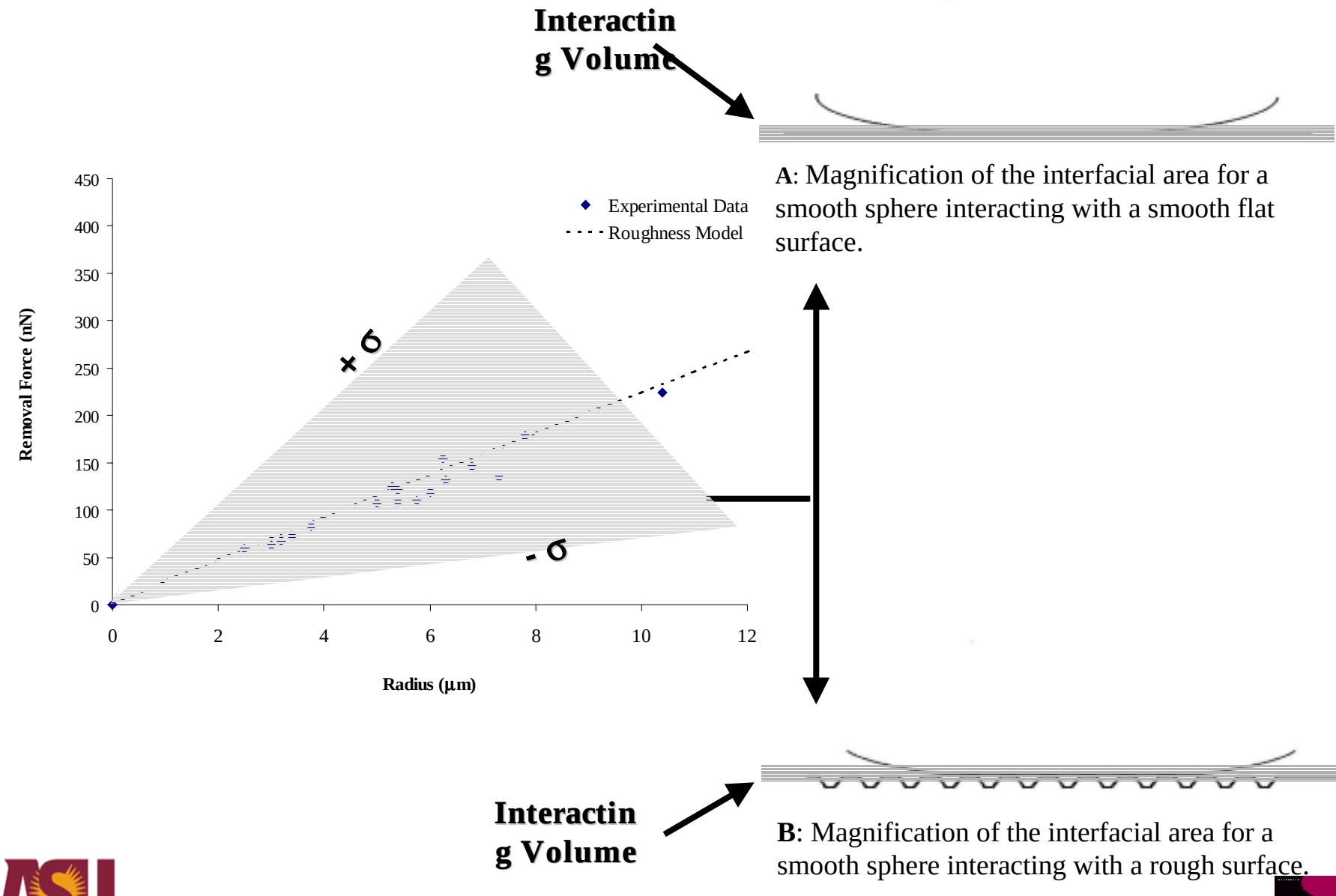
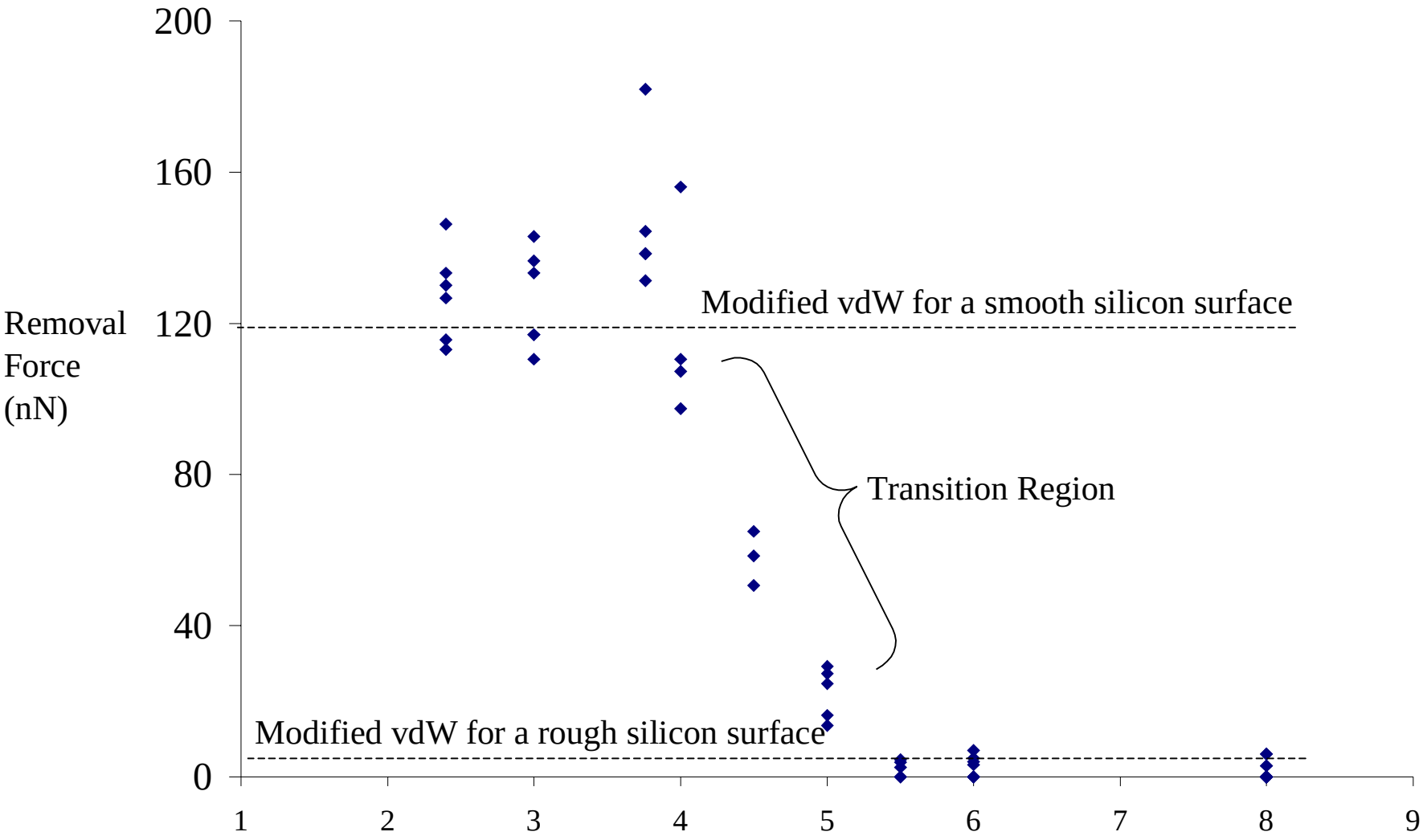
Effect of Surface Roughness on Adhesion



