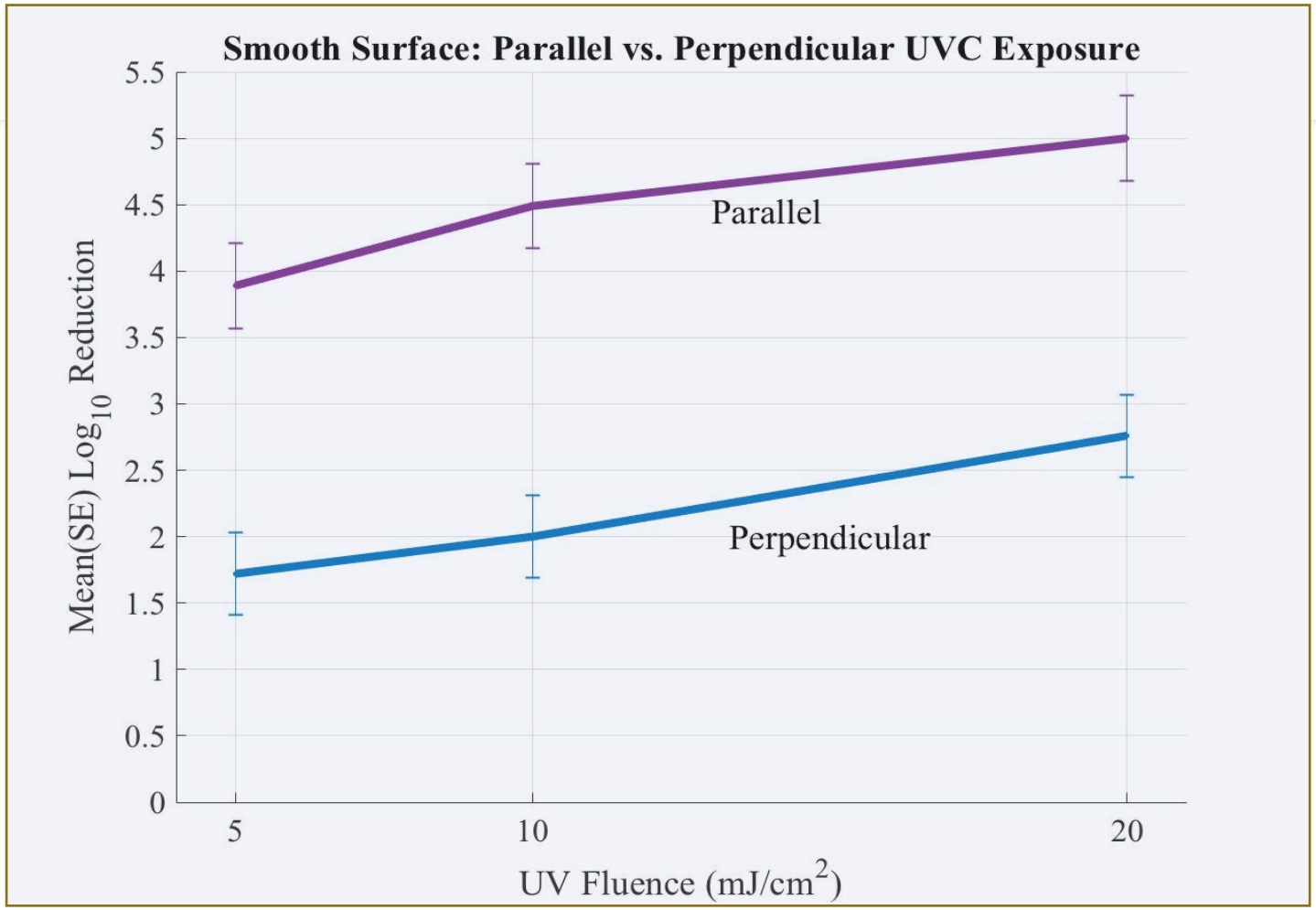
Results

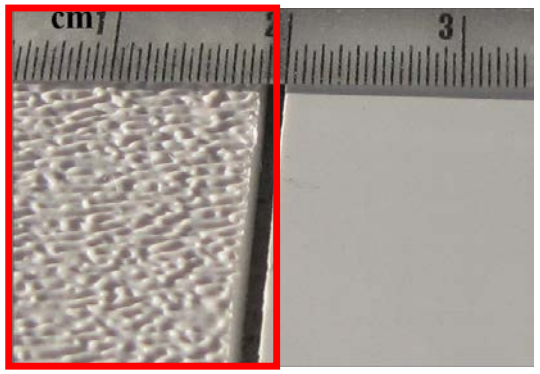
Smooth Surfaces

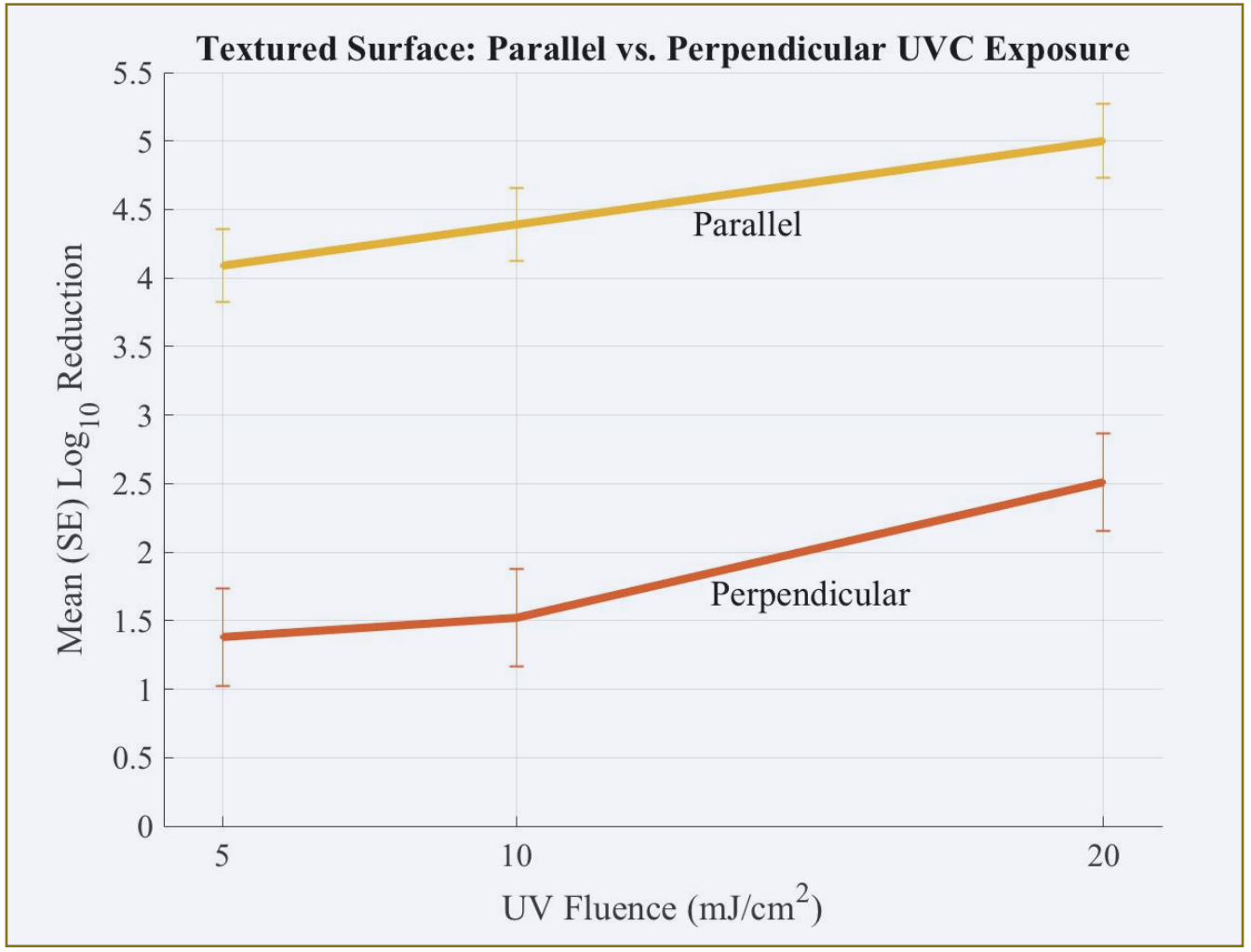




150x difference

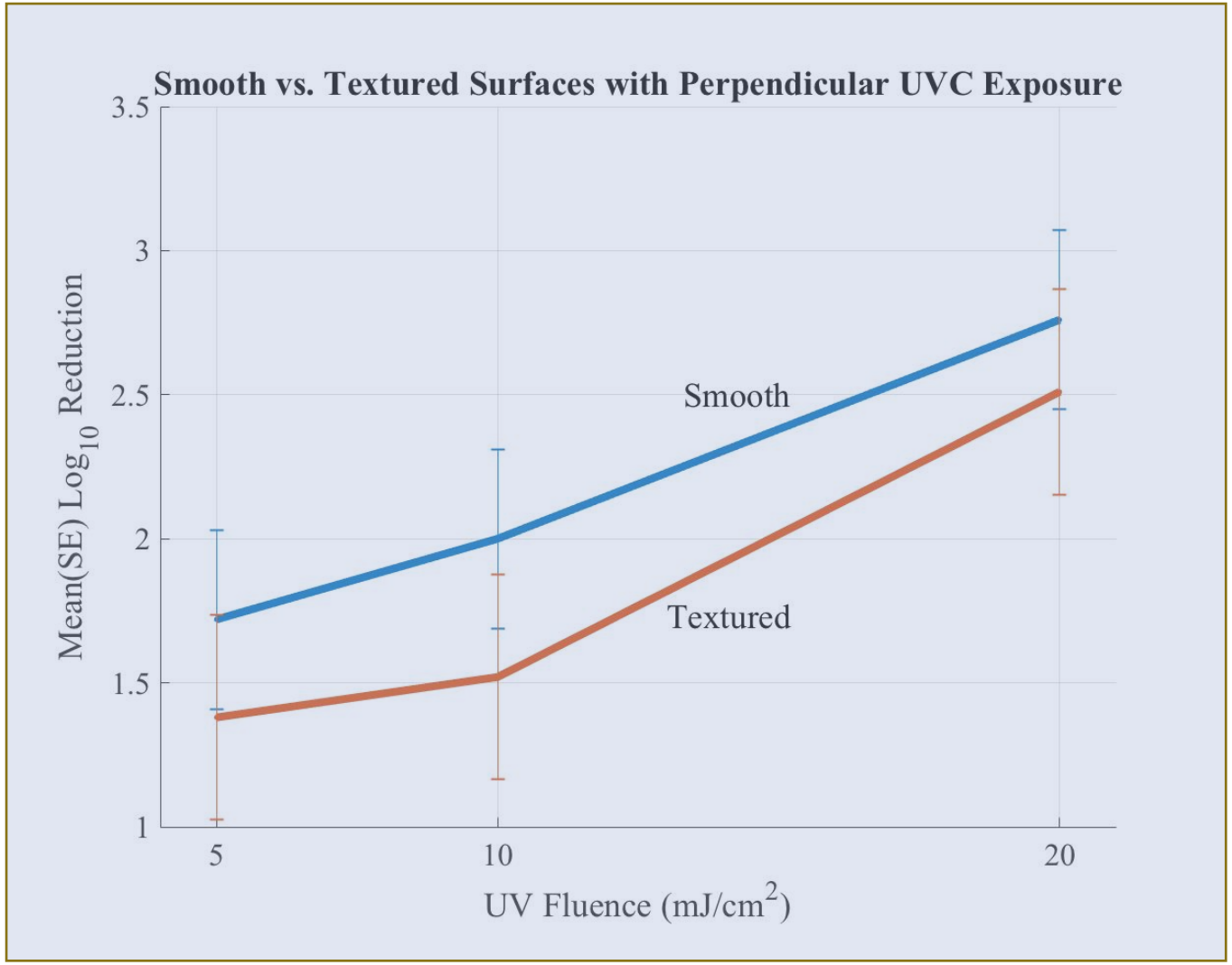
Textured Surfaces





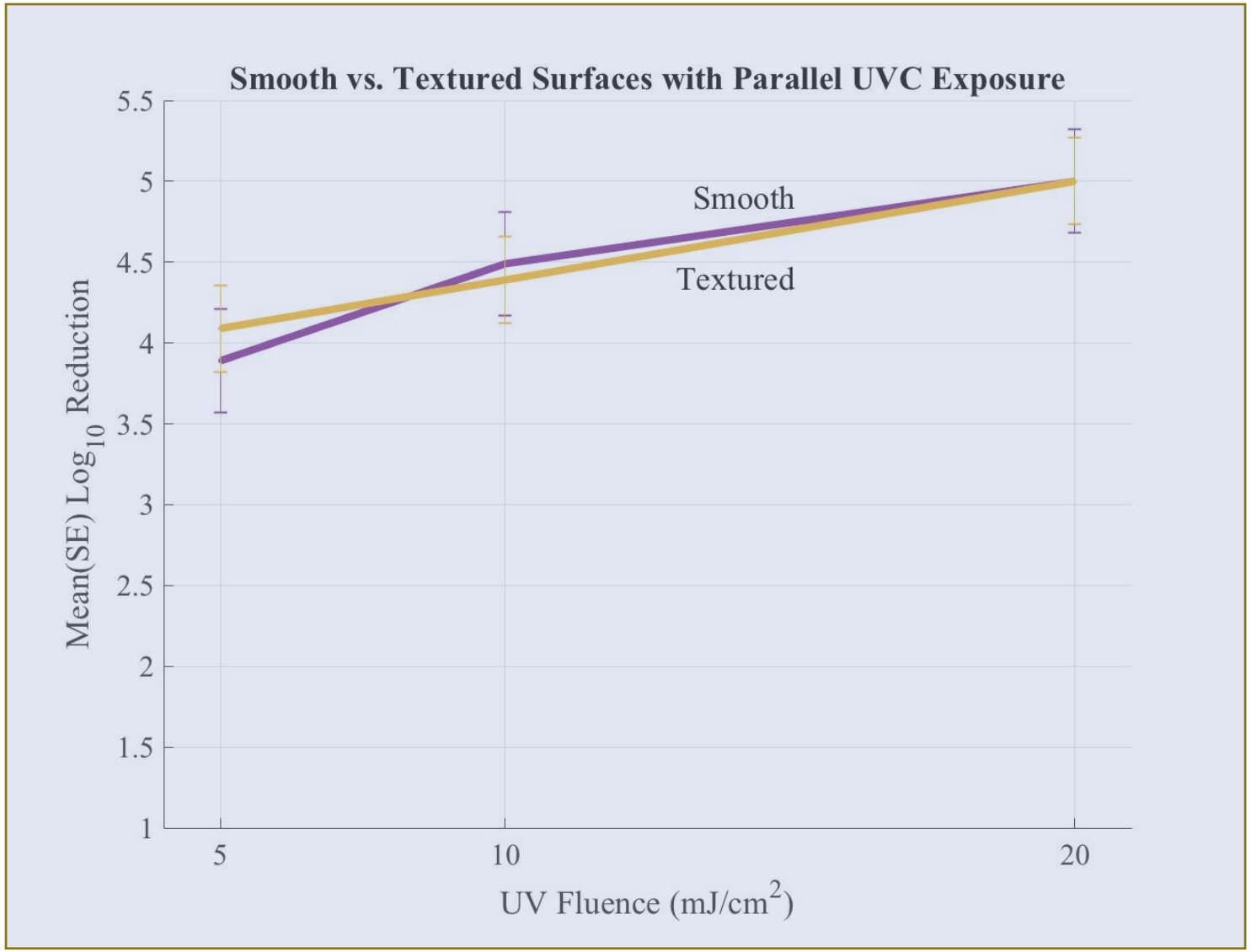
500x difference

Perpendicular



Parallel


UV
HAMMER


Smooth vs. Textured Surfaces with Parallel UVC Exposure
Mean(SE) Log10 Reduction
5.5
5
4.5
4
3.5
3
2.5
2
1.5
1
Smooth
Textured
5
10
20
UV Fluence (mJ/cm2)

Conclusions

- **150x reduction** for smooth tiles when lamps placed parallel vs. perpendicularly
- **500x reduction** for textured tiles with lamps placed parallel vs. perpendicularly
- Significant difference between smooth and textured surfaces when UV applied perpendicularly
- No significant difference between smooth and textured surfaces when UV applied parallel

UV Applied parallel eliminates the canyon wall effect!

Summary

- UV is a practical room disinfection method
- 'Canyon wall effect' is real
  - Shadowing happens on a submillimeter scale
- When disinfecting, must consider:
  - Angle of incidence
  - Degree of texture/smoothness
- Texture cannot be ignored!
- UV applied parallel eliminates the 'Canyon Wall Effect'