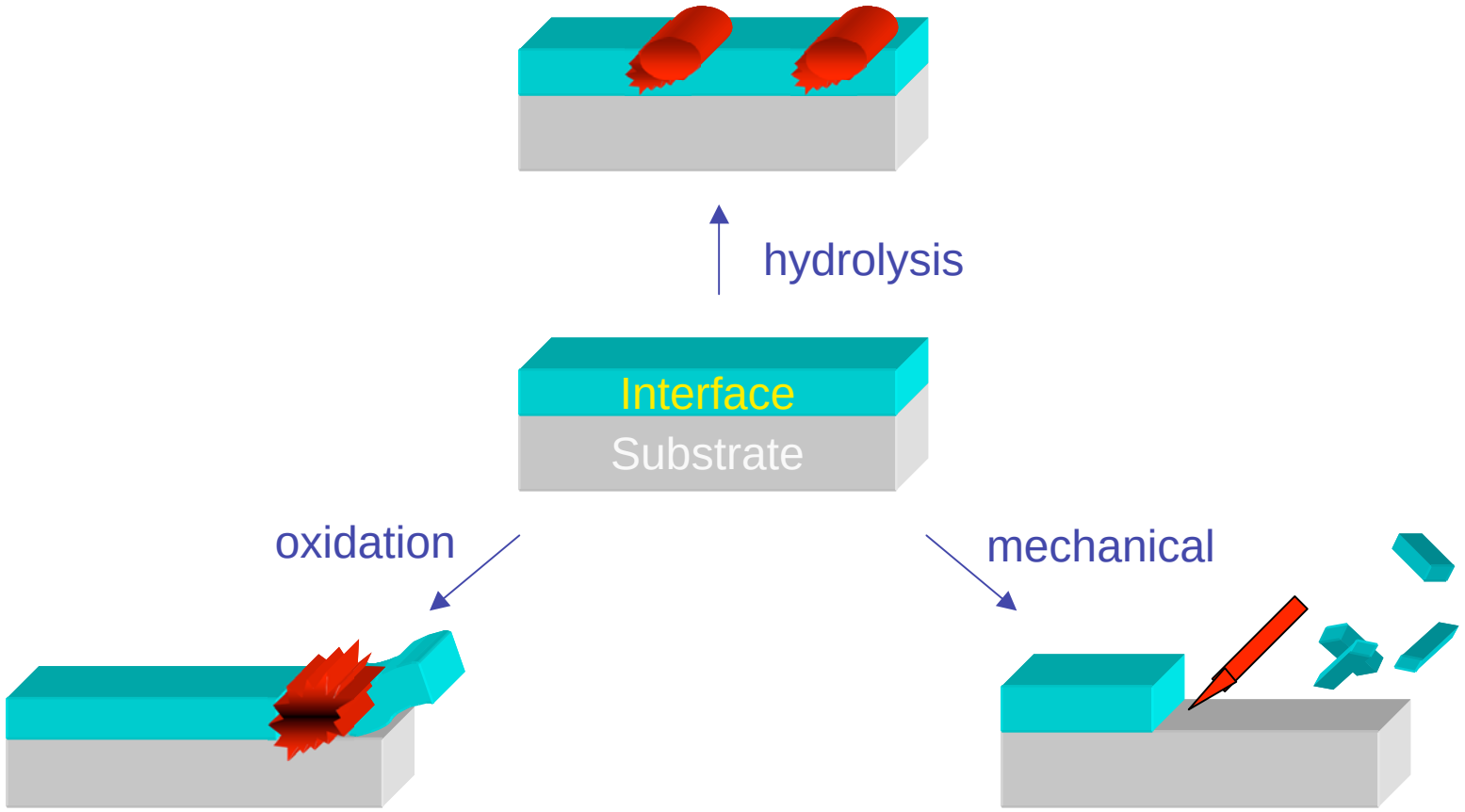
Reactive Interfaces for Functional Surfaces

Surface Modification of Functional Materials:

Synthesis and Characterization

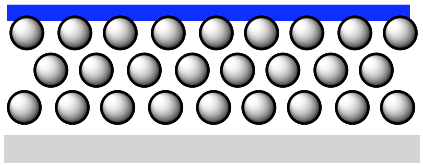
Interfaces in the Real World:

They must withstand various stresses



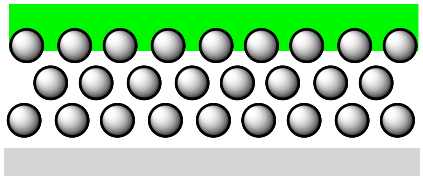
Monolayers Have a Processing Advantage for Coating Biomaterials

sputtered solid



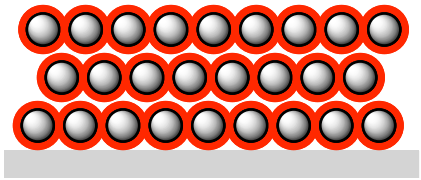
aspect problem:
line of sight deposition

polymer deposition



penetration problem:
solution viscosity

conforming monolayer

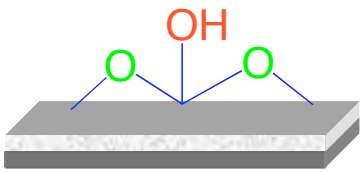


dilute solution:
perfusion possible

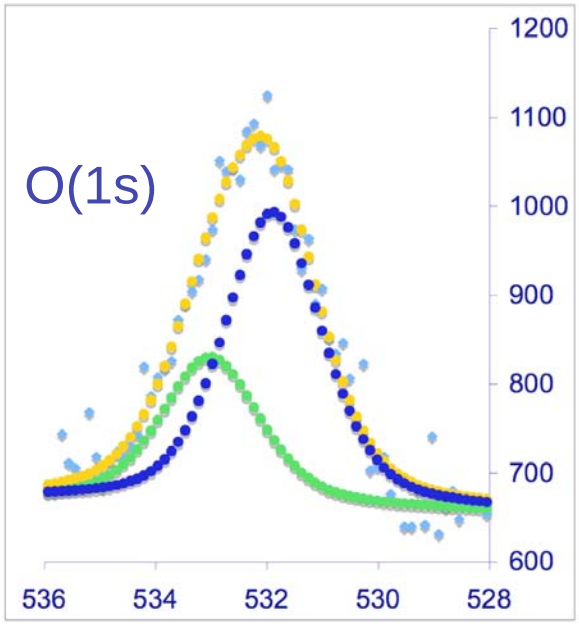
Our solution-based process enables our surface treatment to succeed on curved, textured, beaded, or porous surfaces.

The Key to Success: Surface Science
Constructing a Good Foundation

Interface design is based on knowledge of device surface properties.

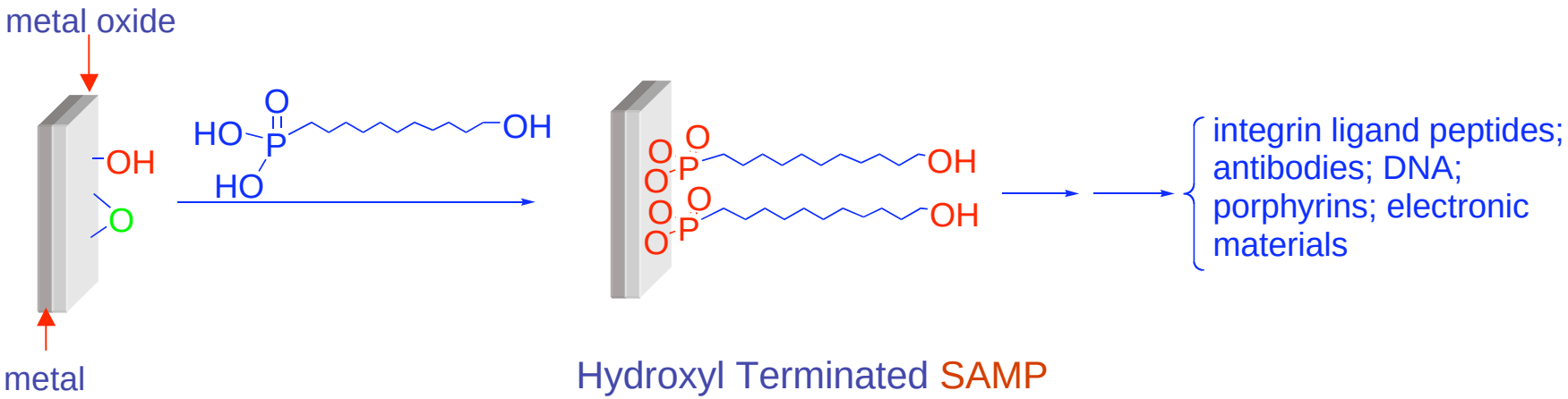


Of the total O on the Ti surface, 16% is OH; the rest is bridging (or μ-oxo) oxide.