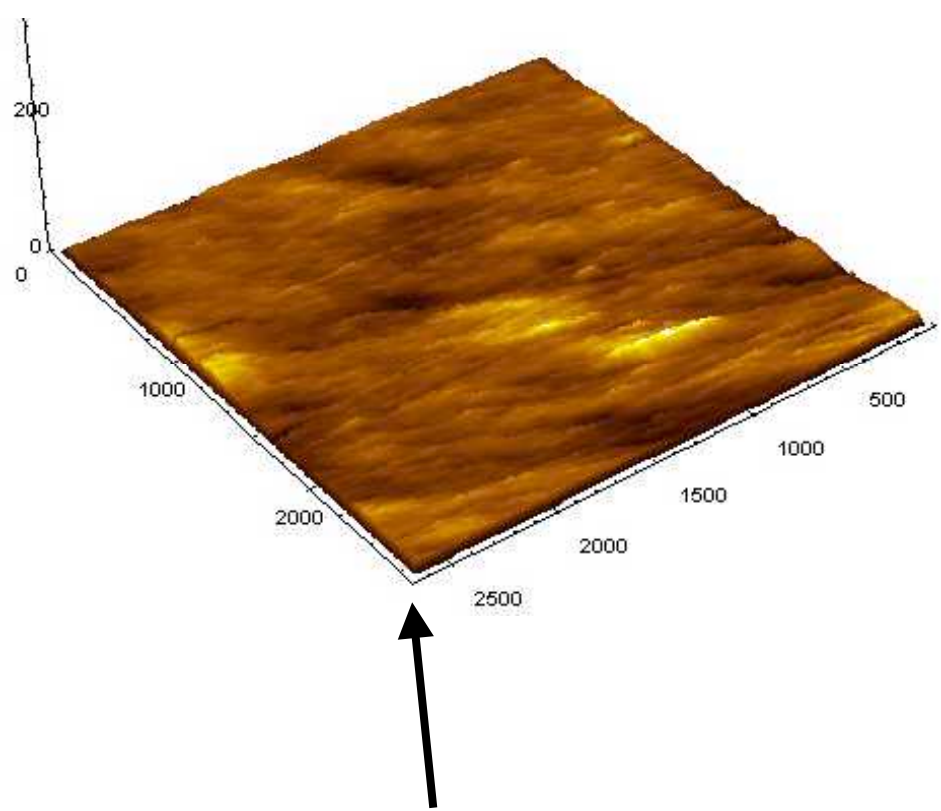
A: Magnification of the interfacial area for a smooth sphere interacting with a smooth flat surface.

