

Surface Modification and Characterization of Nano- Composite Polymers

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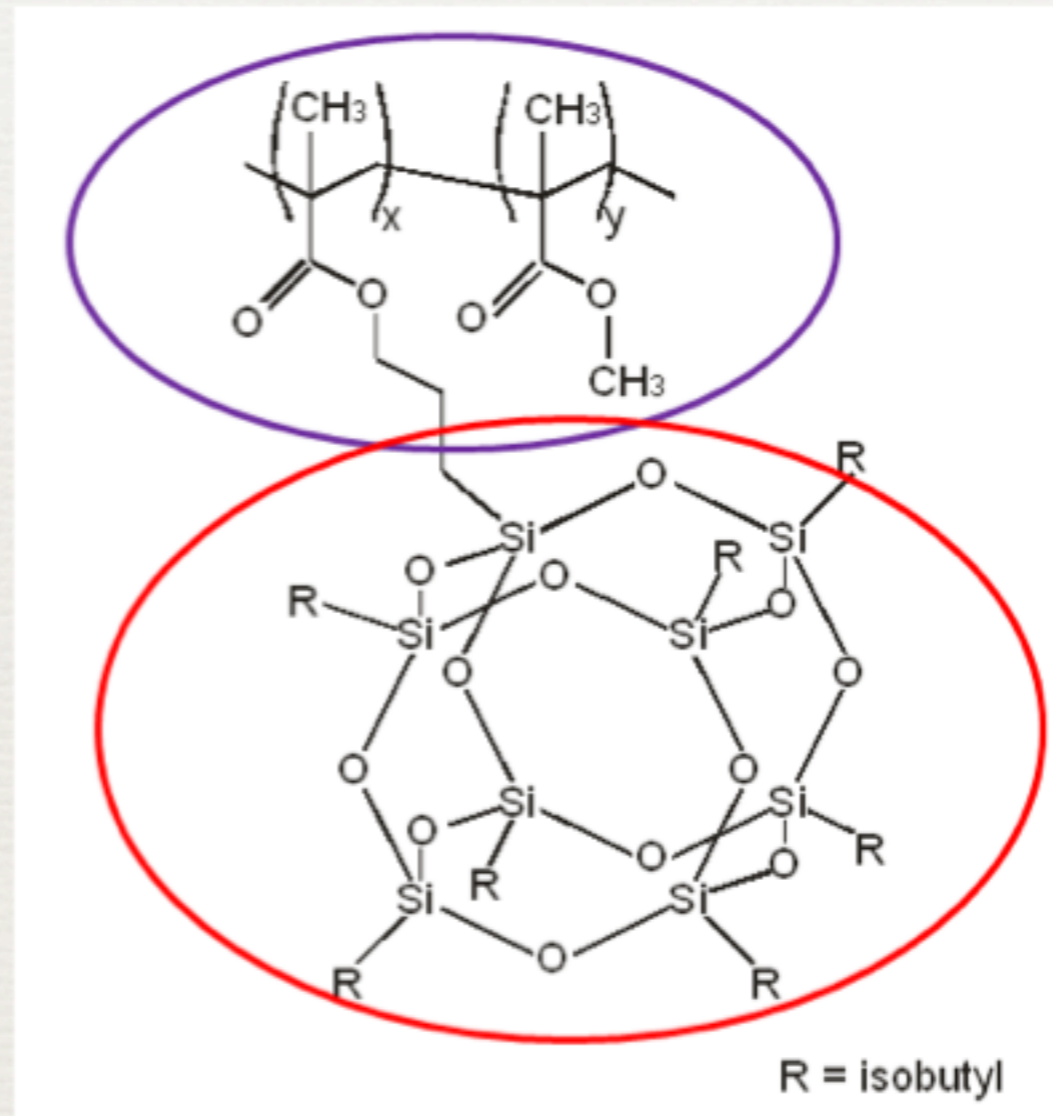
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Outline

- ◆ Nano-Composite POSS-MA/PMMA
- ◆ Time Evolution of Surface Structures
- ◆ Adhesion Promotion of Metals on PMMA

