Surfaces and Films CHEM-E5150 Introduction

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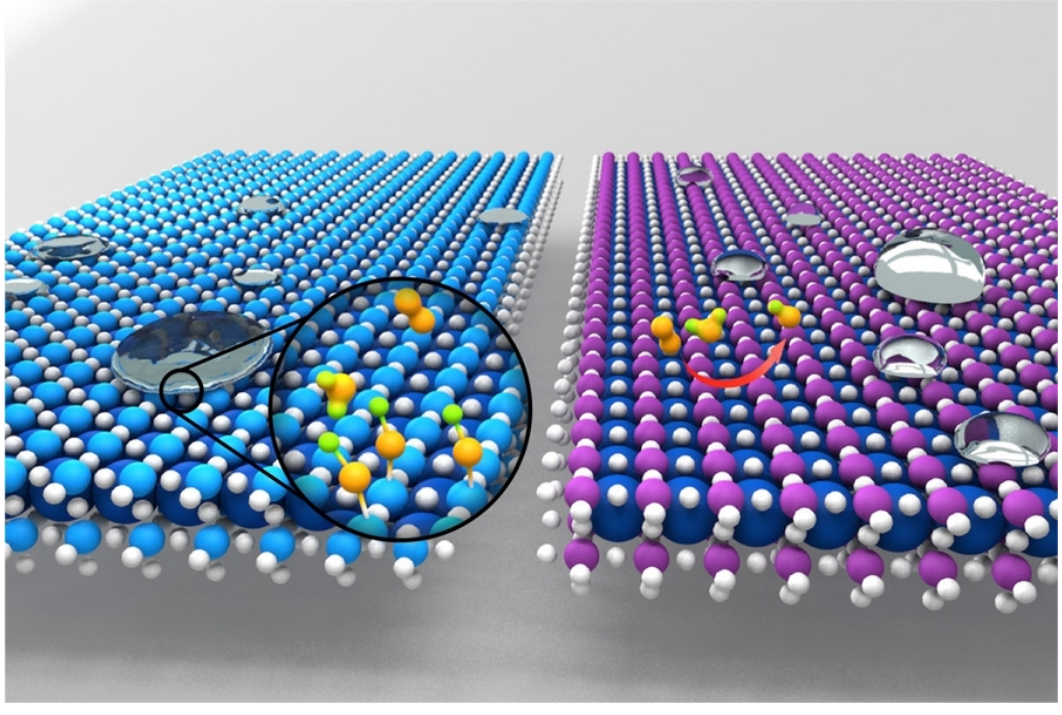
Surface

Surfaces of material ⇝ Properties of material:

- Physical
- Chemical
- Mechanical
- Optical
- Bio compatibility
- Etc.



https://news.mit.edu/2015/looking-for-catalysts-with-perovskites-0730

Surface

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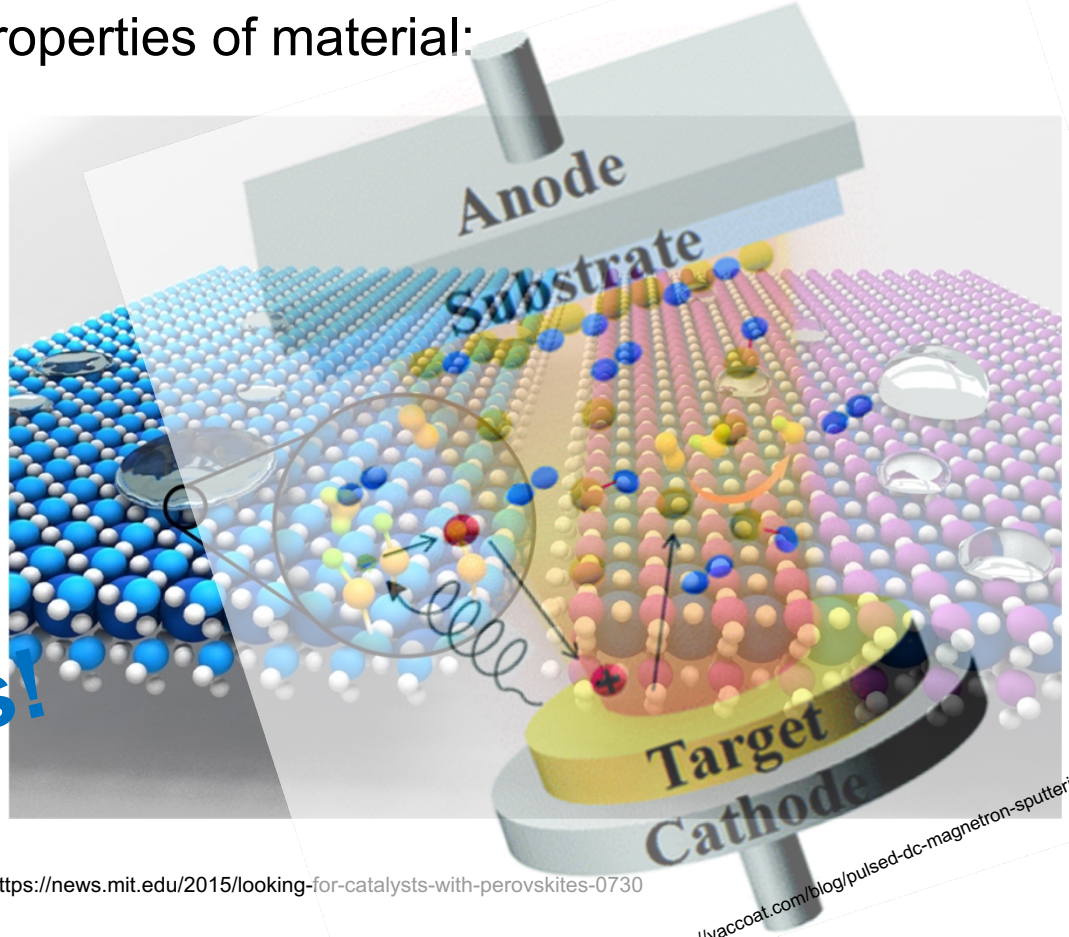
How to benefit the good surface properties

