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Characterization of polymer brushes deposited on gold surfaces by 1D and 3D-AFM in liquid

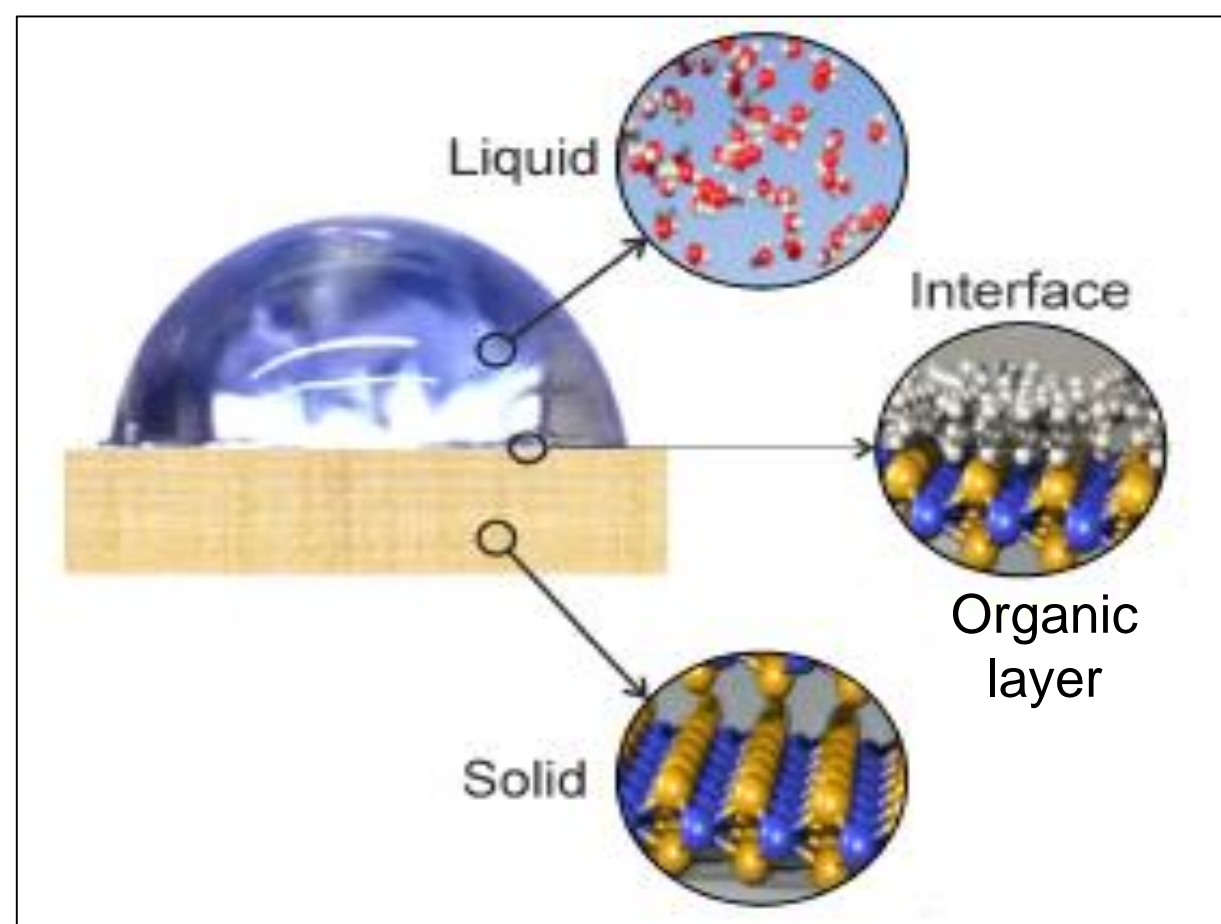
Characterization of gold/thiol layer/liquid interfaces in different liquid environments by 1D-AFM and 3D-AFM to analyze their behavior for applications in biosensing and tribology

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Solid/Organic layer/liquid Interfaces



