



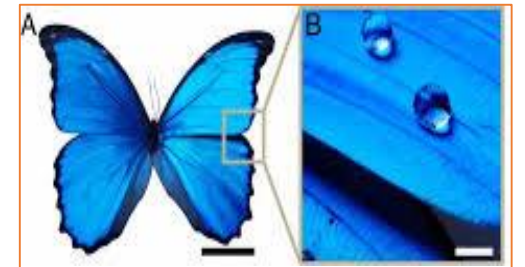
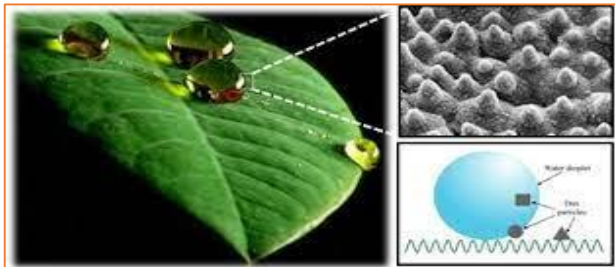
# Understanding the role of surface oxidation on wettability of laser textured surfaces

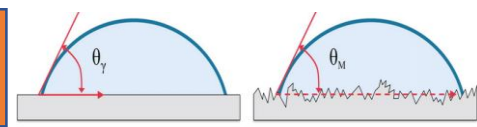
**Ilemona Sunday OMEJE**

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*Supervisor: Tatiana E. ITINA*

**Manutech SLEIGHT Science Event #8 (July 5<sup>th</sup> 2022)**

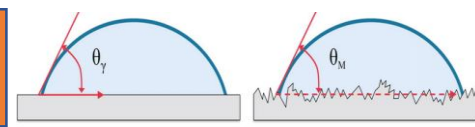




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# Introduction



**Ultrafast laser**

**LIPSS** **OR** **spikes**

**+ sterilization**

**Contact angle**

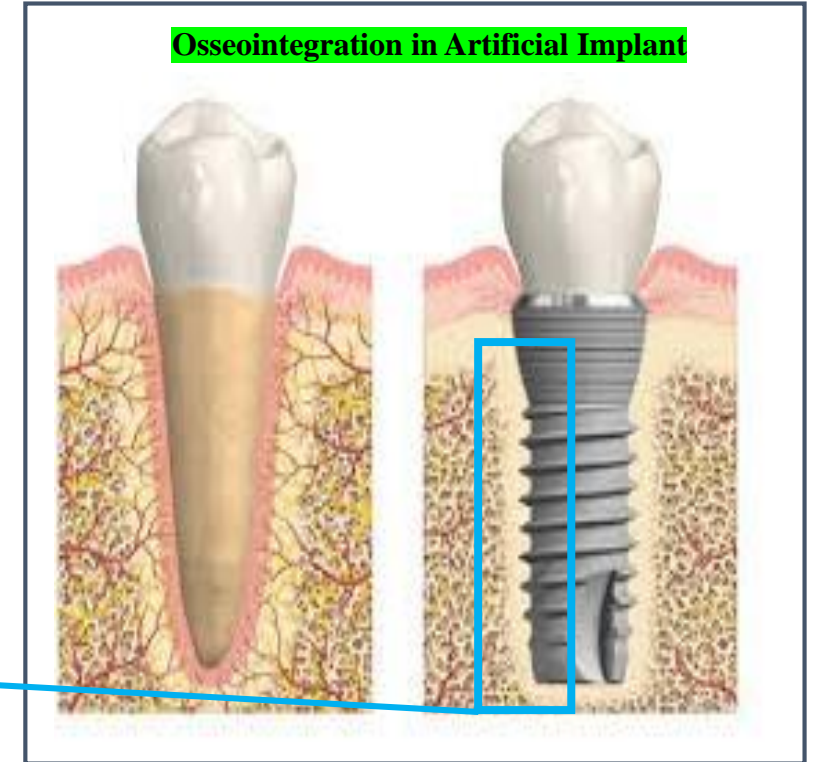
**Hydrophobic nanostructures combined into a micro-pattern to control:**

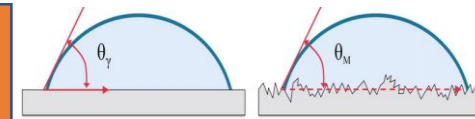
- Protein adsorption
- Focal adhesion location
- Nucleus location
- Cell morphology and migration

**Human mesenchymal stem cells**

**30 µm**

<https://doi.org/10.3390/nano10050864>





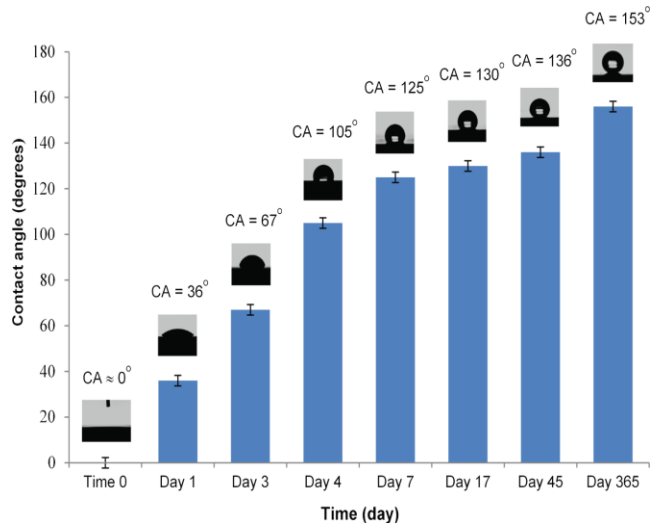
## Challenge Wettability of laser textured surfaces