We grow films!



https://news.mit.edu/2015/looking-for-catalysts-with-perovskites-0730

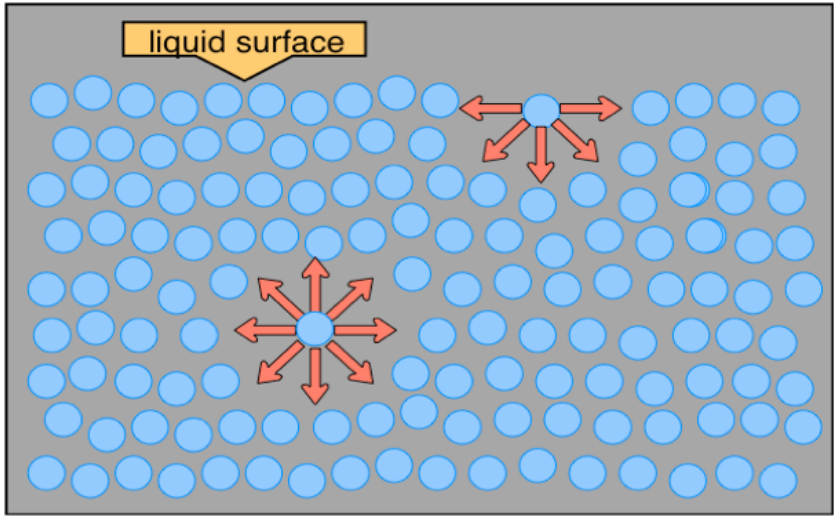
https://vaccoat.com/blog/pulsed-dc-magnetron-sputtering/

Why is surface different?

Atoms in bulk and surface

Surface atoms have less neighbours (lower coordination number) than bulk atoms

- high energy
- different electronic structure (surface electronic states, dangling bonds)
- possibly different (reconstructed) structure
- capability to bind (adsorb) gases