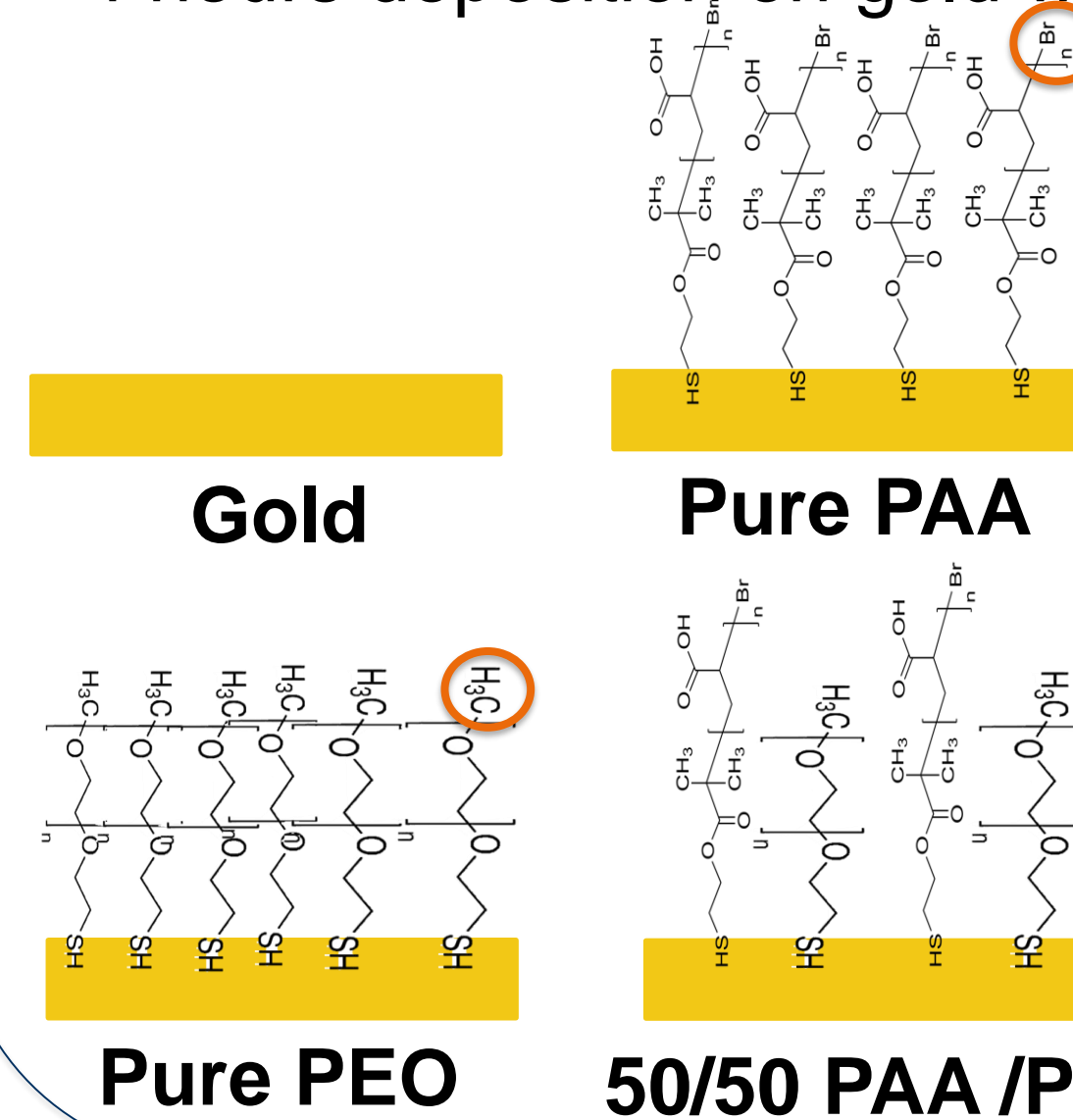
"Grafted onto" Organic layers

- Sensing layers in biosensors
- Protective layers for tribology applications

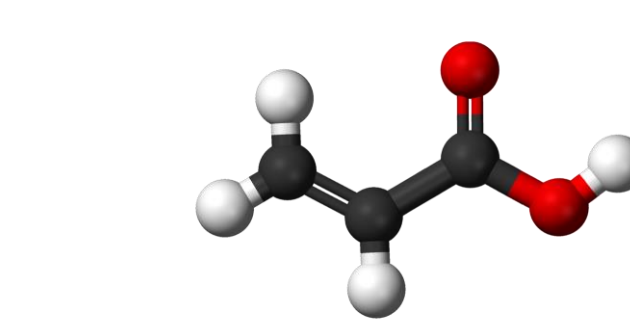
M. Ralph Uhlig (Thesis, Instituto de Ciencia de Materiales de Madrid, 2019) Page 18