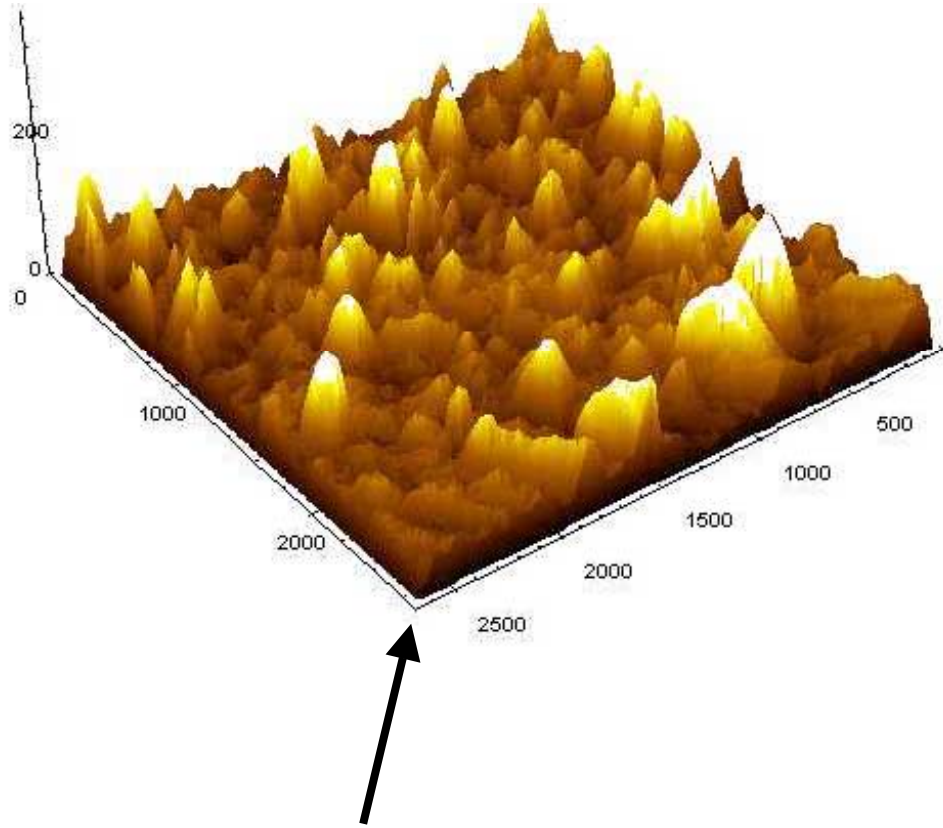
B: Magnification of the interfacial area for a smooth sphere interacting with a rough surface.