- Changes over time under ambient conditions

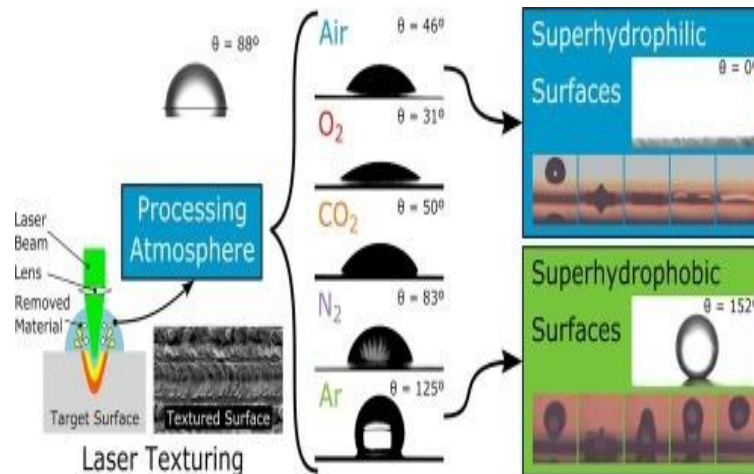
- Changes from superhydrophilic to superhydrophobic

- The existing wetting models is difficult to account for this wetting mechanism;  
- **Wenzel and Cassie-Baxter**

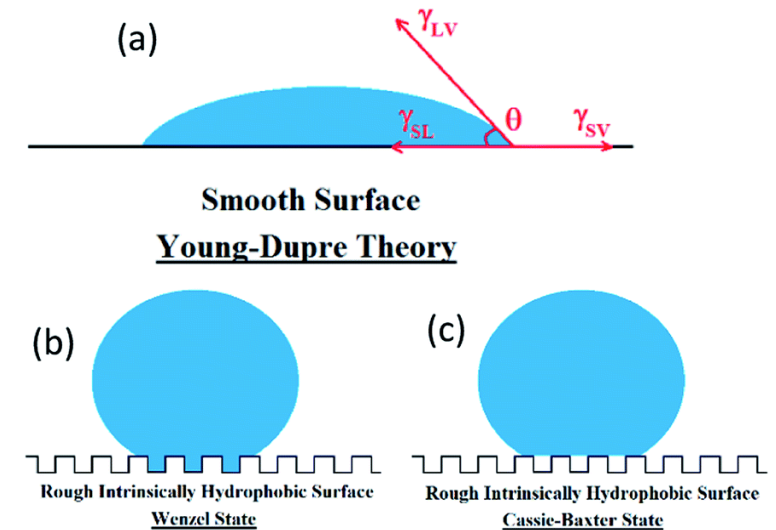
### Wettability changes with time



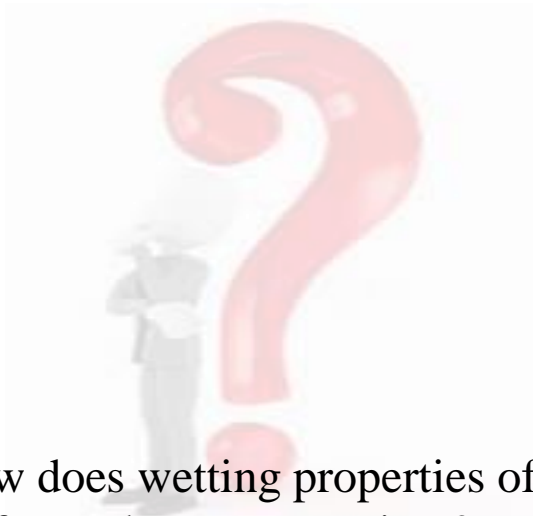
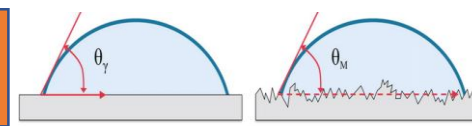
### Alternate hydrophobic and hydrophilic properties