Sample preparation

- Polymers dissolved in distilled water (C = 1,5 g/L)
- 4 hours deposition on gold wafers



Poly (acrylic acid) PAA

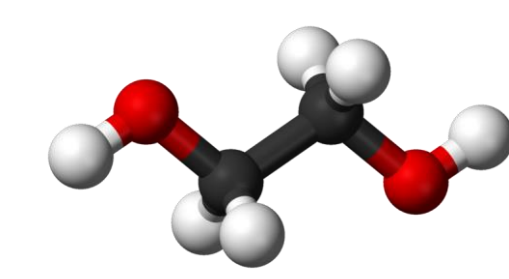


● Carbon ● Hydrogen ● Oxygen

Protein adsorption and trapping

- Biocompatible, non-toxic, biodegradable
- Interesting swelling properties

Poly (ethylene oxide) PEO

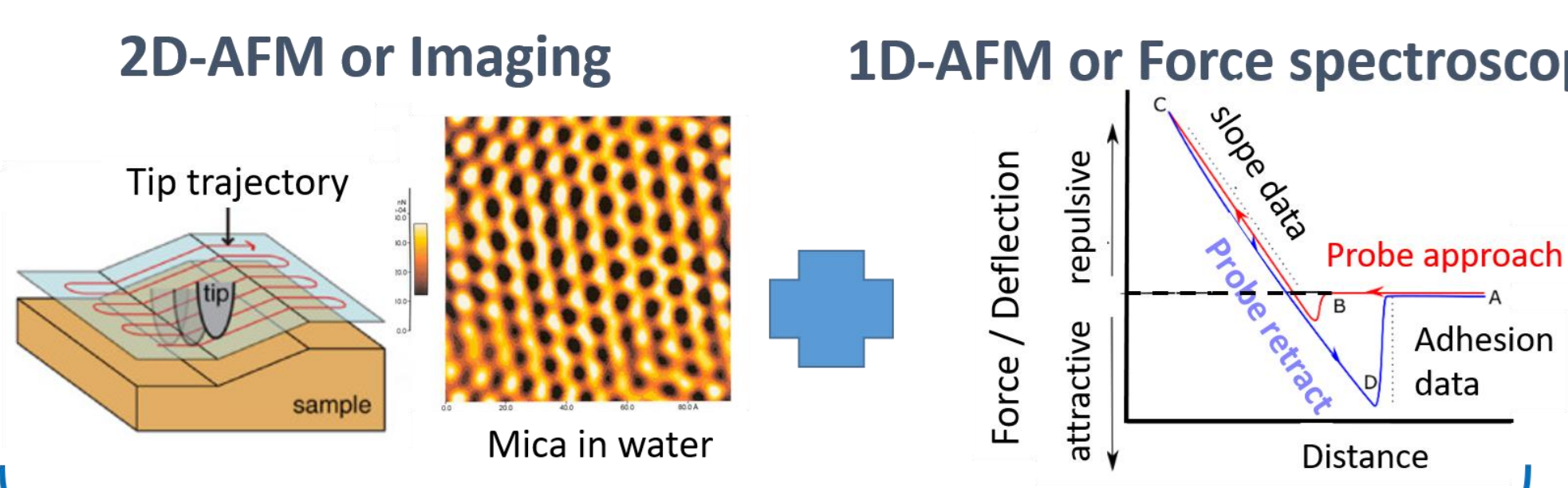