Effect of Surface Roughness on Adhesion



Effect of Surface Roughness on Adhesion





Low pH

silicon (with native oxide)

* not etched
* atomically smooth
* strong adhesion w/ PSL

High pH

silicon (with native and grown oxide)

* anisotropically etched (KOH)
* rough surface (35 nm peaks)
* weak adhesion w/ PSL

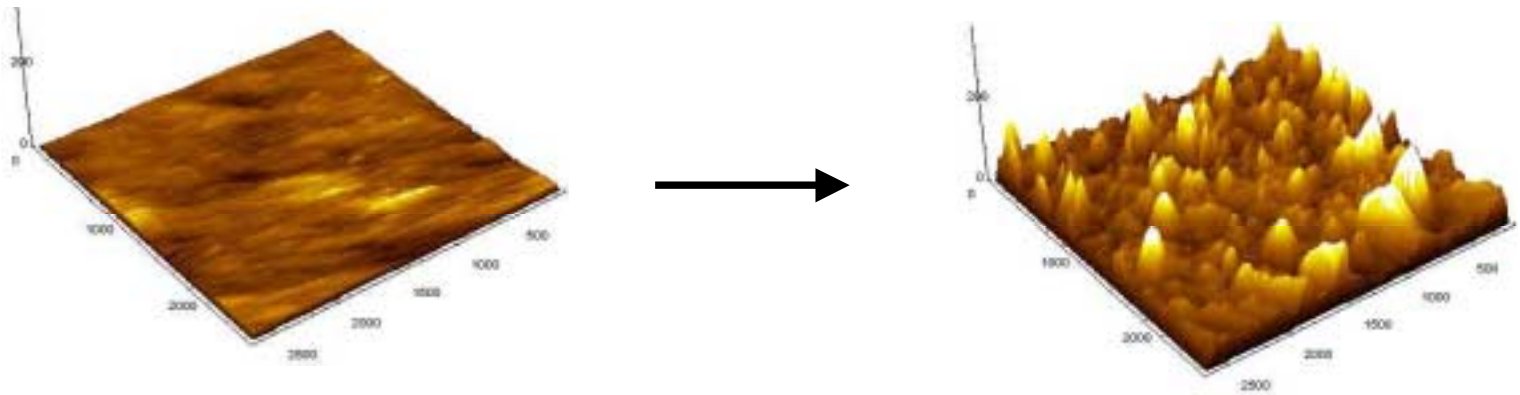
Conclusion--1st Generation Model

- **Ideal vdW models and Equilibrium Models (JKR, DMT, MP) are limited to:**
  - geometric (spherical particles interacting with flat surfaces)
  - morphology (smooth systems)

- **1st Generation model incorporates these factors**

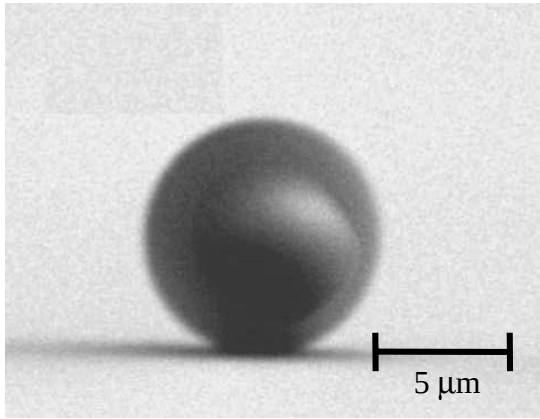
Conclusion--1st Generation Model (cont'd)