POSS-MA/PMMA

PMMA
Backbone



POSS Cage

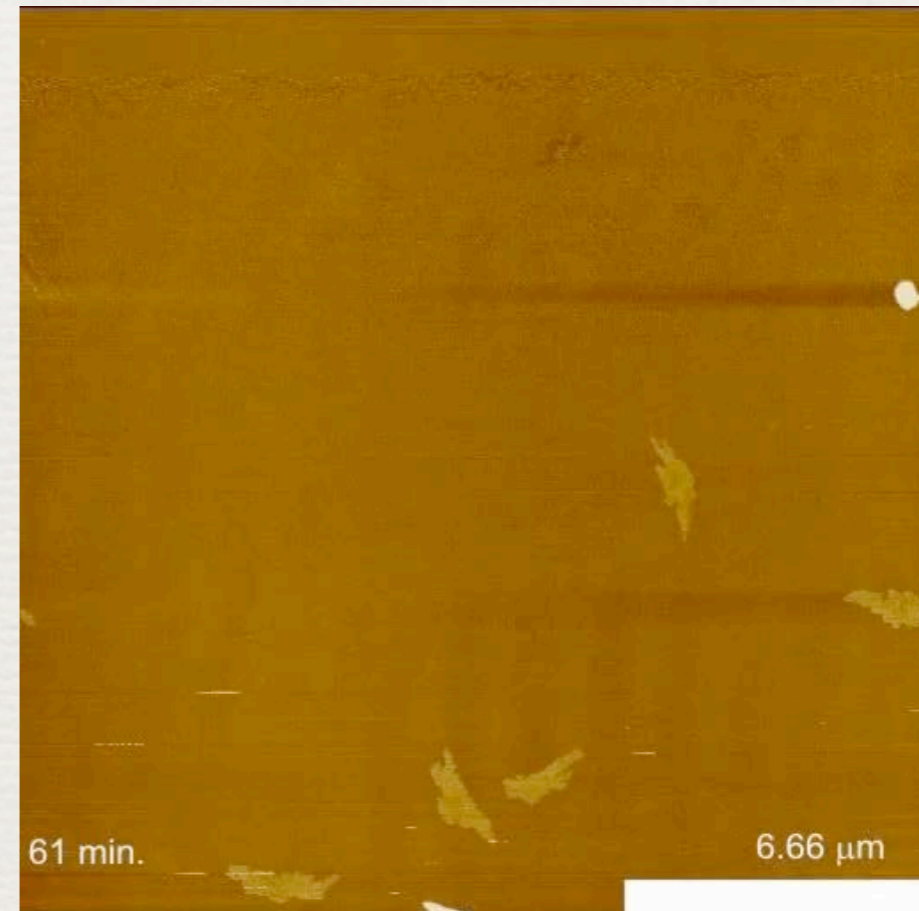
poly[(propylmethacryl-heptaisobutyl-polyhedral oligomeric silsesquioxane)-co-(methylmethacrylate)]

Sample Prep

- ◆ Oxidized silicon wafers using a tube furnace at 1000°C for 4 hours.
- ◆ Cleaned 1 cm x 1 cm SiO₂ samples with acetone, isopropanol, and water using ultrasonic cleaner. Dried thoroughly with N₂.
- ◆ Spun-cast 0.2 - 0.3 mL POSS-MA dissolved in CHCl₃ using a 0.2 μm syringe filter onto clean substrates at 1000 rpm spin speed.