Protein repulsion and friction decrease

- Non-toxic
- Interesting repulsion properties

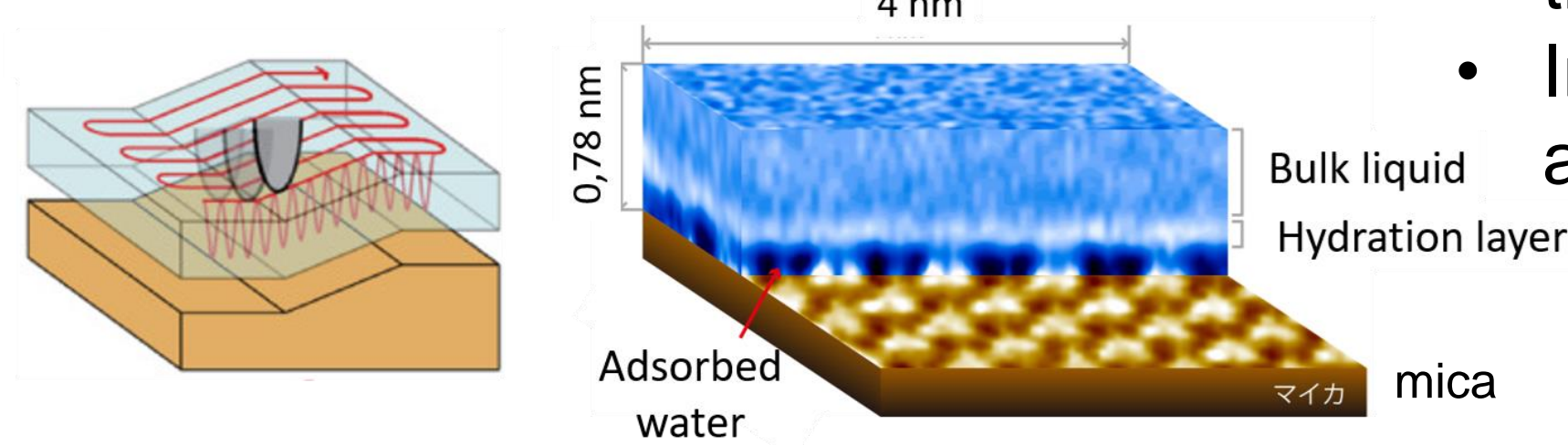
Principle of 3D-AFM

Combination between 1D-AFM and 2D-AFM



- Technique for high resolution interfacial characterization
- Implementation in a conventional 2D-AFM
- Additional sine wave signal to the z-piezo (Lock-in amplifier)
- Image of the first liquid layers above the surface