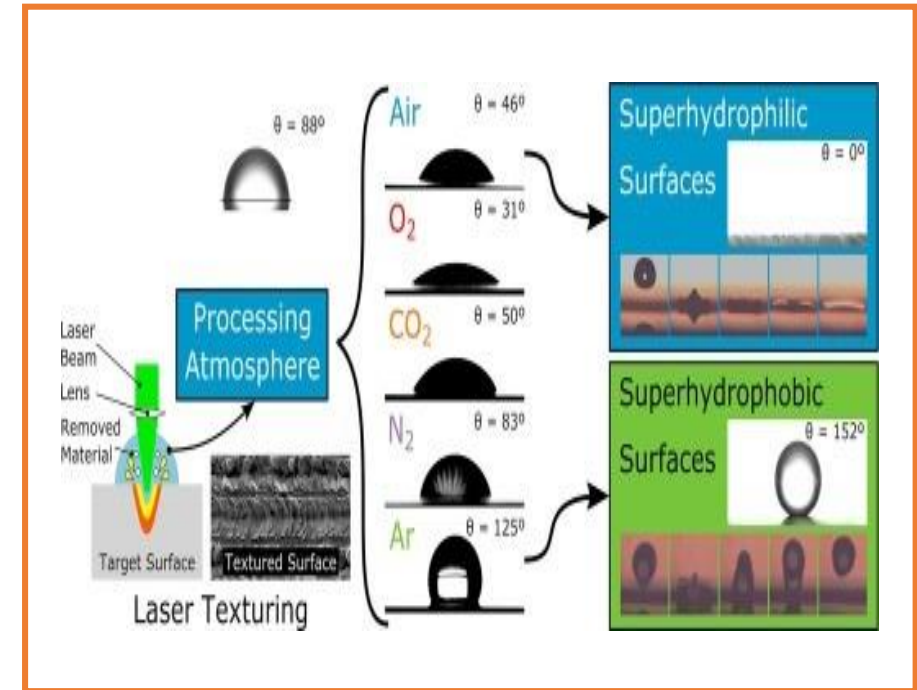
### Existing wetting model



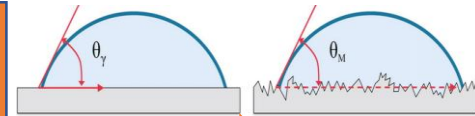




- How does wetting properties of laser textured surfaces changes over time?
- Can the existing wetting model be precise enough for understanding the wetting mechanism of laser textured surfaces?
- How can we stabilize wettability of surfaces to achieve either hydrophilicity or hydrophobicity?



# Work Plan



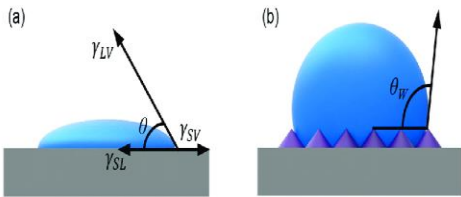
**1.** Develop a more realistic wettability model accounting for the changes in surface structure

**2.** We want to use a **multi-scale numerical approach such as the MD (molecular dynamics) method to model** physico-chemical changes induced by laser

**3.** We want to connect wettability with relief and laser treatment, and as well find conditions when **SUPEHYDROPHOBIC** state can be achieved

**First:** We will start with simulation of water drop behavior on flat surface using CFD approach  
**Second:** We introduce surface relief to understand the wetting dynamics.

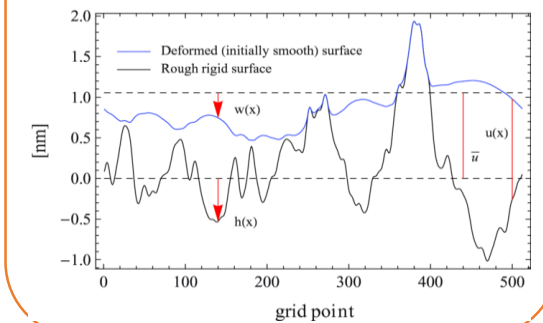
■ Liquid ■ Microstructure ■ Substrate



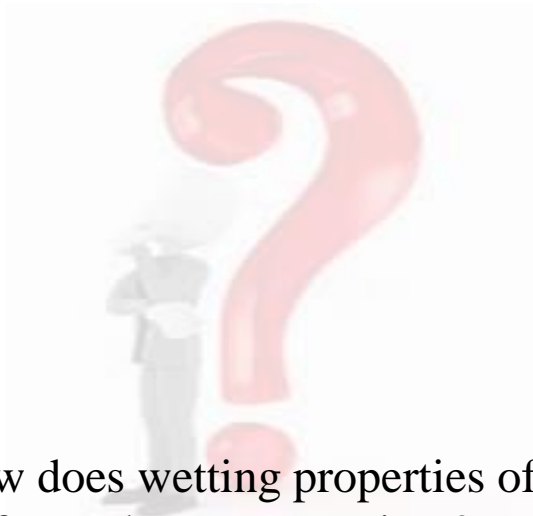
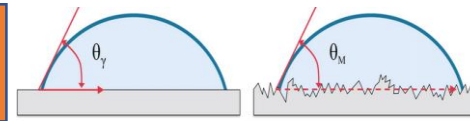
**Collaboration with different axis**



**Optimization model:** Find relief which will be optimize for hydrophobic.



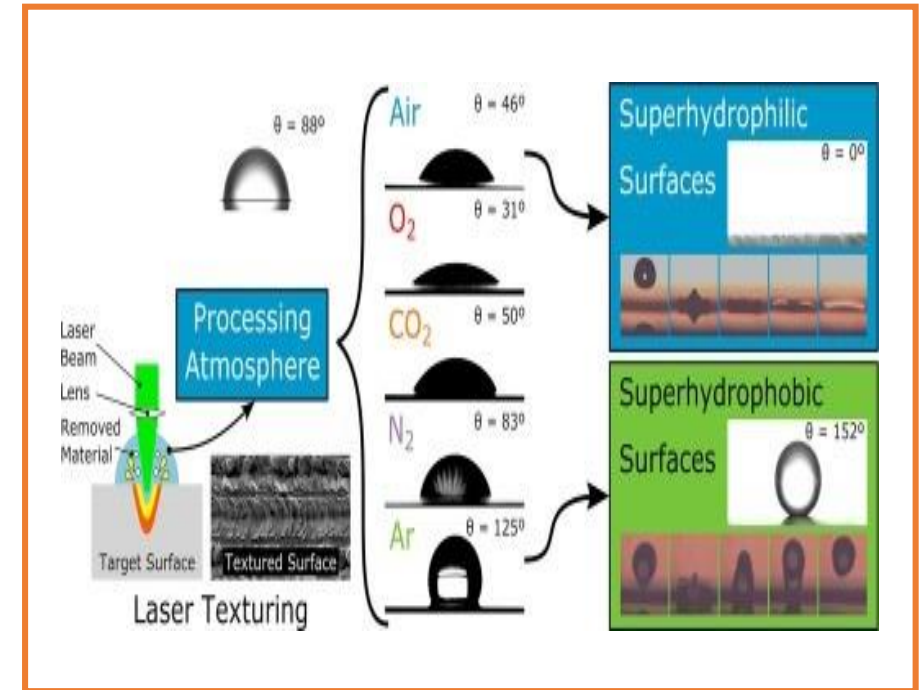
**Comparison of the MODEL RESULTS with EXPERIMENTS**



- How does wetting properties of laser textured surfaces changes over time?