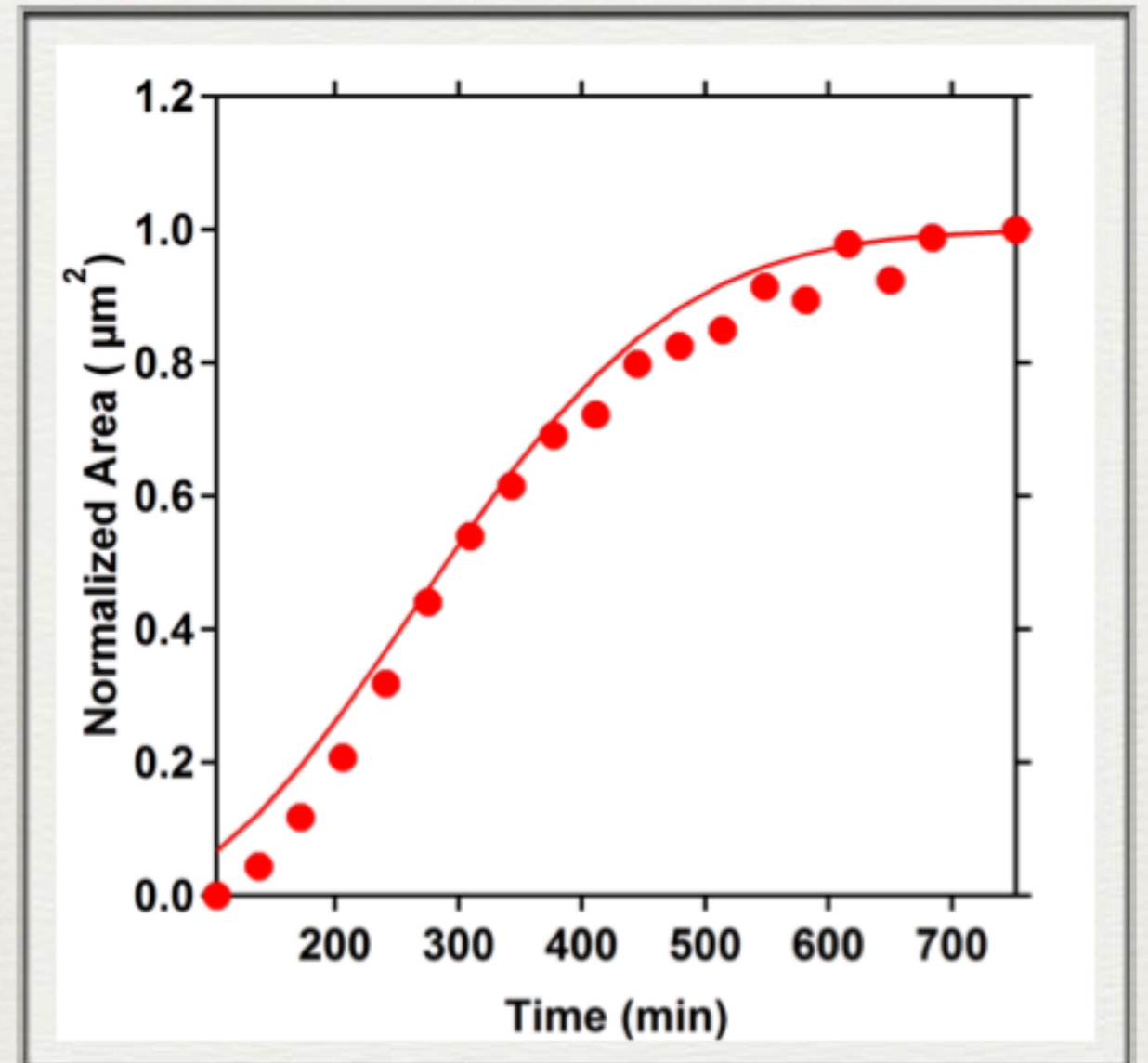
AFM Imaging

- ◆ Smooth surfaces were seen for low POSS wt% thin films.
- ◆ 45 wt% POSS films had micron-sized features on surface.
- ◆ 30 wt% POSS films showed an distinct evolution of structures over the space of hours.



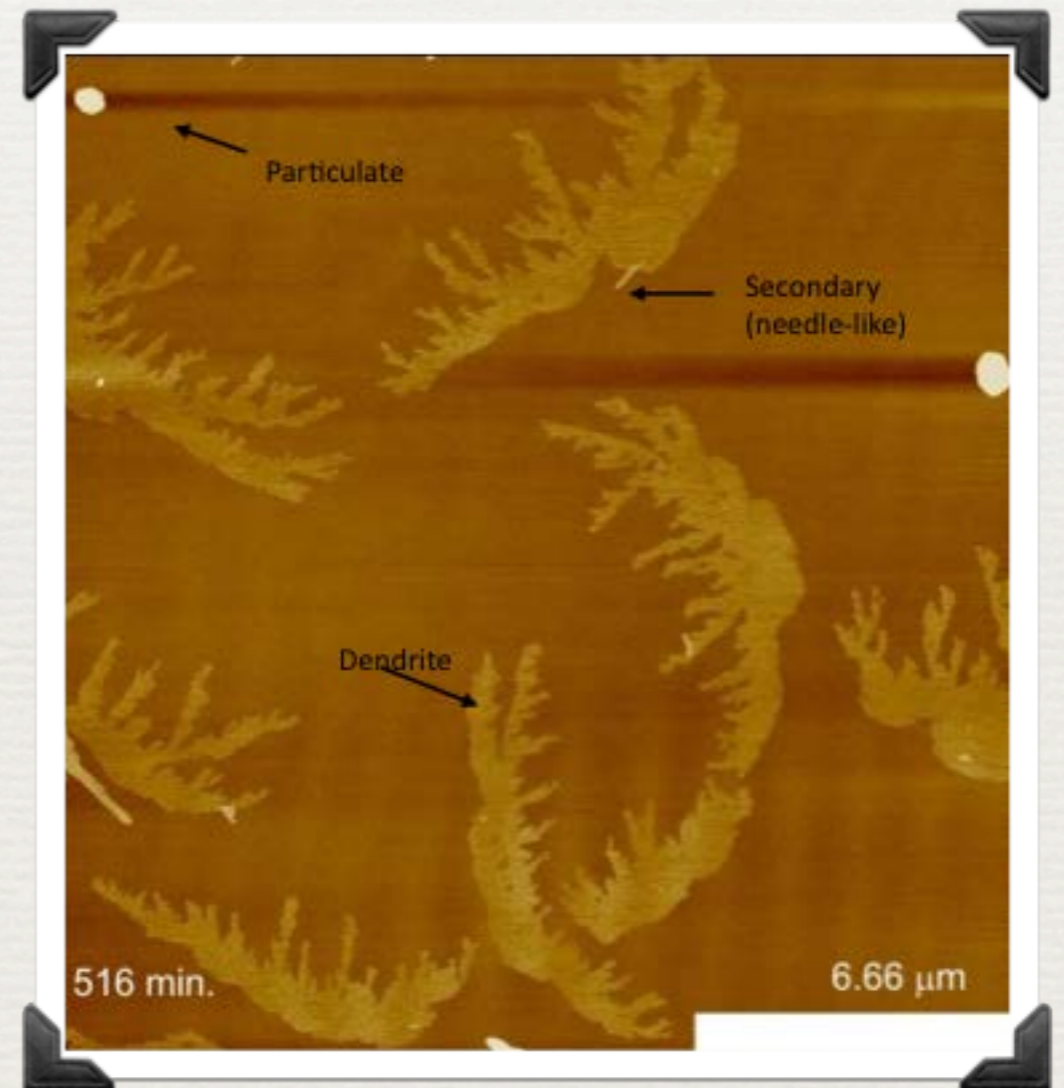
Determining Kinetics

- ◆ Attempts have been made to determine the area of the growths as a function of time.
- ◆ Should fit to an Avrami relationship.
- ◆ Secondary growth was observed.