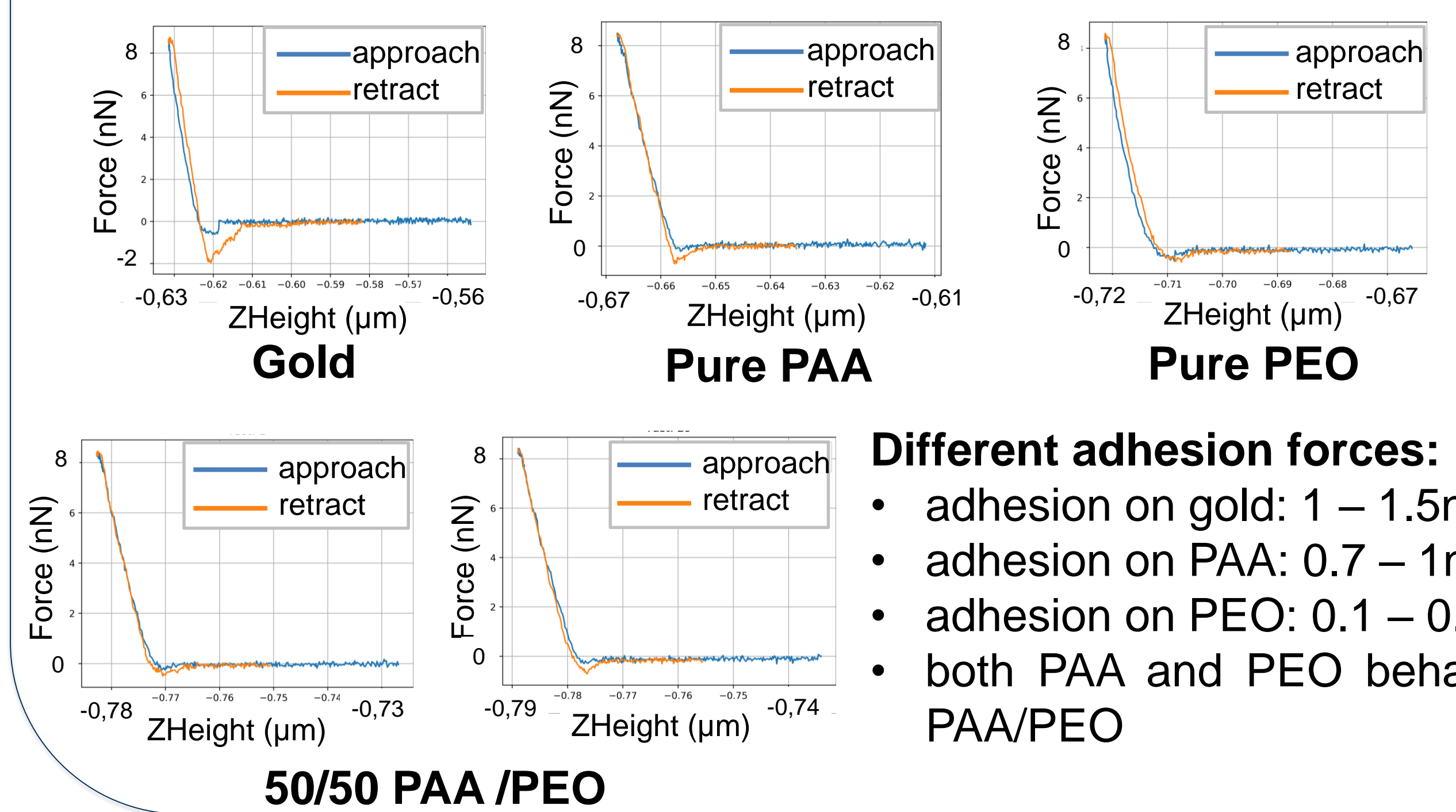
3D-AFM



T. Fukuma, Y. Ueda, S. Yoshioka, H. Asakawa, Phys. Rev. Lett. 104 (2010) 016101

1D-AFM Measurements

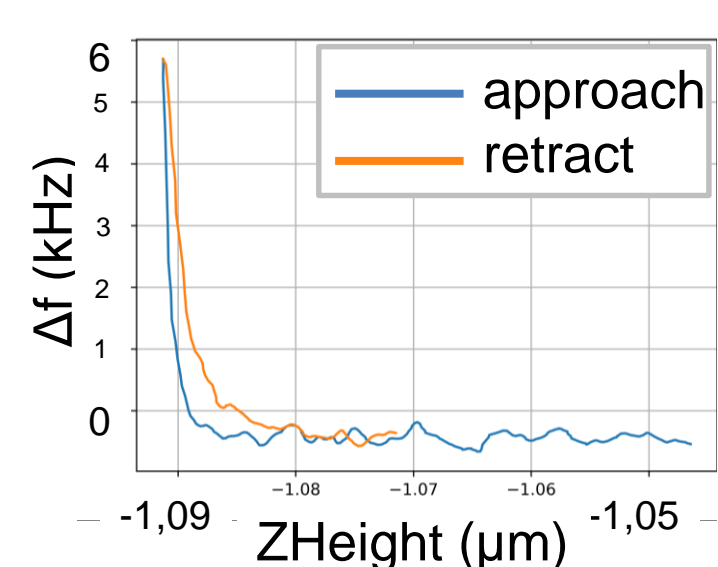