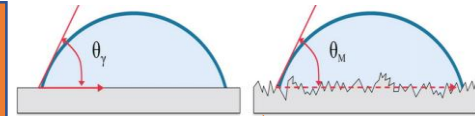


- Can the existing wetting model be precise enough for understanding the wetting mechanism of laser textured surfaces?



- How can we stabilize wettability of surfaces to achieve either hydrophilicity or hydrophobicity?

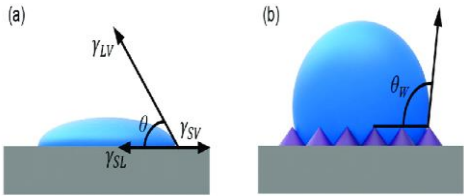
# Work Plan (CFD Approach)



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**First:** We will start with simulation of water drop behavior on flat surface using CFD approach  
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■ Liquid ■ Microstructure ■ Substrate



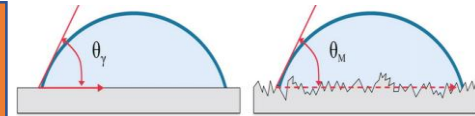
Collaboration with different axis



Comparison of the MODEL RESULTS with EXPERIMENTS



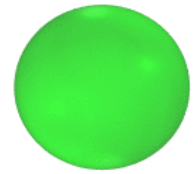
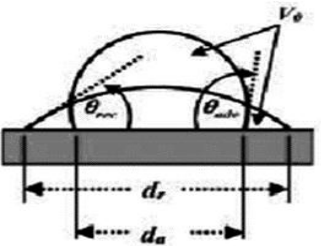
# Model Validation (CFD) Approach



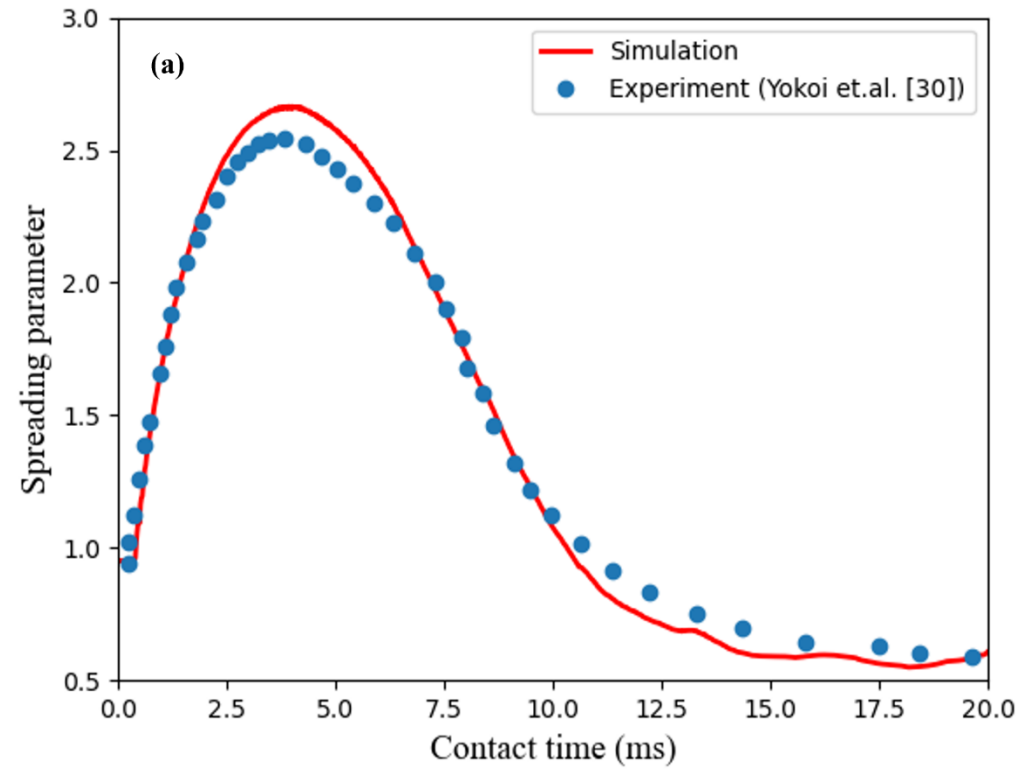
## Water Droplet on Glass

Diameter of droplet = 2 mm  
 Impact velocity = 0.52 m/s  
 Equili. Contact Angle = 106°

Spreading Parameter  $\beta^* = \frac{d_a}{D}$   
 Here  $d_a$  = diameter of droplet  
 D = Initial diameter of droplet

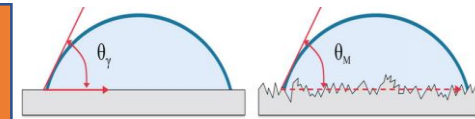


## Spreading Parameter



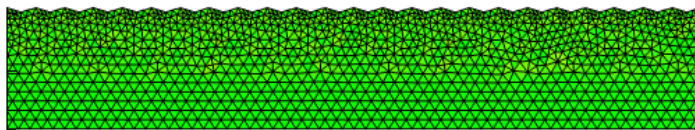
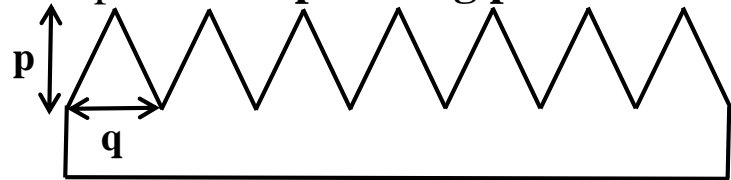
Experiment	Simulation 2D & 3D	Experiment	Simulation 2D & 3D

Omeje, Ilemona S., et al. Applied Surface Science Advances 9 (2022).