Determining Kinetics

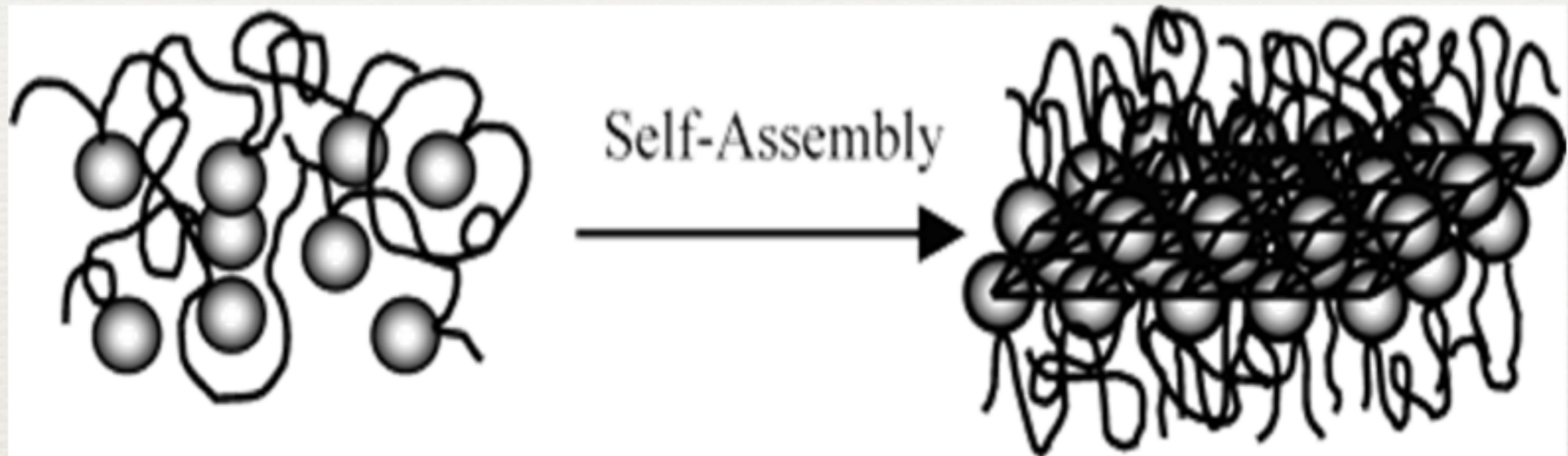
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Possible Model

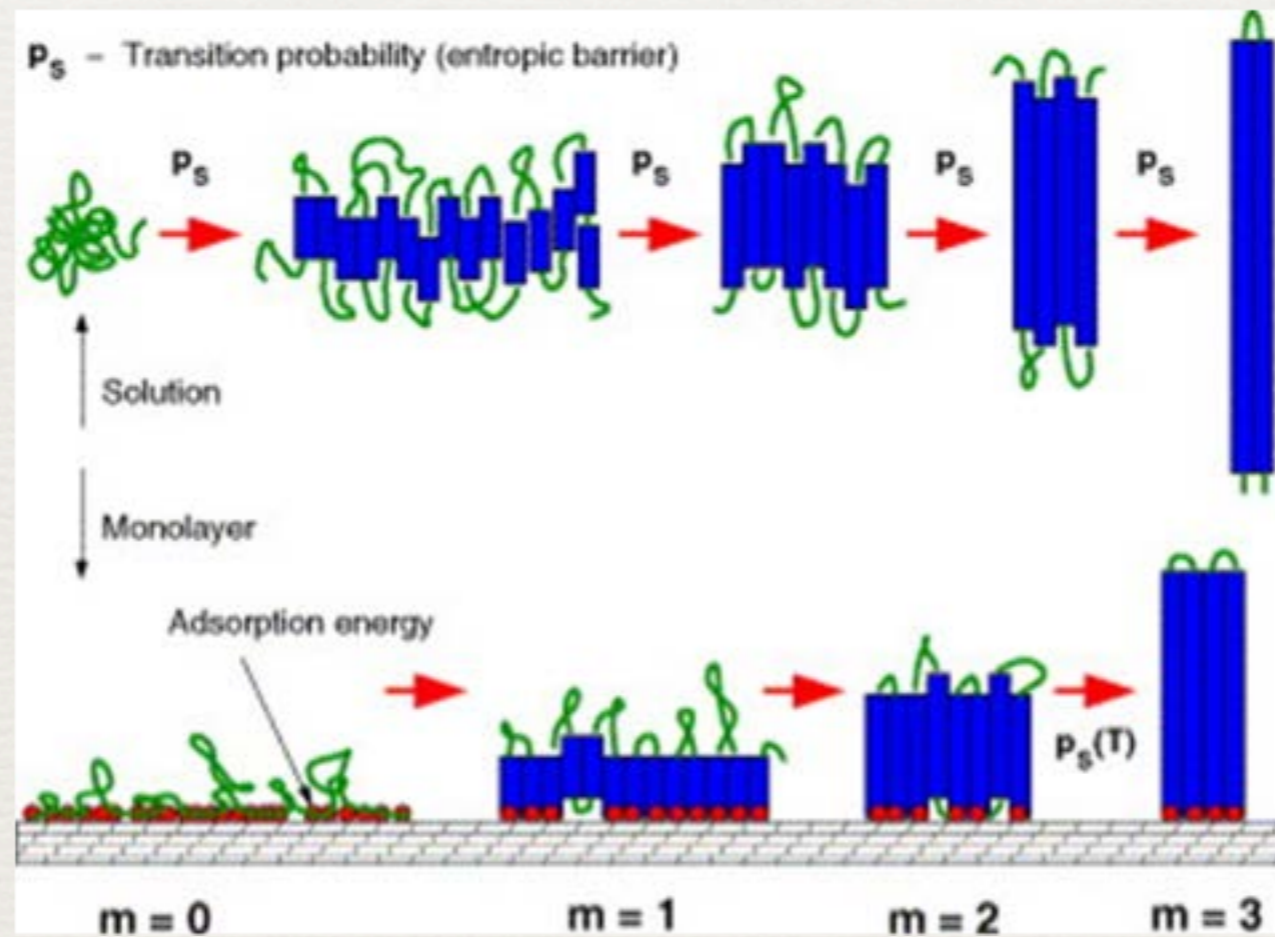
- ◆ At the moment, we aren't sure what these structure are...
 - ◆ crystallization
 - ◆ phase separation
 - ◆ impurities