http://butane.chem.uiuc.edu/pshapley/enlist/labs/surfaceten/surface.html

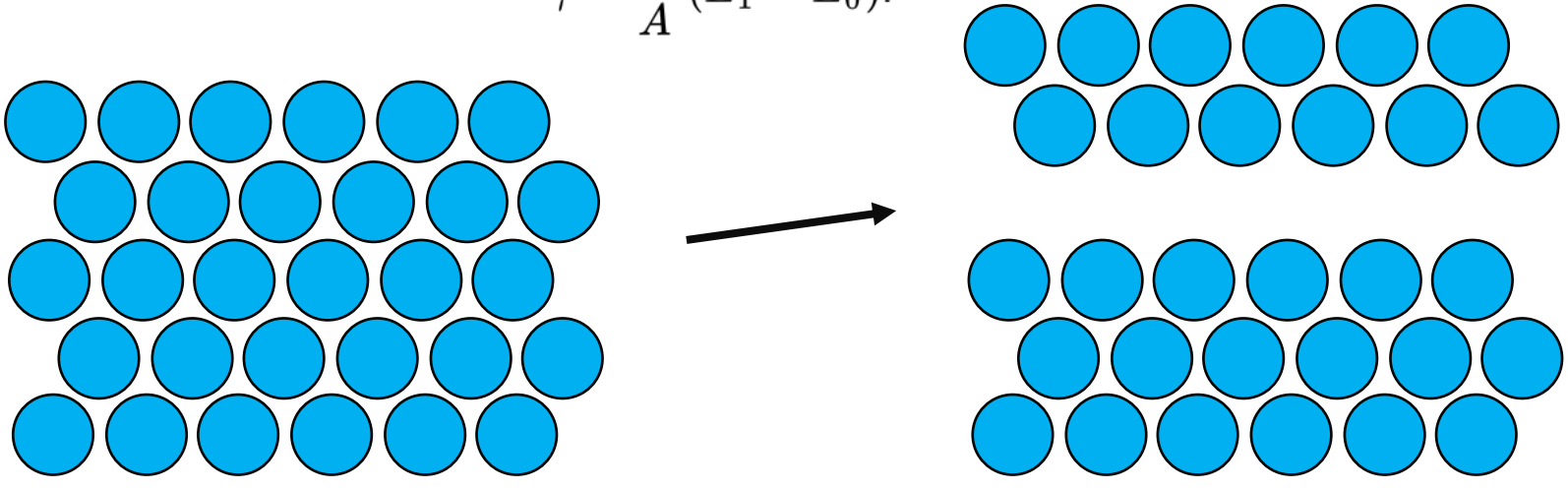
Surface energy

$$\gamma = \left(\frac{\partial G}{\partial A}\right)_{n,T,P} \qquad [\gamma] = \frac{J}{m^2} = \frac{N}{m}$$

G = Gibb's free energy
A= surface area
n = number of moles
T= temperature
P = pressure

Creating new surface – breaking atomic bonds – increase of surface energy

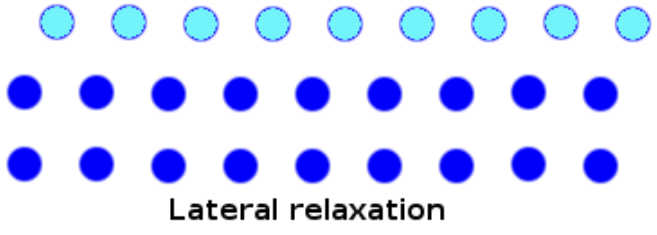
$$\gamma = \frac{1}{A}\left(E_1 - E_0\right).$$