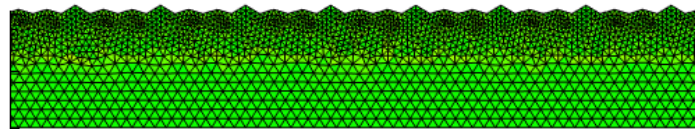
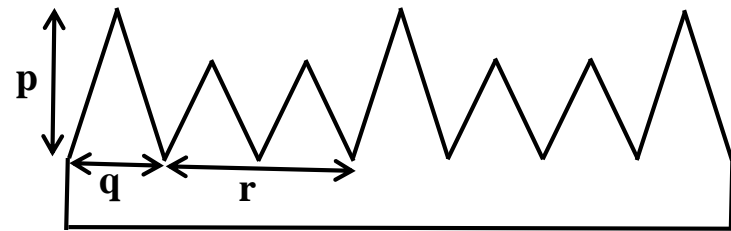


- Performed wettings studies: **Ti-6Al-4V**
- 1. Plain,
- 2. Triangular relief and one with 2 periods and height

- Explore the spreading parameter



(a)

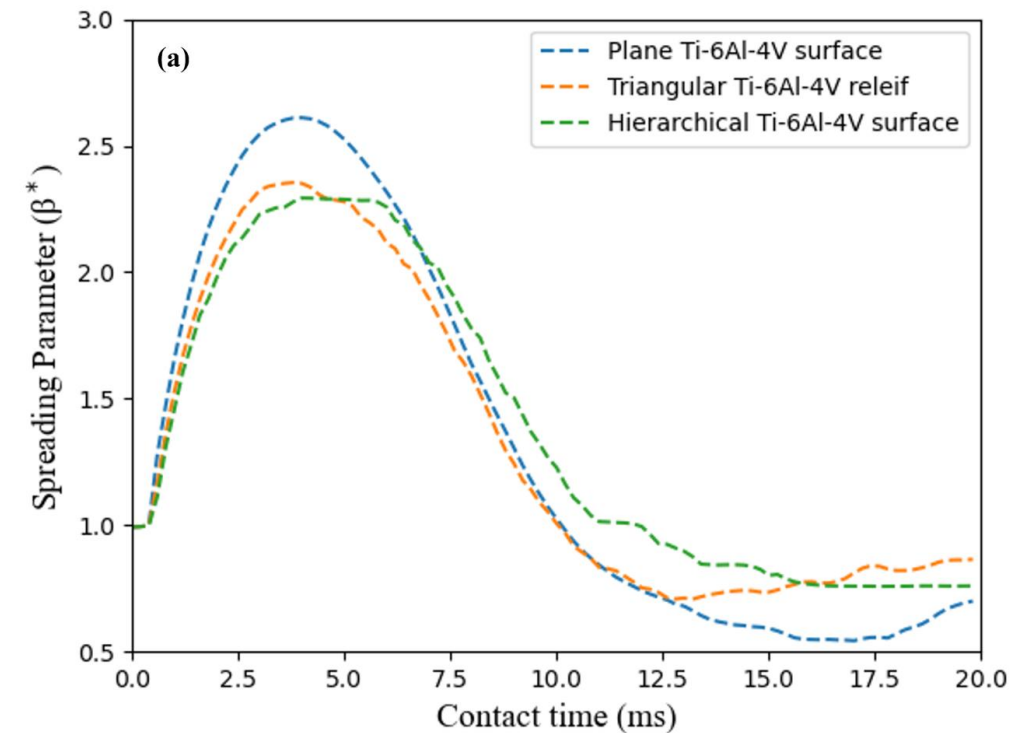
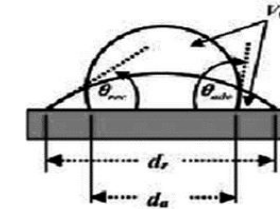


(b)

## Spreading Parameter

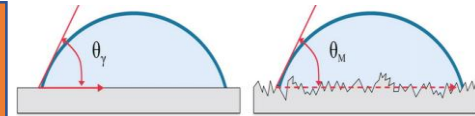
$$\text{Spreading Parameter } \beta^* = \frac{d_a}{D}$$