Possible Model



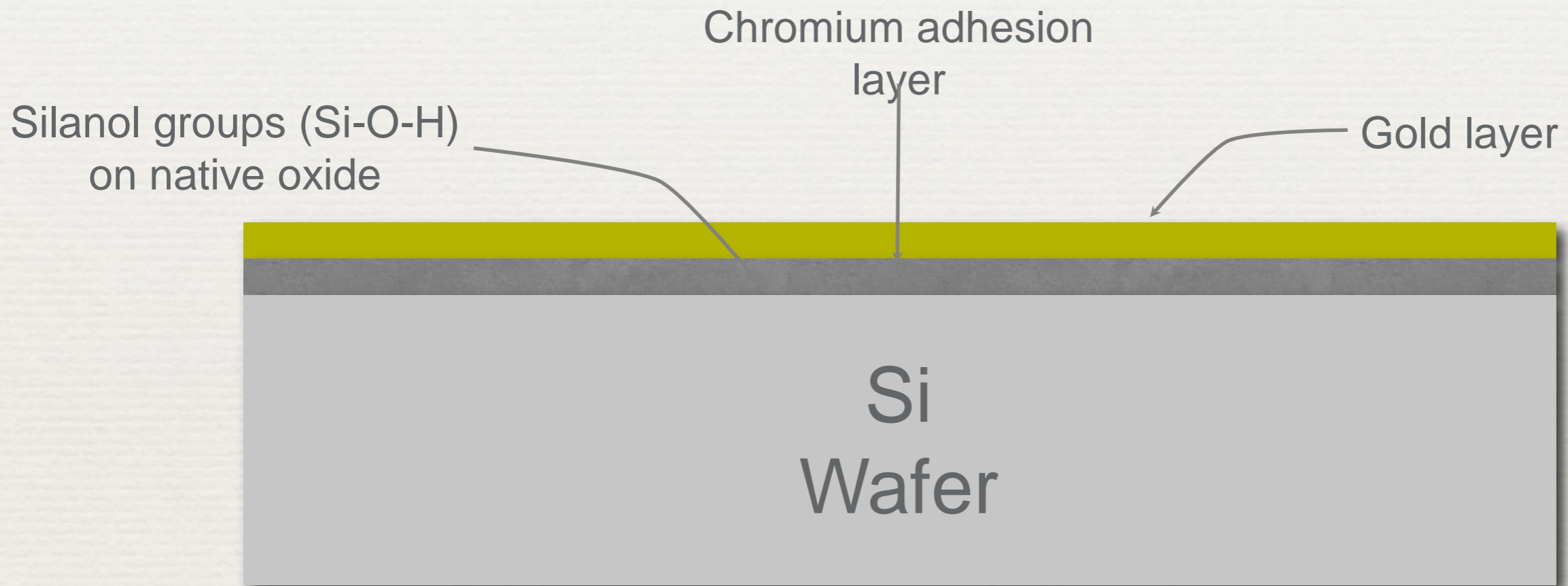
Zheng, et al., "Polymer Nanocomposites through Controlled Self-Assembly of Cubic Silsesquioxane Scaffolds", *Macromolecules*, **37**, (2004), 8606-8611

Possible Model



Sommer, J-U; Reiter, G.; "Crystallization in ultra-thin film polymer films: Morphogenesis and Thermodynamical Aspects", *Thermochemica Acta*, **432**, (2005), 135-147