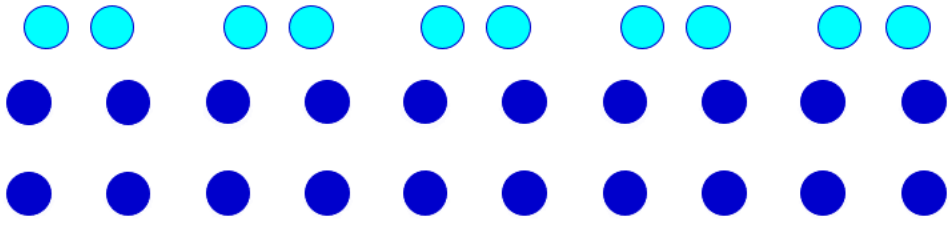


Minimizing surface energy

- **Liquids tend to form droplets**
- **Solids relax stess**

Surface relaxationa and construction



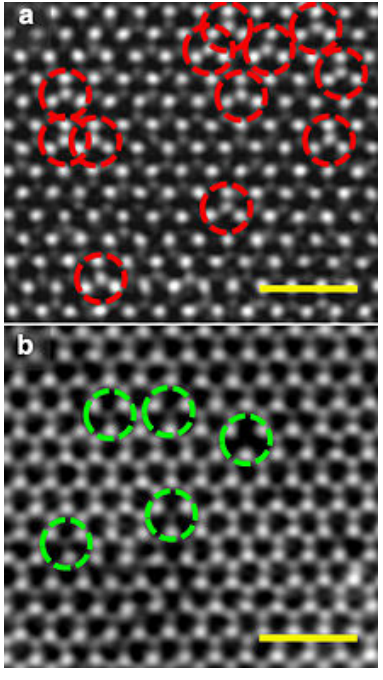


reconstruction

https://en.wikipedia.org/wiki/Surface_reconstruction

Defects on surface

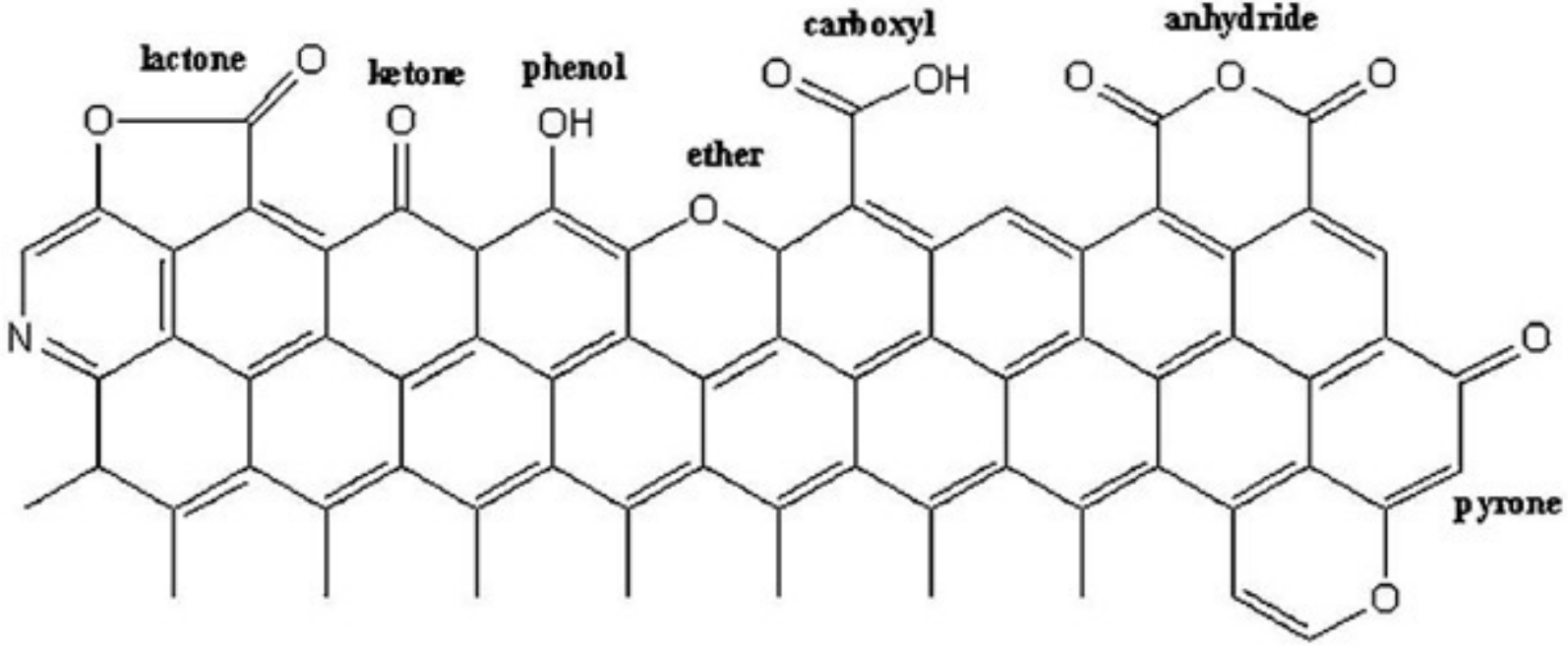
Point defect on surface



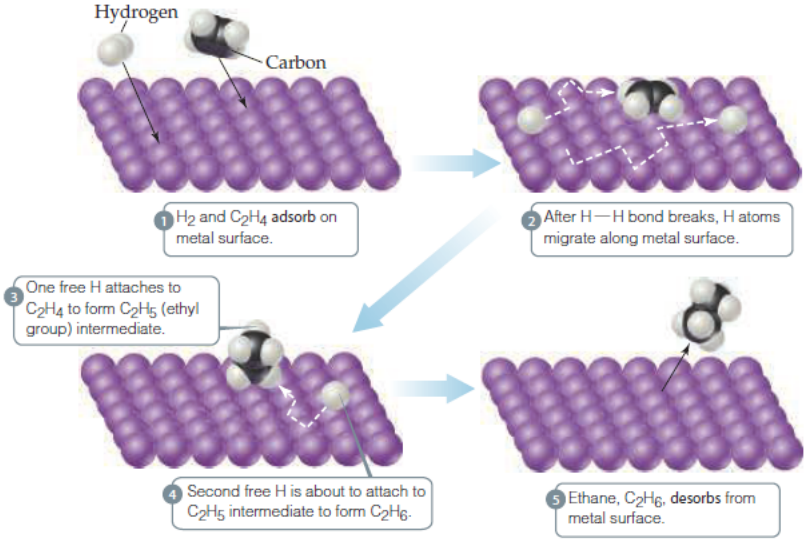
Electron microscopy of antisites (a, Mo substitutes for S) and vacancies (b, missing S atoms) in a monolayer of molybdenum disulfide. Scale bar: 1 nm.[1]