Here  $d_a$  = diameter of droplet  
 $D$  = Initial diameter of droplet



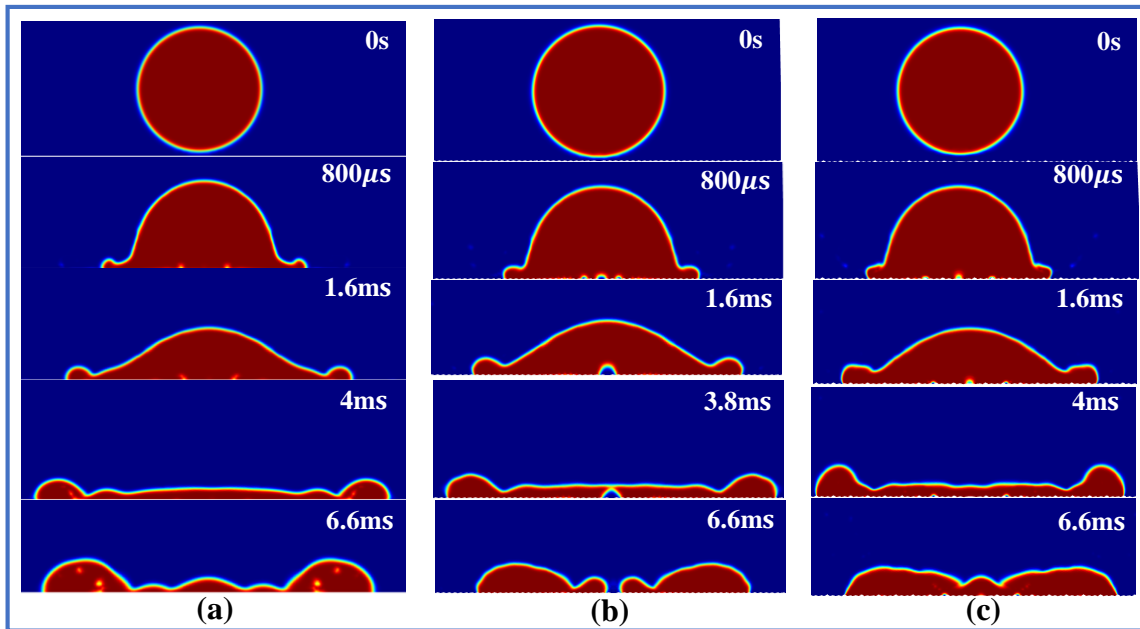
Omeje, Ilemona S., et. al. Applied Surface Science Advances 9 (2022).

# CFD Results

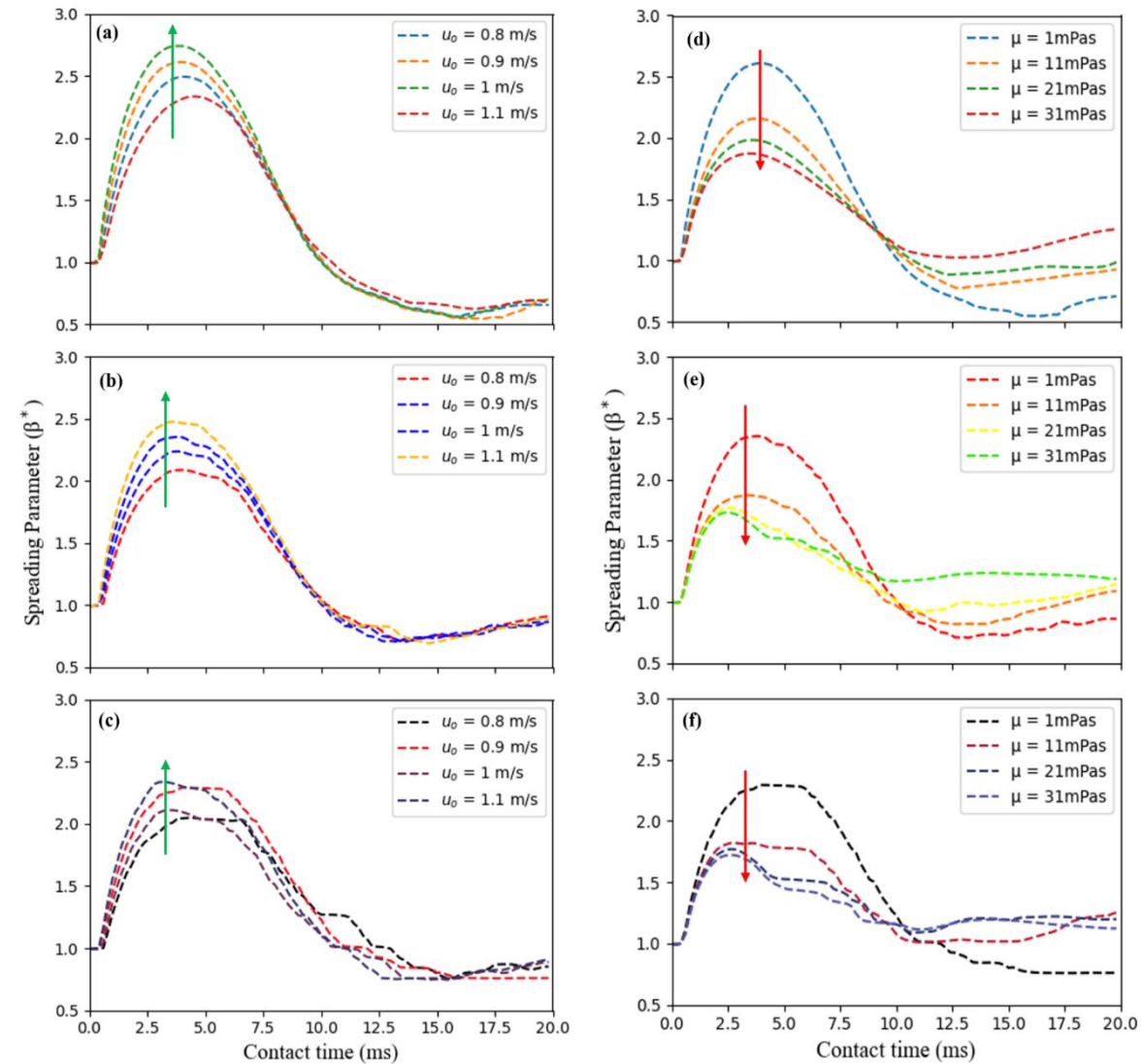


Snapshot of water impact on (a) **solid**, (b) **triangular**, and (c) **hierarchical Ti-6Al-4V alloy surface** at different time scale