Lu, Bernasek, Schwartz. Surf Sci. 2000;458

Our Platform Technology for Metals: Self-Assembled Monolayers of Phosphonates

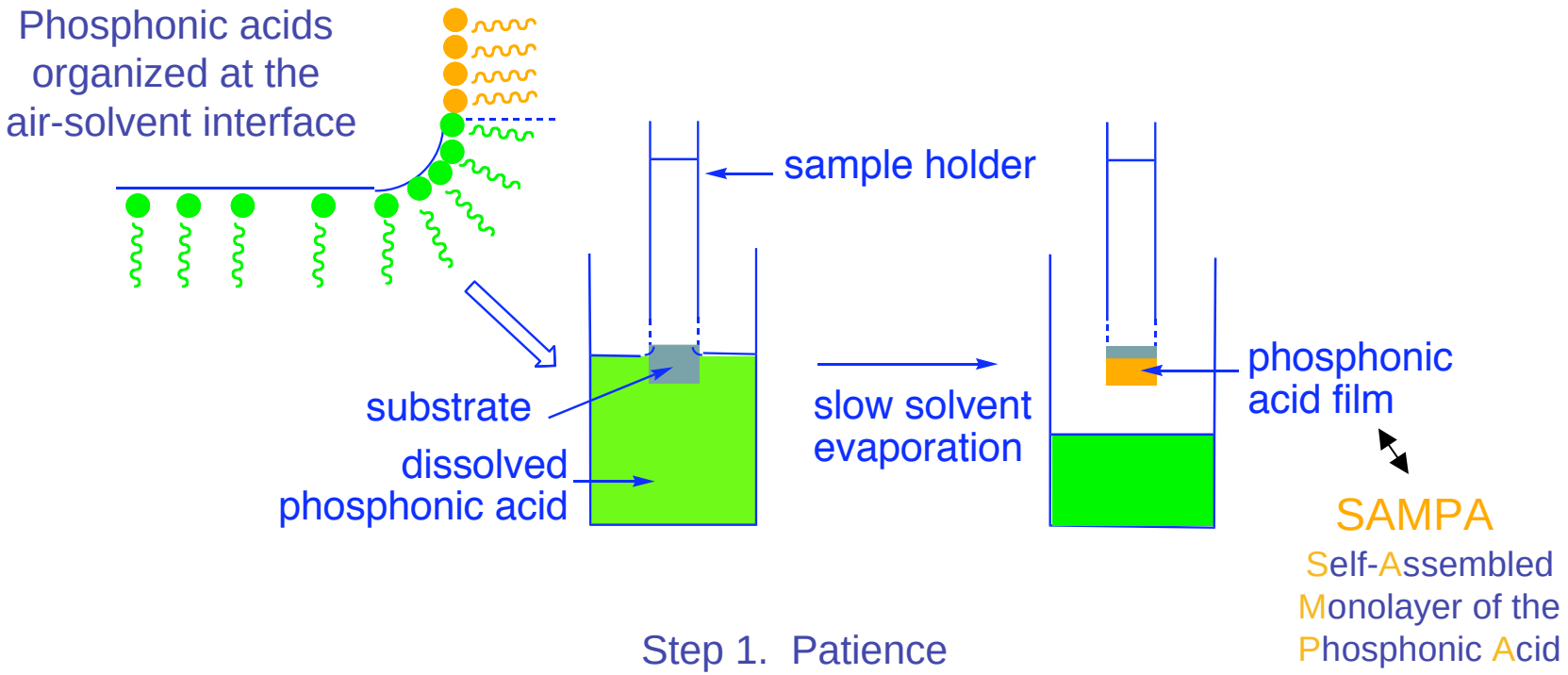


Hydroxyl Terminated SAMP
(PUL)
The Platform Monolayer

- Reactivity of the metal oxide layer is not limited by its surface OH content (as is the case for siloxane reagents)
- Phosphonates react both with -OH and μ-oxo groups
- SAMP coatings are stable to air and water