https://en.wikipedia.org/wiki/Crystallographic_defect

Functional groups on graphene surface



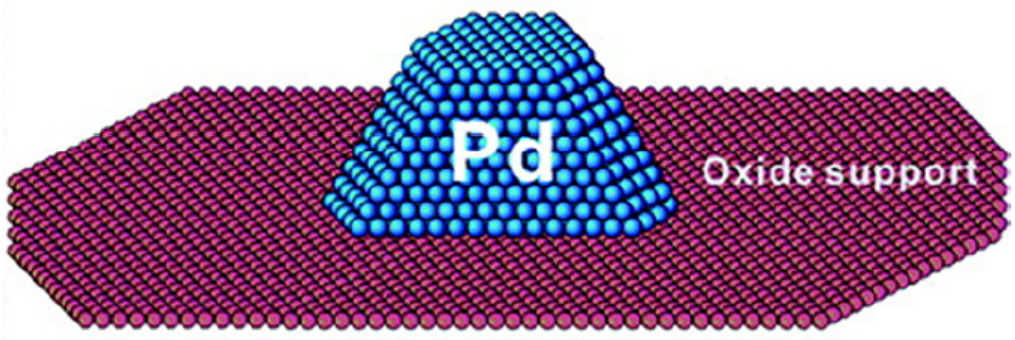
Catalytic surfaces



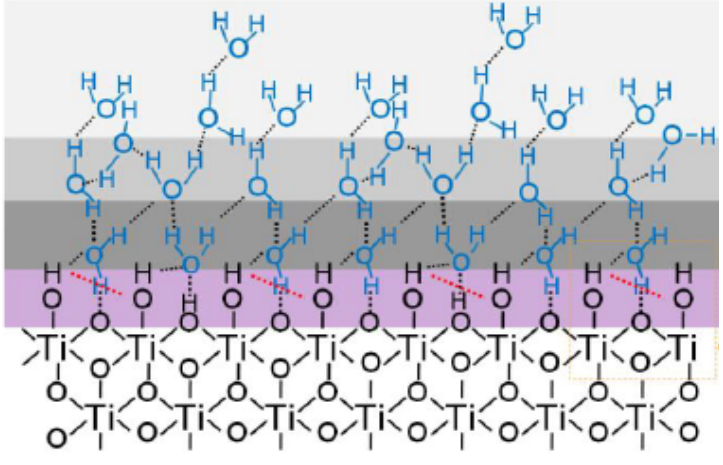
◀ **Figure 14.23 Heterogeneous catalysis.** Mechanism for reaction of ethylene with hydrogen on a catalytic surface.

https://www.bartleby.com/questions-and-answers/1-figure-14.23-heterogeneous-hydrogen-catalysis.-mechanism-for-reaction-of-ethylene-with-hydrogen-on/40a398b8-9d10-4955-9f52-953b6ed96a51

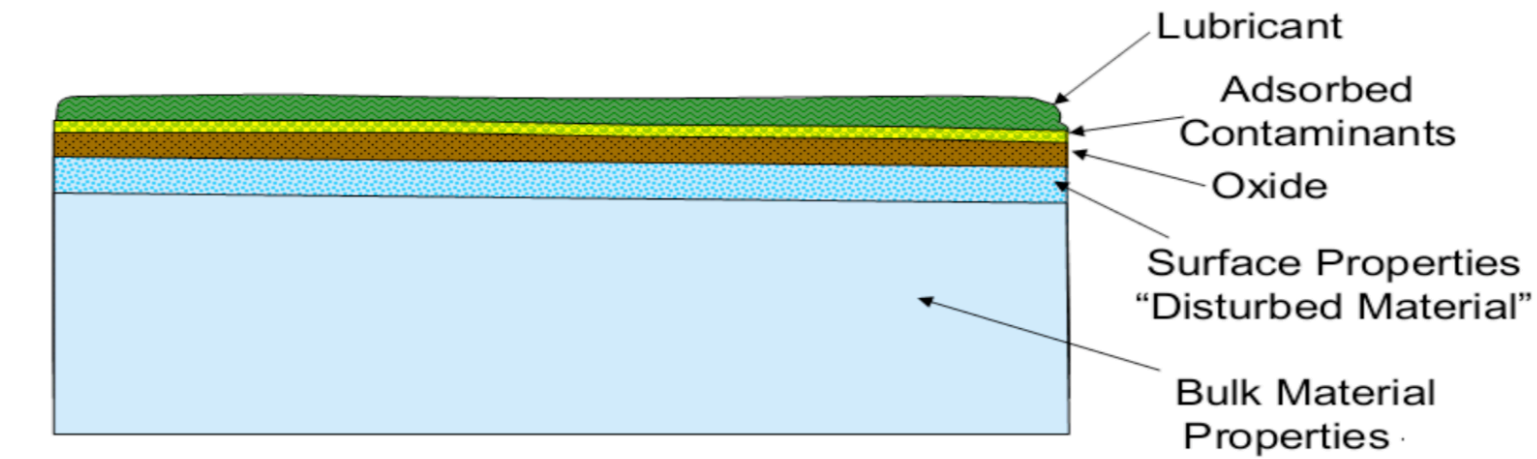
What are surfaces like?