Standard Method for Au Adhesion on SiO₂

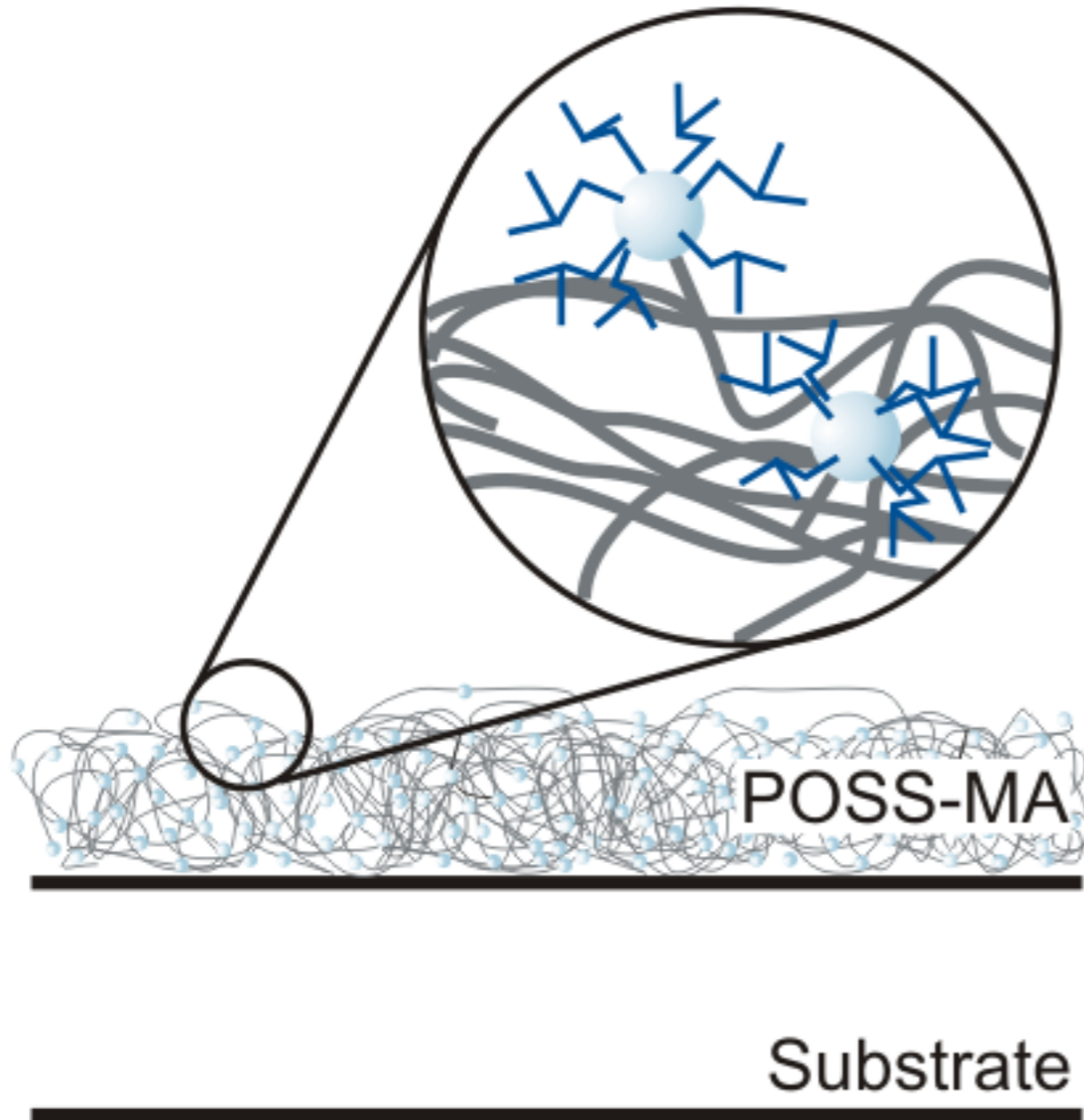


How to make this work on PMMA?