- **Aqueous media can help prevent or promote surface adhesion by:**
  - Changing the surface chemistry of the interacting surfaces
  - Changing the morphology of the interacting surfaces



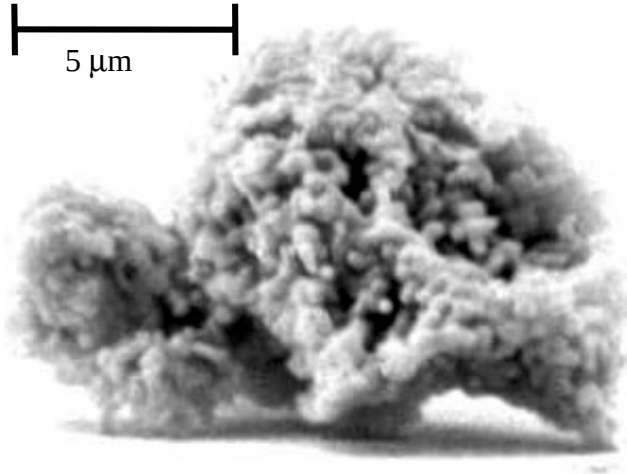
- **Particle and surface roughness is a controlling factor in particle adhesion**

Second Generation Model



1st generation model

- ideal geometries
- ability to model contact area
- uniform microscopic morphology



2nd generation model

- any geometry
- random microscopic morphology
- compression/deformation of surface asperities
- chemical heterogeneities
- bonding
- settling (tilting, shifting)
- **statistical information**

Second Generation Model

SEM
volume
reconstruction

3-D Volume Reconstruction of Alumina/Silica Colloids -- Contact Area

AFM Topographic Data

Mathematically Generate Surface

Applied Load

2nd Generation Model
- van der Waals
- Covalent Bonds

Compression/Deformation
- surface asperities

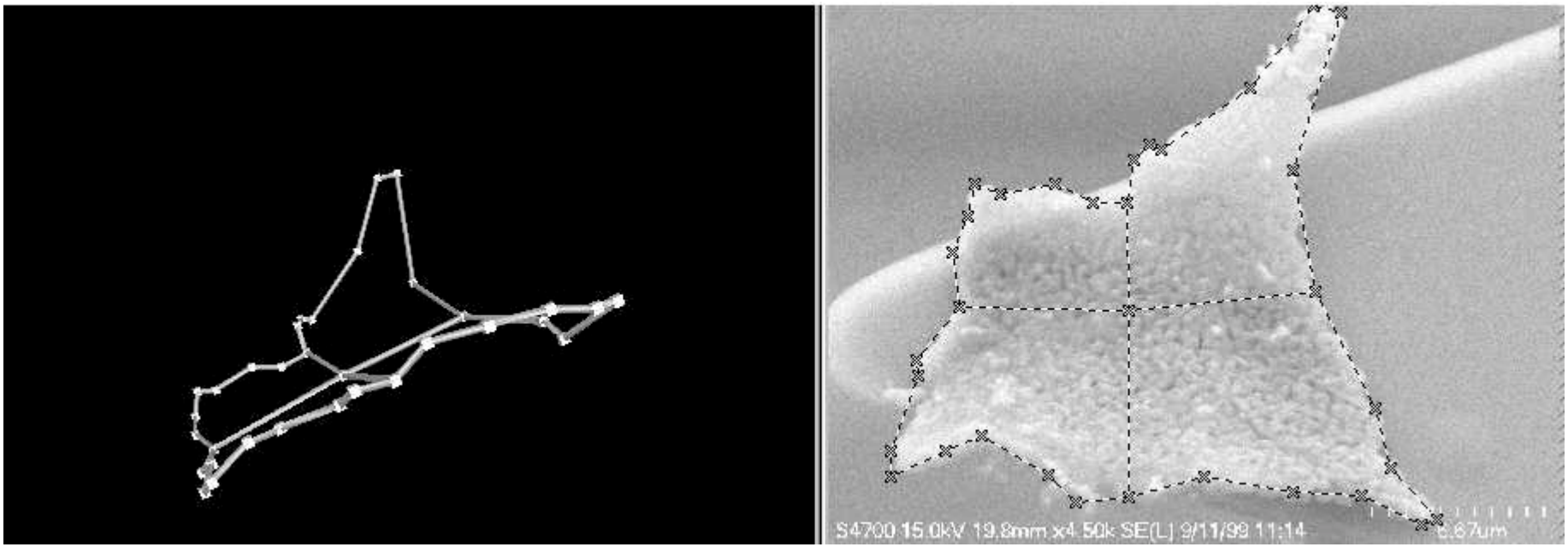
Settling of the Particle
(tilting, shifting)