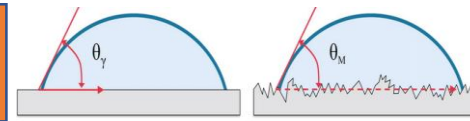
Velocity of Impact = 1m/s  
 $\theta_{ECA} = 96^\circ$



## Effect of velocity and viscosity of droplet



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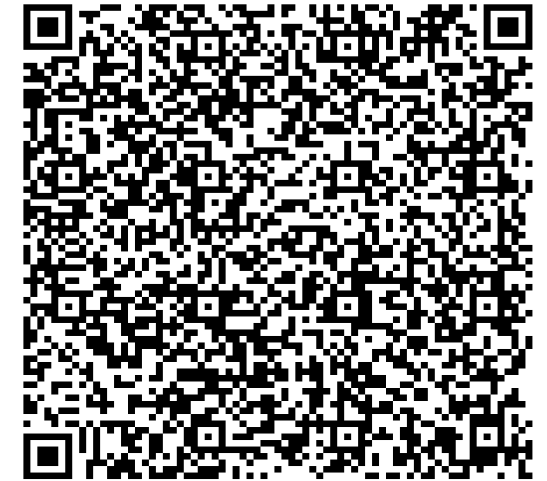


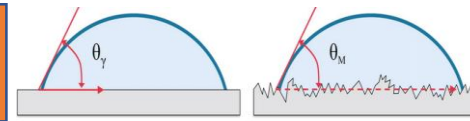
## Summary

- Reliefs play a crucial role in spreading behavior of the liquid and hierarchical reliefs are promising for the wettability enhancement.