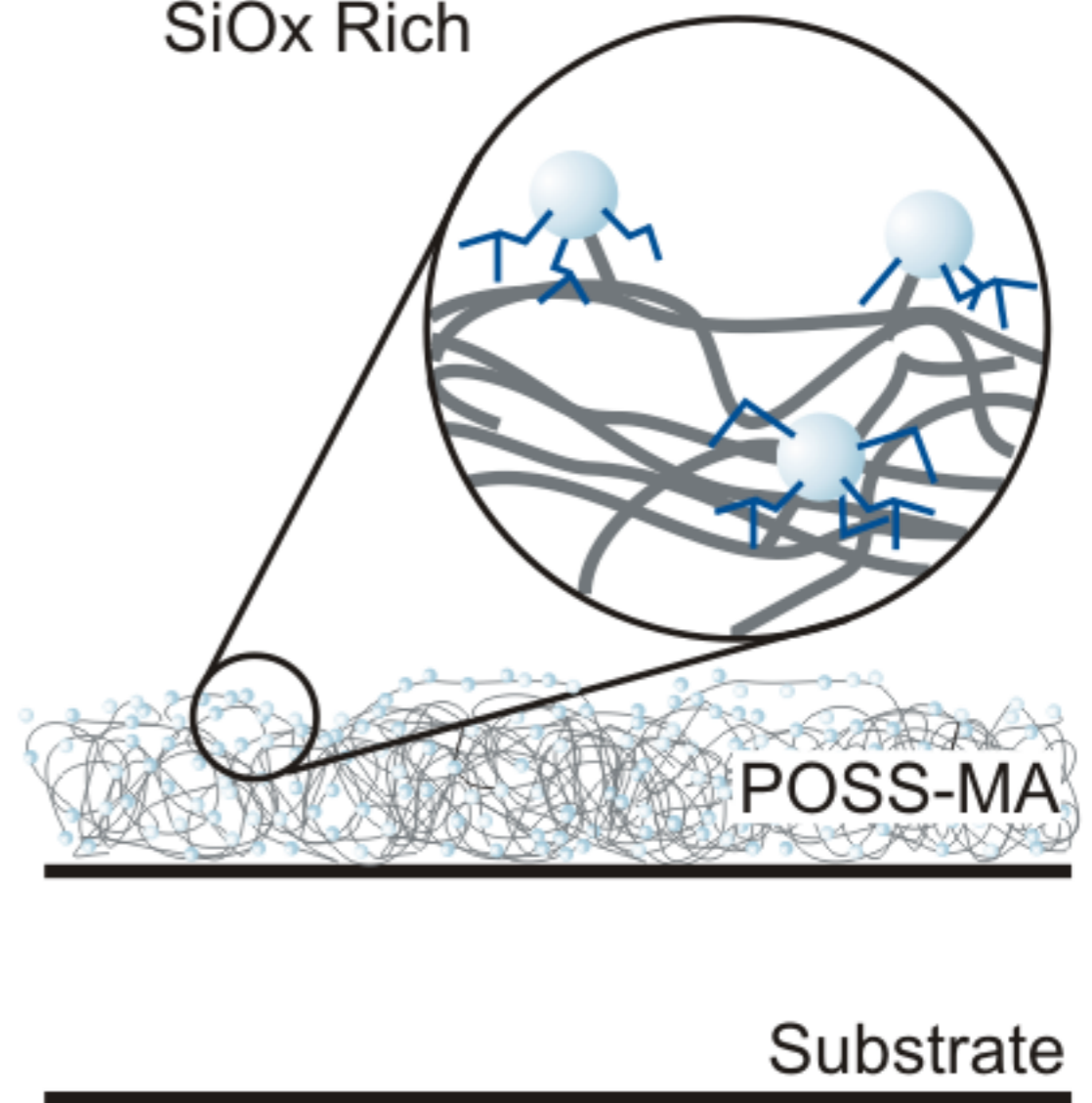
Our Model

As-deposited

After Oxygen Plasma Exposure



SiOx Rich



Tape Testing for Adhesion

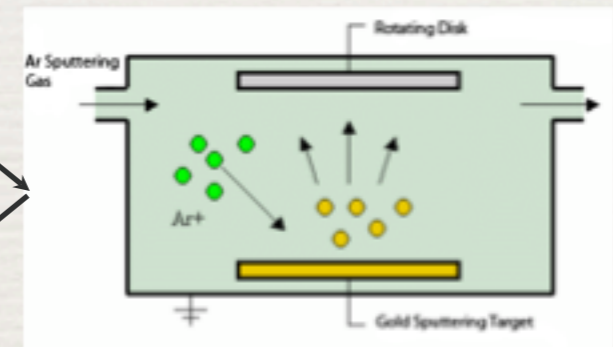
PMMA Substrate (1 in x 1 in)



Spin cast solvent
(1000 rpm, 1 min)



Sputter deposit metals
(1 nm Cr; 54 nm Au)