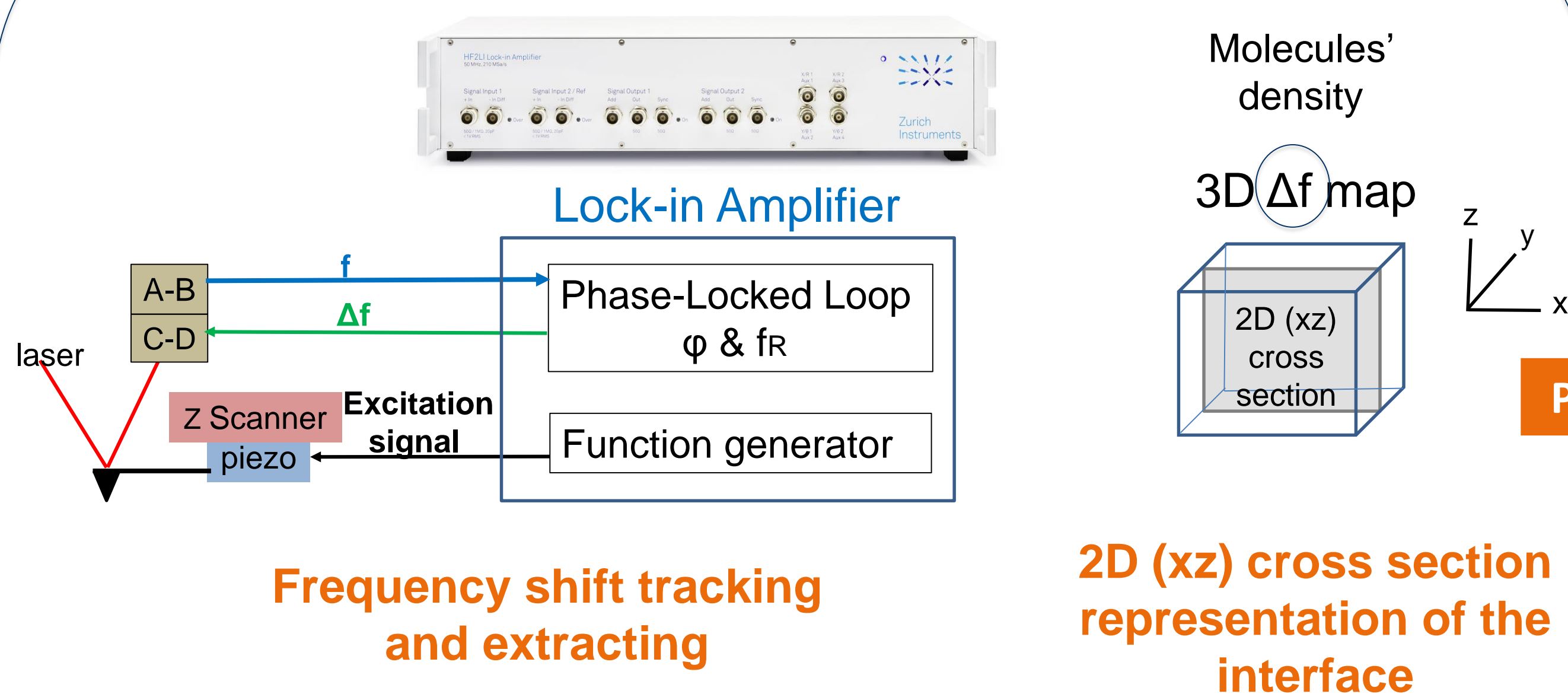
Force curves in pure water



Different adhesion forces:

- adhesion on gold: 1 – 1.5nN
- adhesion on PAA: 0.7 – 1nN
- adhesion on PEO: 0.1 – 0.5nN
- both PAA and PEO behaviors on PAA/PEO