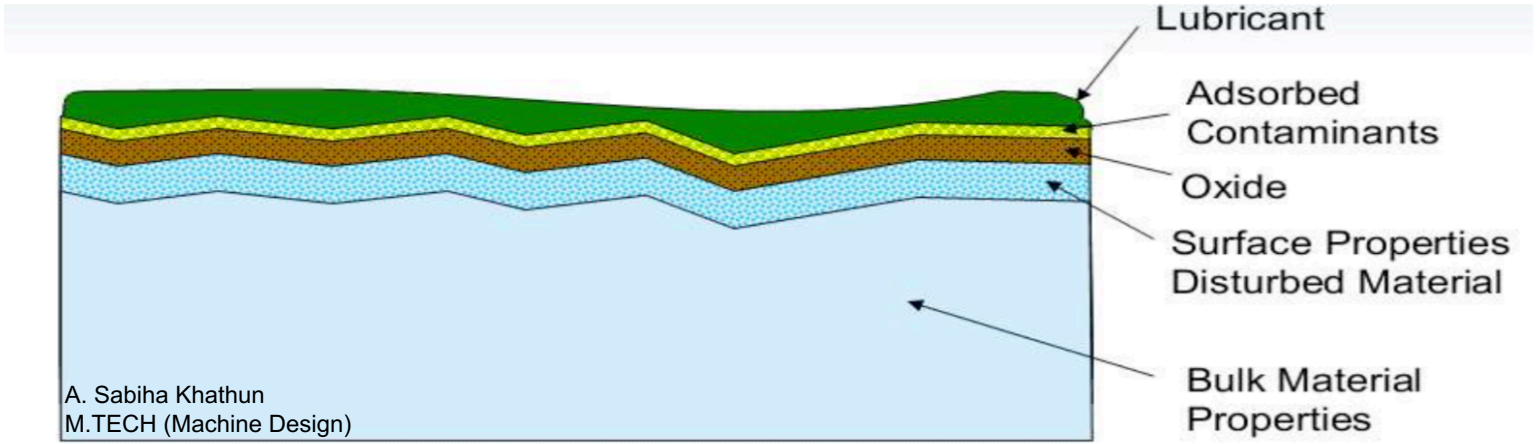


Or a bit dirty ?