Gawalt, Avaltroni, Koch, Schwartz, Langmuir. 2001; 5376
Silverman, Wieghaus, Schwartz. Langmuir. 2005; 225

Optimizing Our Platform Technology: The T-BAG Method for Growing SAMPs



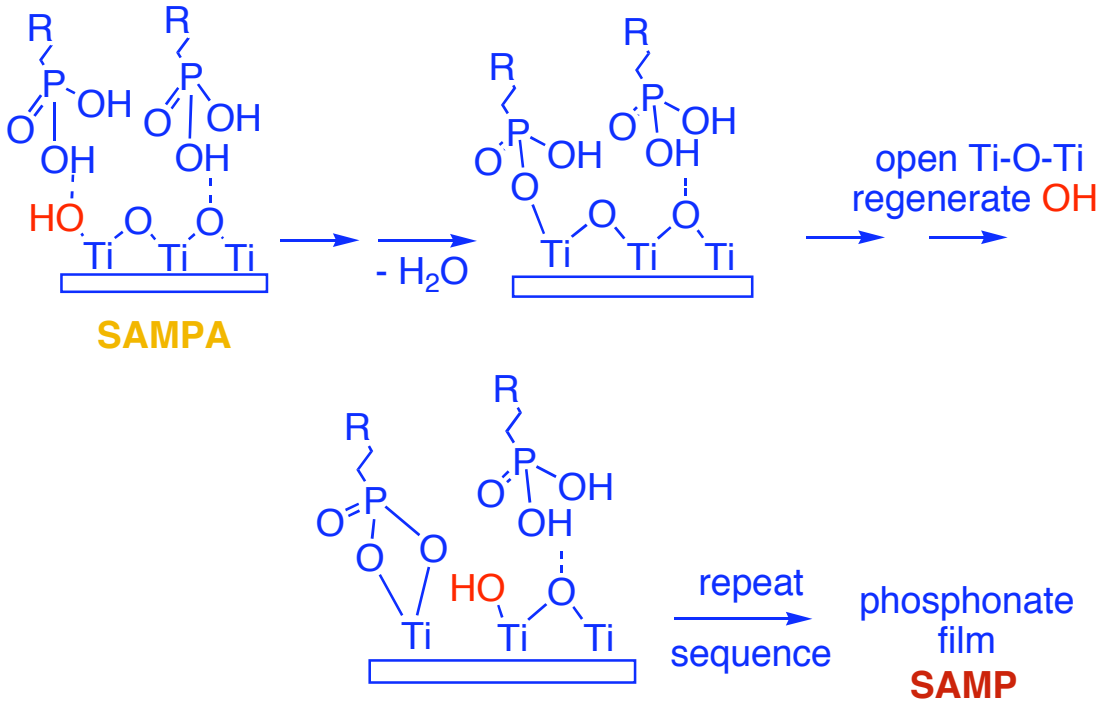
Step 1. Patience
Step 2. Heat converts the SAMPA to a SAMP

Any shape substrate can be easily coated!

Hanson, Schwartz, Nickel, Koch, Danisman. J Am Chem Soc. 2003;125

Our Surface Chemistry Is Different from Methods that Consume OH Groups

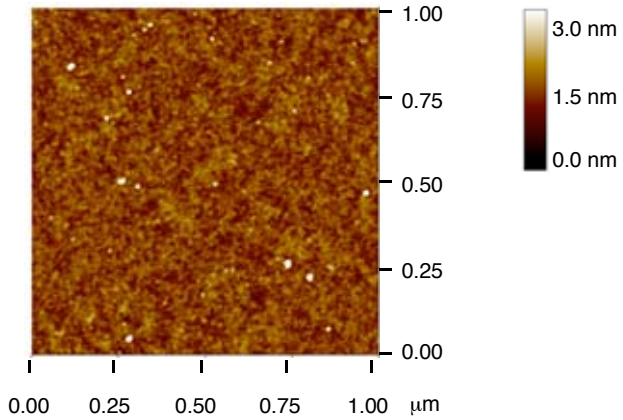
Phosphonic acids transfer protons to the surface

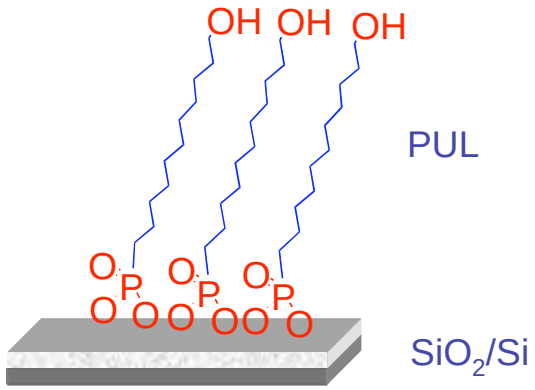


Interface strength is derived from the metal ion-phosphate covalent bond.