3D-AFM implementation

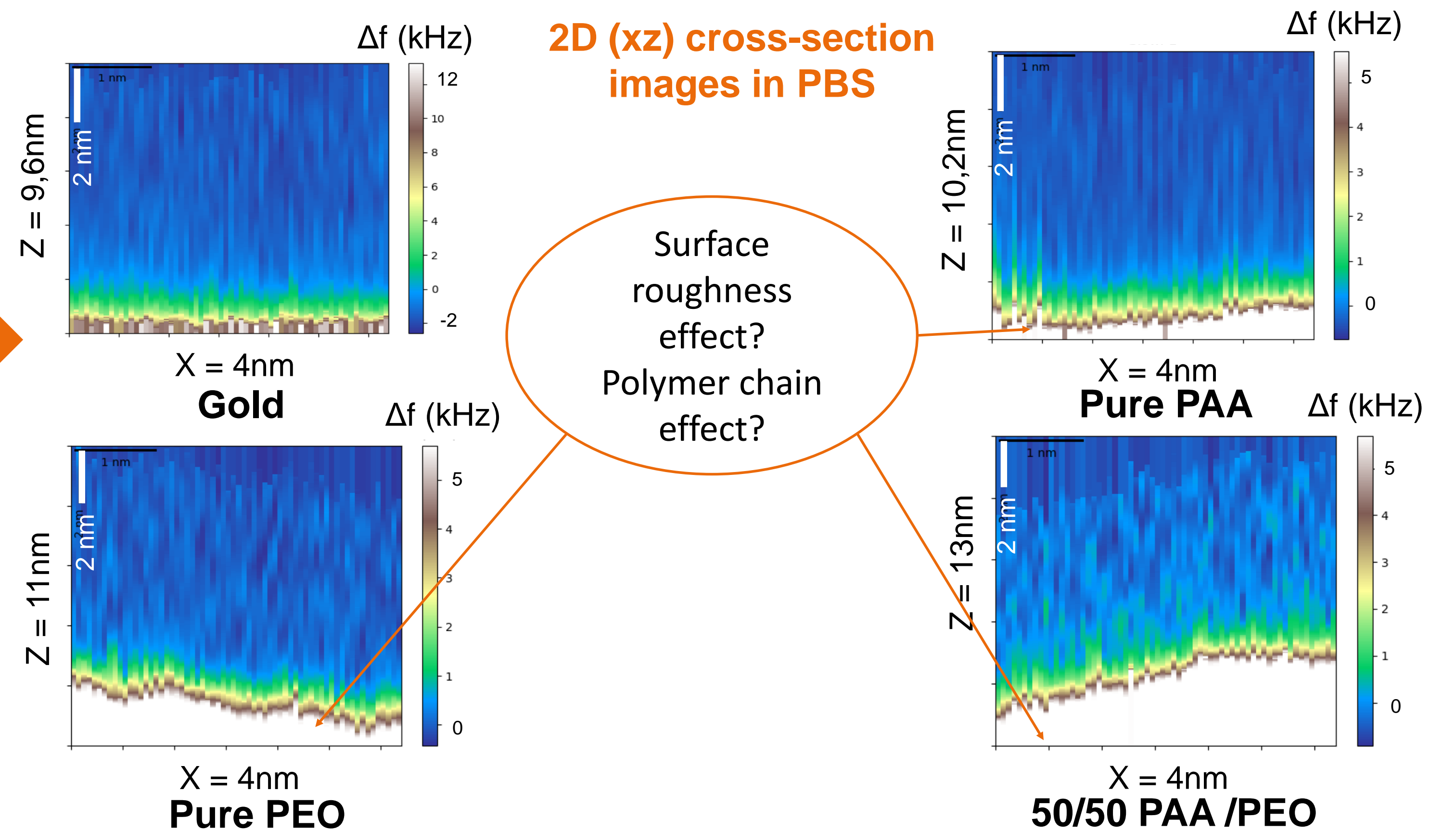


$\Delta f \rightarrow \Delta F \rightarrow$ 3D force maps

$$F(z) = 2k \int_{-z}^{\infty} \left(1 + \frac{a^{1/2}}{8\sqrt{\pi(t-z)}} \right) \Omega(t) - \frac{a^{3/2}}{\sqrt{2(t-z)}} \frac{d\Omega(t)}{dt} dt$$

Sader et al. Appl. Phys. Lett. 84, 1801 (2004)

3D-AFM Measurements



- Successfully implemented 3D-AFM
- Successfully generated 2D vertical images representing the interface
- Result analysis still in process

This 3D-AFM method is appropriate to visualize the interface between solid/polymer chains/liquid. It is promising to interpret the difference in behavior depending on the polymers' headgroups and the nature of the liquid. Our future work consists in improving the technique (vertical resolution, surface roughness,...) and calculating the force between the tip and the samples' surfaces and then generating a 3D force map of the interfaces. Furthermore, we are going to develop new interfaces by functionalizing silicon wafers with silane and then analyzing them using the improved version of 3D-AFM.

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