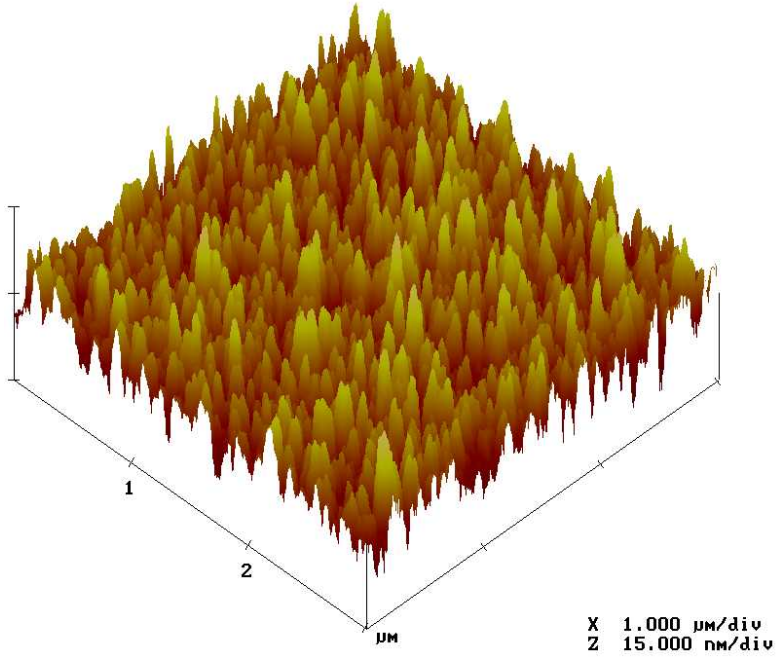


So let's begin by looking closely at a surface…

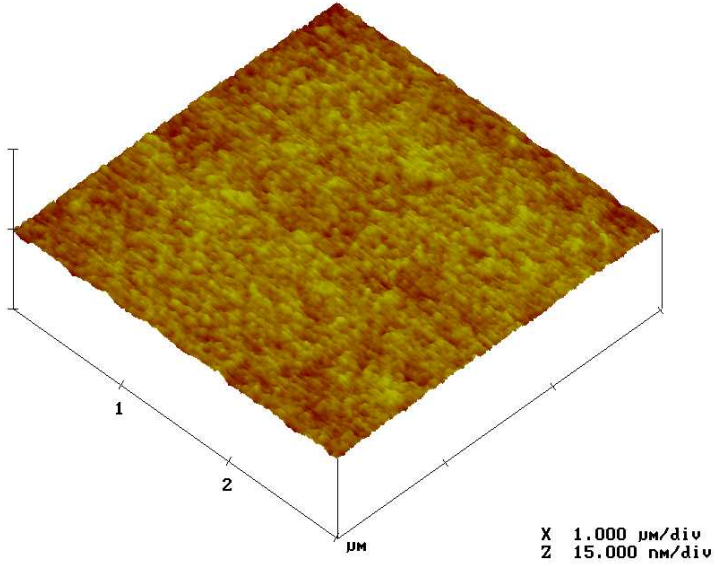




A. Sabiha Khathun
M.TECH (Machine Design)



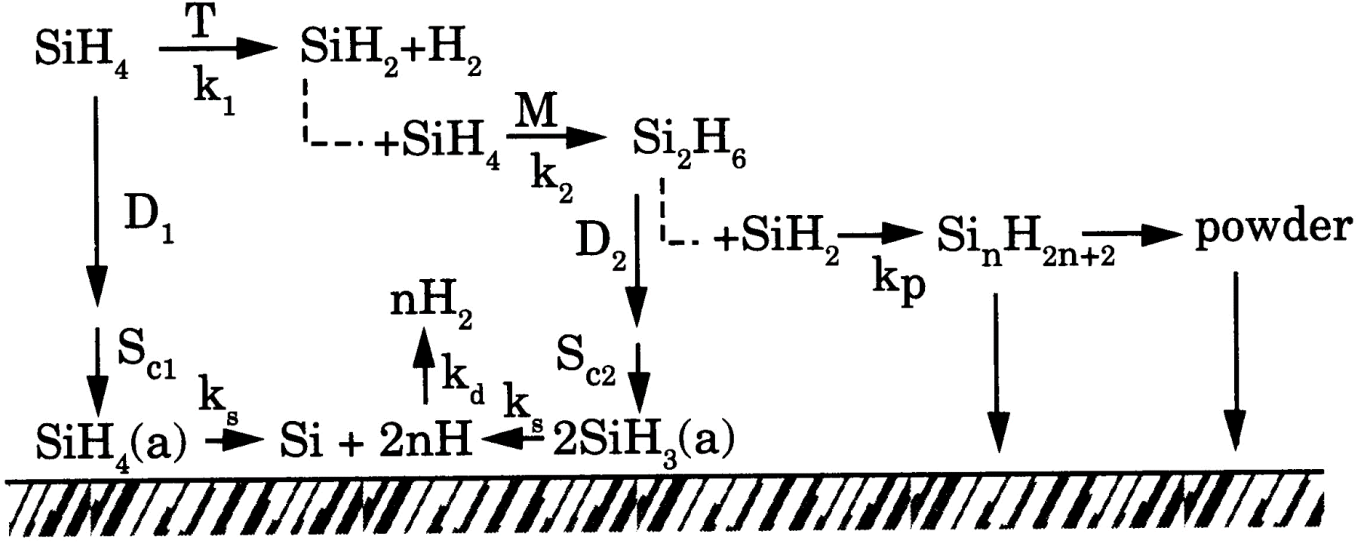
RMS roughness 3.3 nm



RMS roughness 0.2 nm

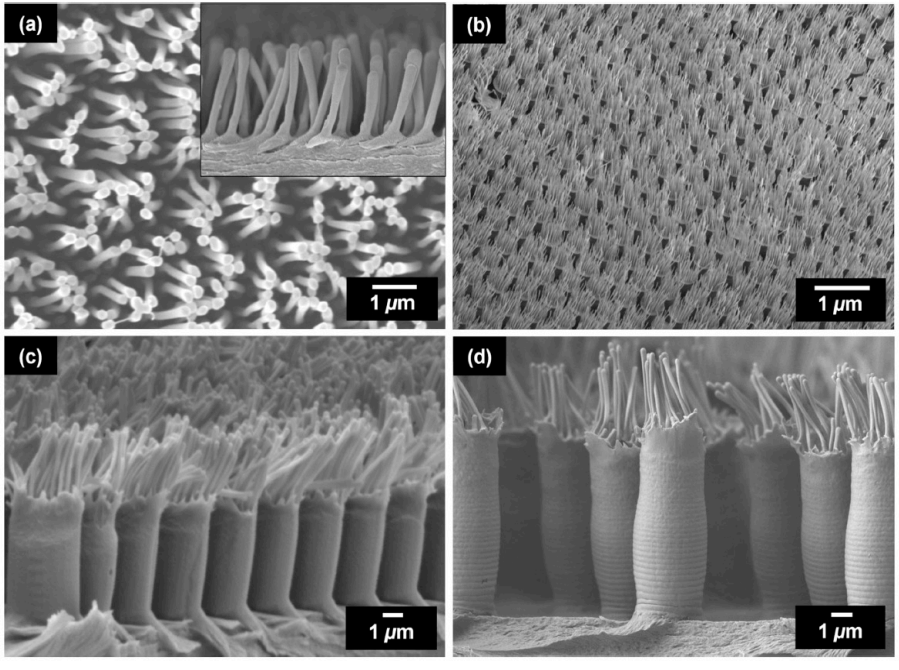
In theory: SiH_4 (g) → Si (s) + 2 H_2 (g)

In practice:

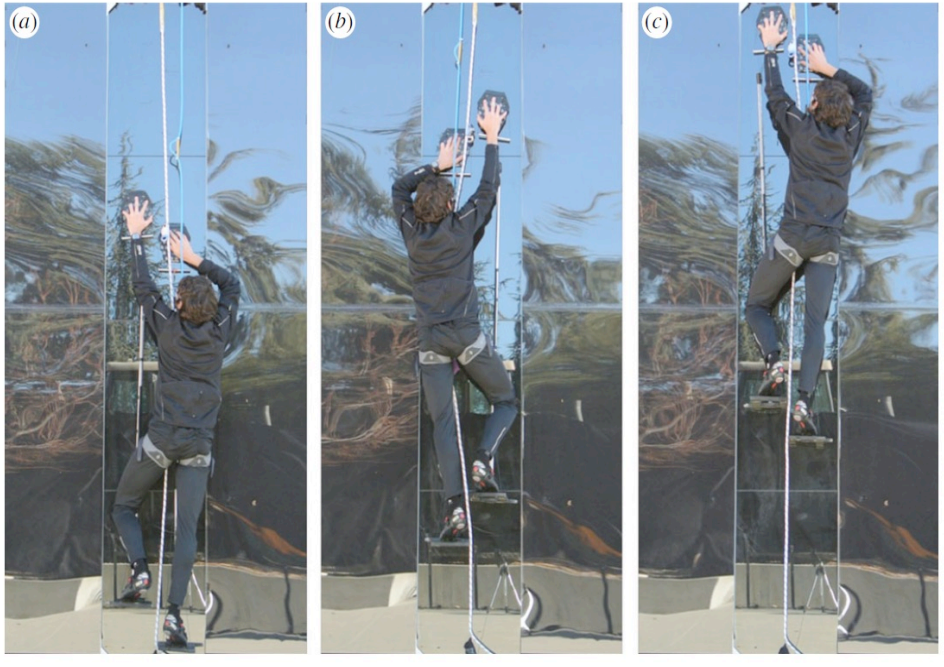


Functional surfaces