Removal Force Statistics

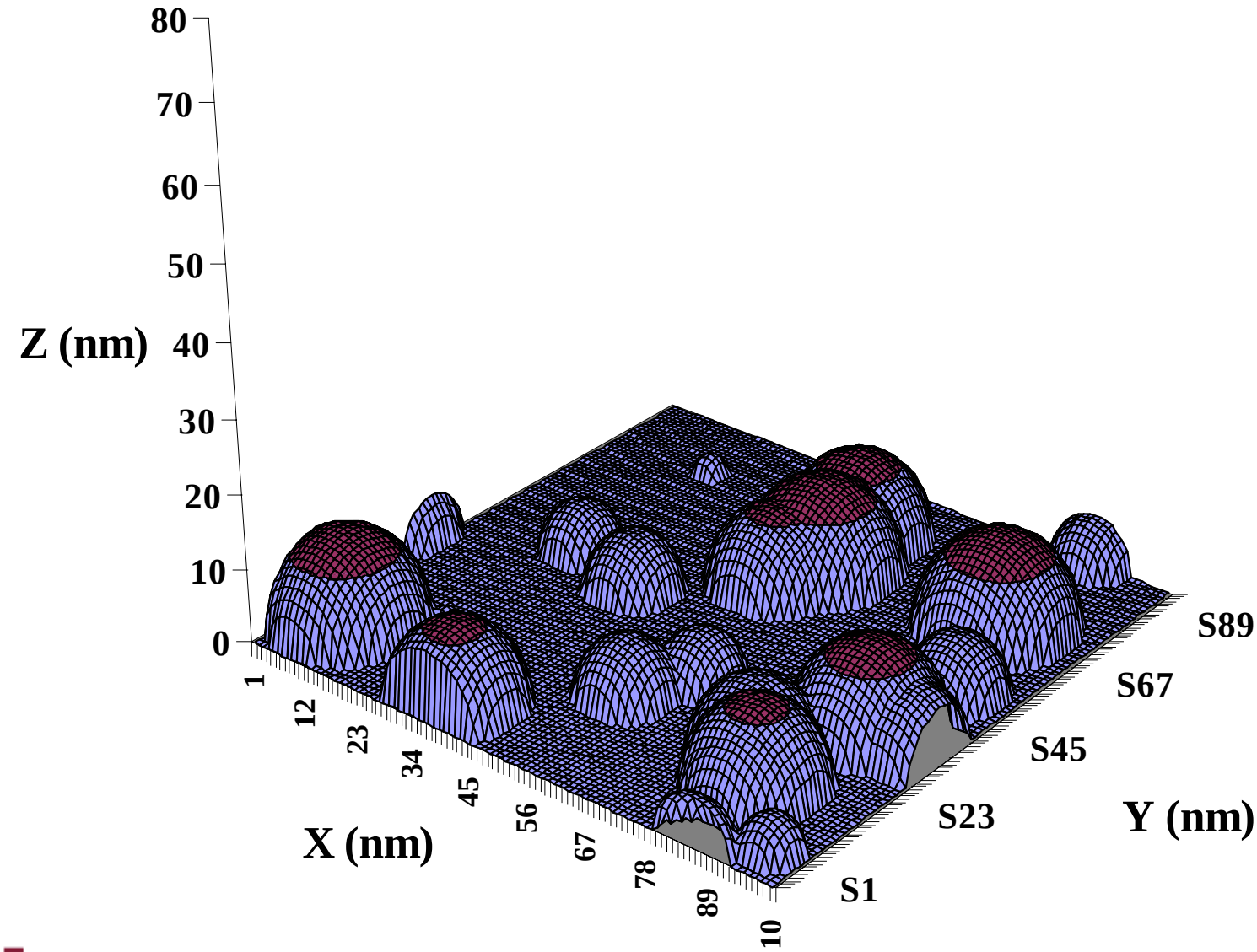
Force Boundaries (Max, Min, Avg.)