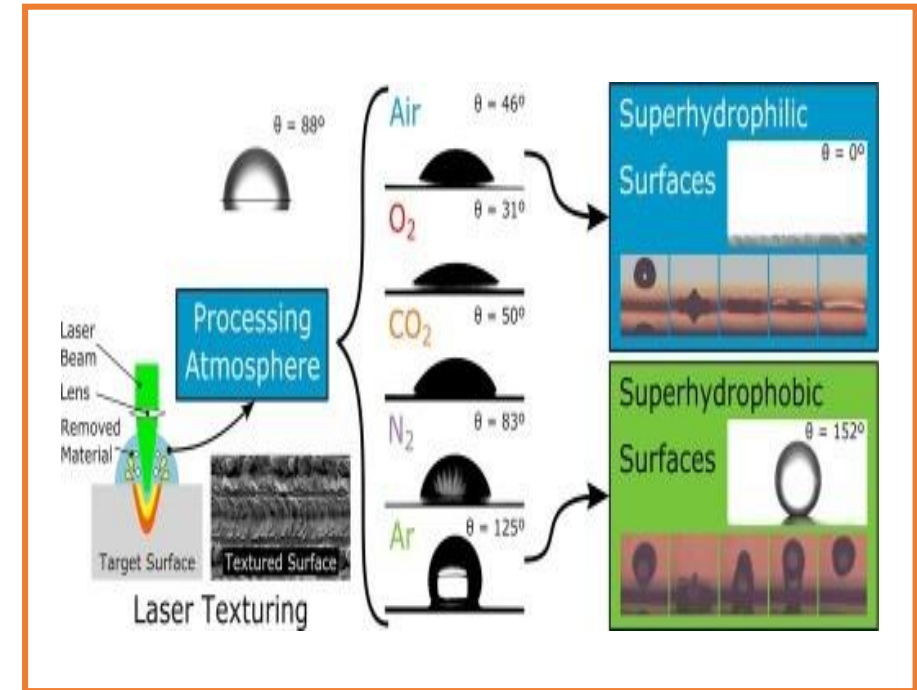
## Next Step

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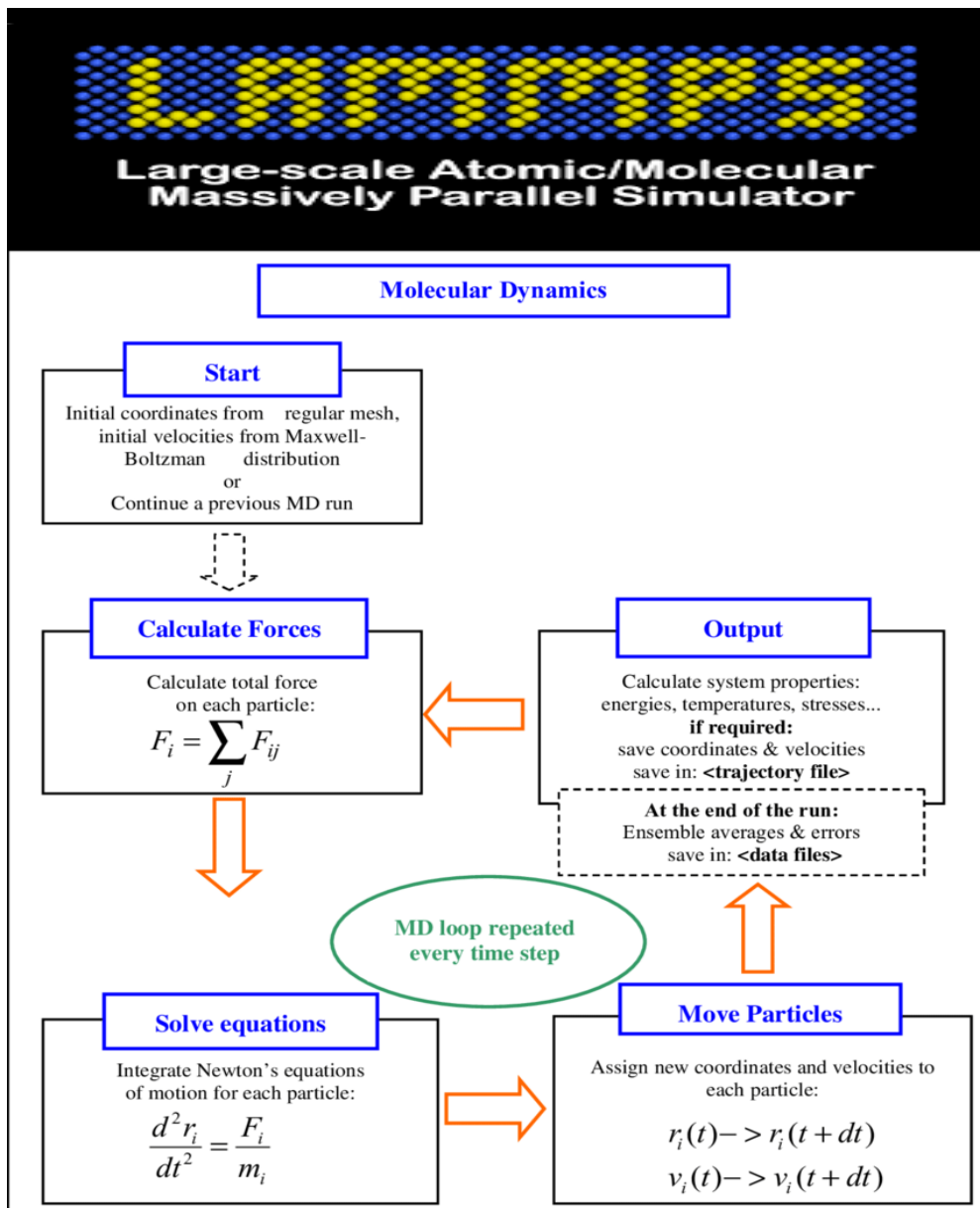
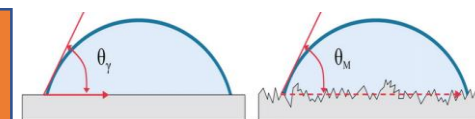




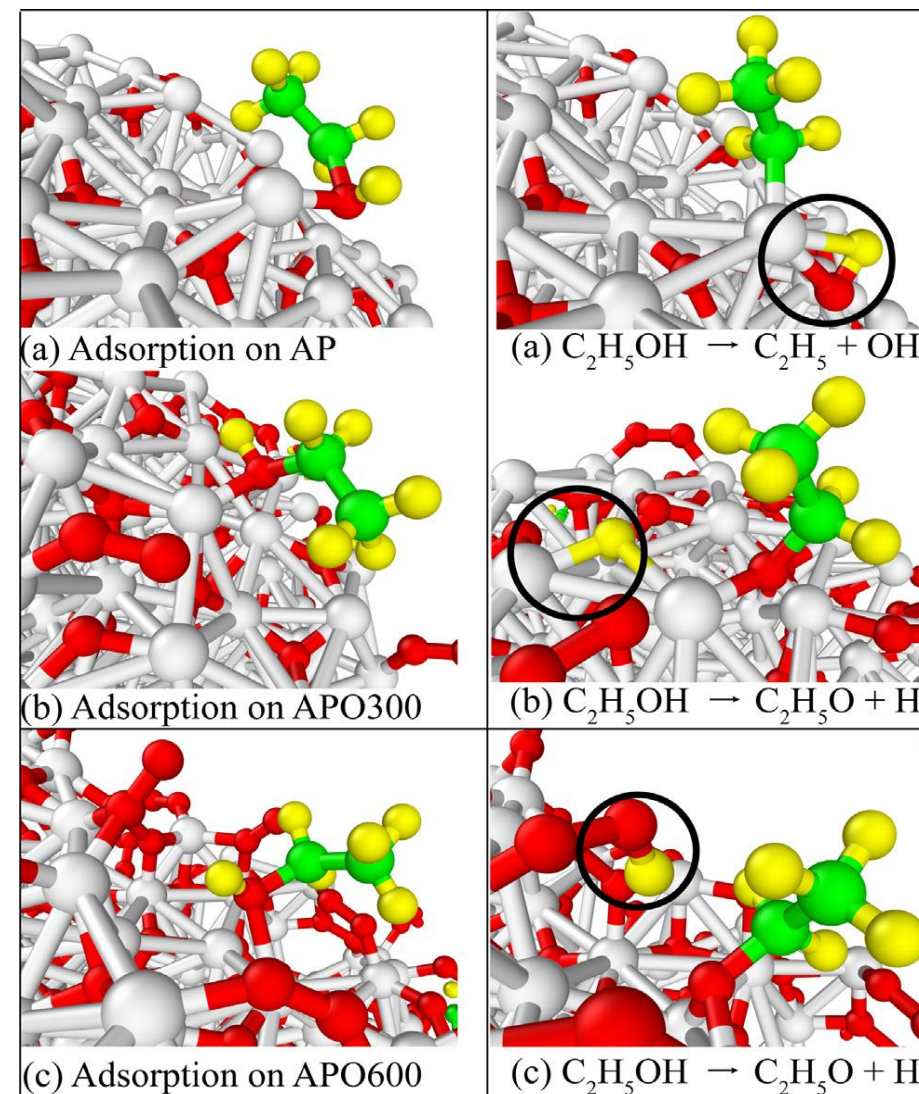
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## Reaction of ethanol and oxygen mixture over aluminum nanoparticles



doi.org/10.1016/j.fuel.2018.06.119