Gecko inspired dry adhesive



Gecko mimic structures…

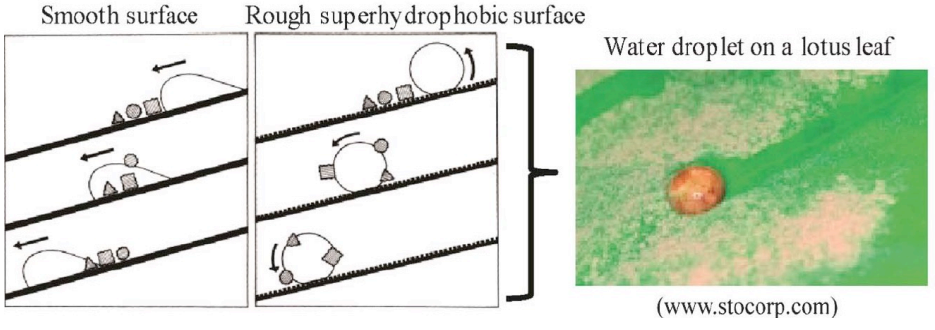


…might allow you to climb vertical walls!

DOI: 10.1021/acsami.7b09526

http://dx.doi.org/10.1098/rsif.2014.0675

Self cleaning superhydrophobic surfaces



Lotus leaf uses rain water to keep itself clean.

Solar panels can use the same effect.

RSC Advances, 2013, **3**, 671

Solar Energy Materials & Solar Cells 165 (2017) 128–137

Practical course details