AFM-based force measurement

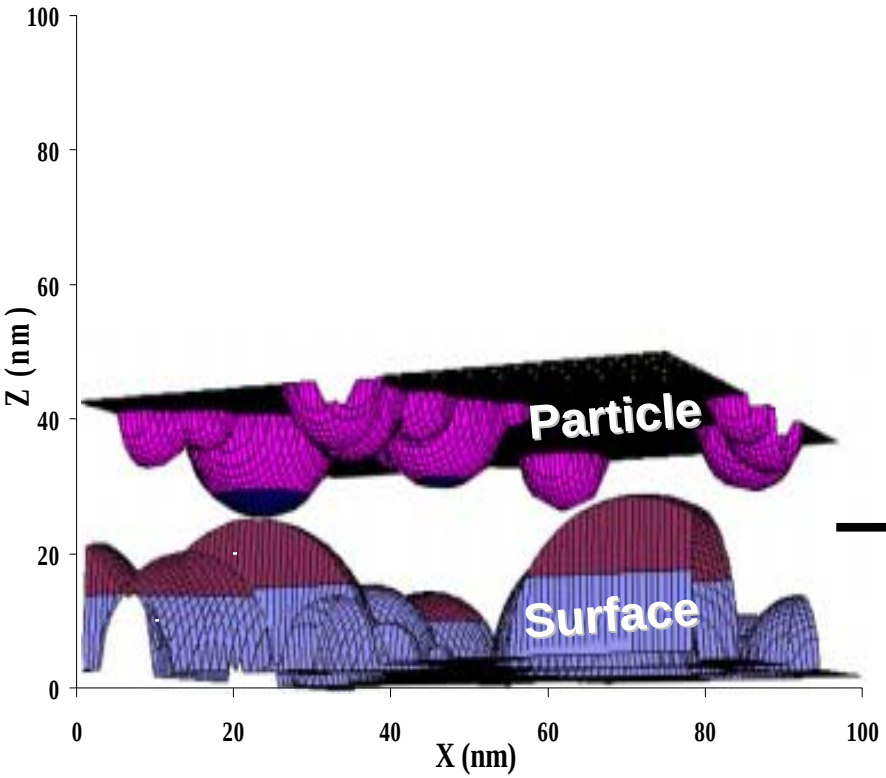
3-D Reconstruction

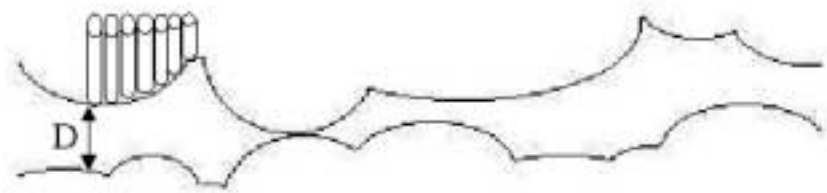


Random Surface Generation



Surface Interaction





Cylindrical Volume Elements

$$F_{attr} = -\frac{A \cdot (\text{Area cylinder})}{6 \cdot \pi \cdot D^3}$$

- Elements are placed every nm