The SAMPs Have Close-Packed Chains

An AFM image of PUL on SiO_2/Si





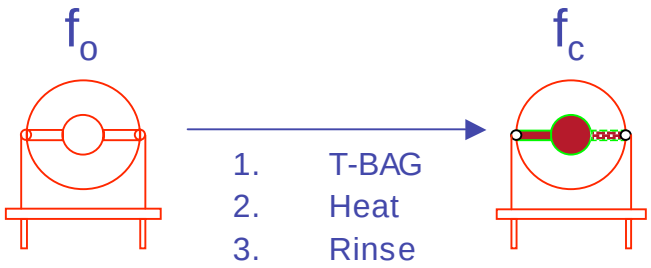
- Film thickness measured by AFM section analysis or X-ray reflectivity;
- AFM shows the film is of high quality, with few, if any, pinholes.

Hanson, Schwartz, Nickel, Koch, Danisman, J. Am. Chem. Soc. 2003; 16074

Midwood, Carolus, Danahy, Schwarzbauer, Schwartz. Langmuir. 2004; 5501

The SAMPs Have Close-Packed Chains

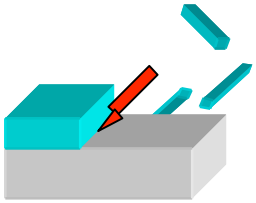
The Quartz Crystal Microbalance measures surface film content gravimetrically.



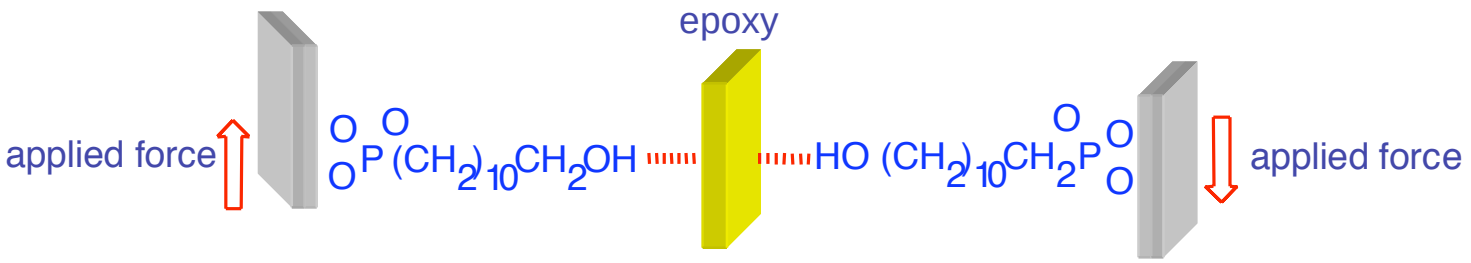
1. Electrodes coated with the surface of interest are deposited on opposite sides of a thin quartz wafer;
2. A potential is applied, and the crystal oscillates;
3. The organic species is deposited on the electrodes, and the crystal frequency decreases;
4. The mass of the deposited organic is calculated from the frequency change.

PUL Loading on SiO_2/Si: 0.9 nmole/cm^2 →

16.6 Å^2/molecule, chain packing comparable to crystalline polyethylene



Shear Strength is Important for Load-Bearing Applications



1. Prepare SAMPs of hydroxyundecylphosphonate (PUL) on coupons of Ti terminated with TiO_2.
2. Glue two coupons together in an offset manner using super strong epoxy. Let the epoxy set.
3. Put the "sandwich" of the epoxied coupons into a press, and apply force until the "sandwich" fractures.
4. Measure the interface strength: it takes >50 MPa to fracture the "sandwich" using our SAMP vs ~30 MPa to fracture a "sandwich" using untreated Ti.

Schwartz, Avaltroni, Danahy, Silverman, Hanson, Schwarzbauer, Midwood, Gawalt. Mat Sci Engr C. 2003; 395