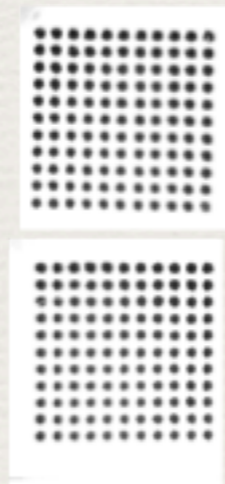


Control



CHCl₃

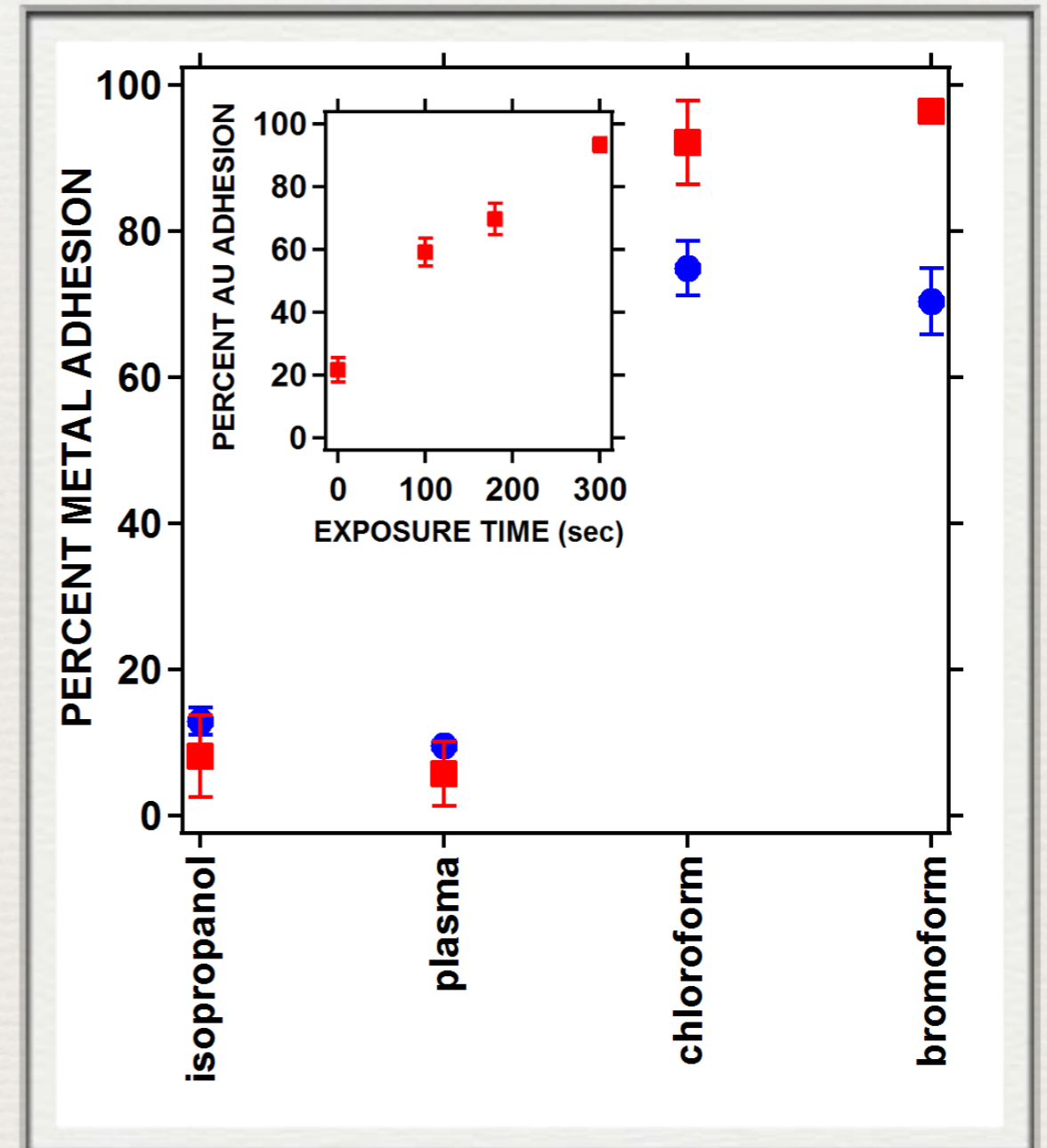
Tape Test



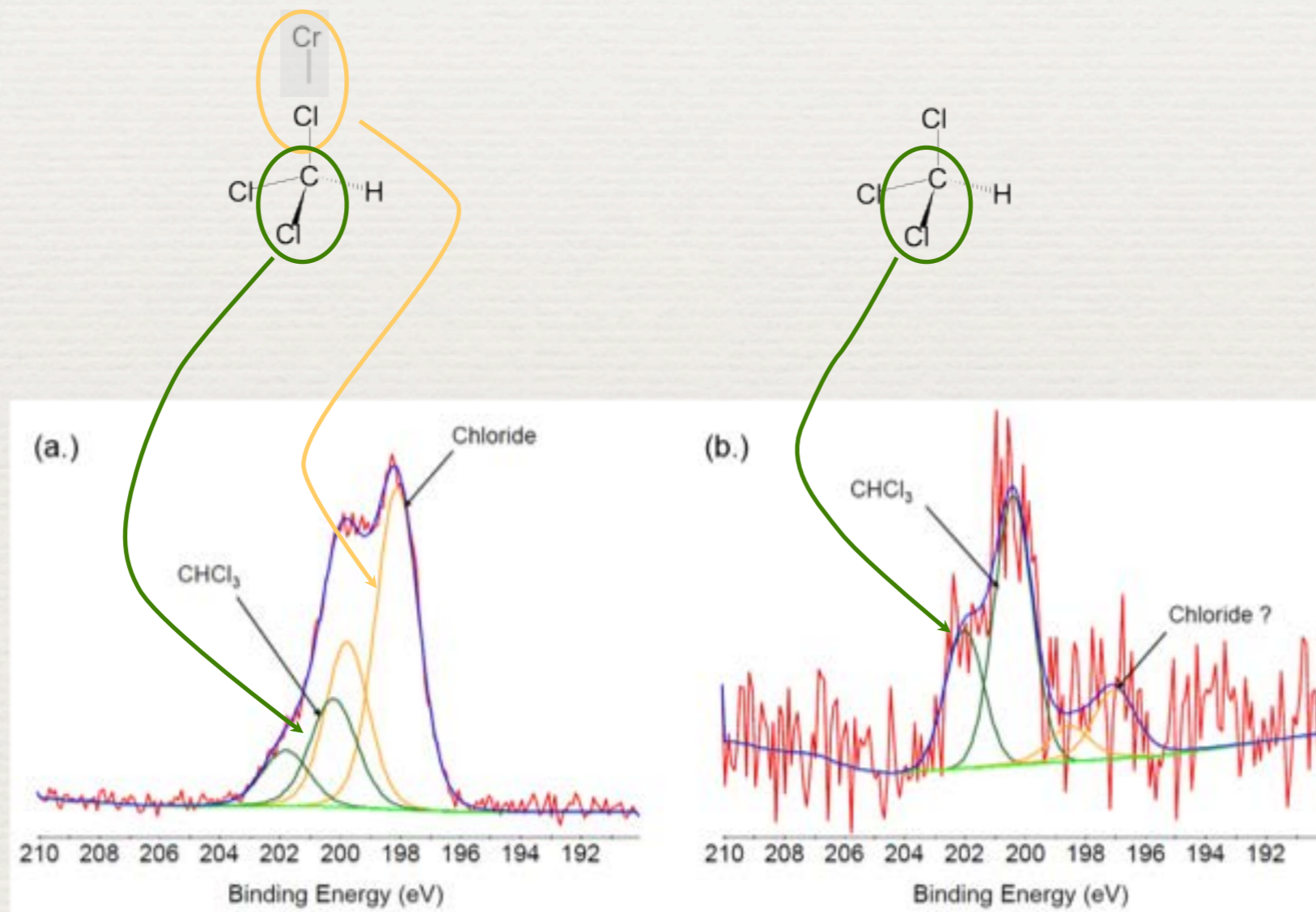
Optical Microscopy
(calculate area)

Metal Adhesion Promotion

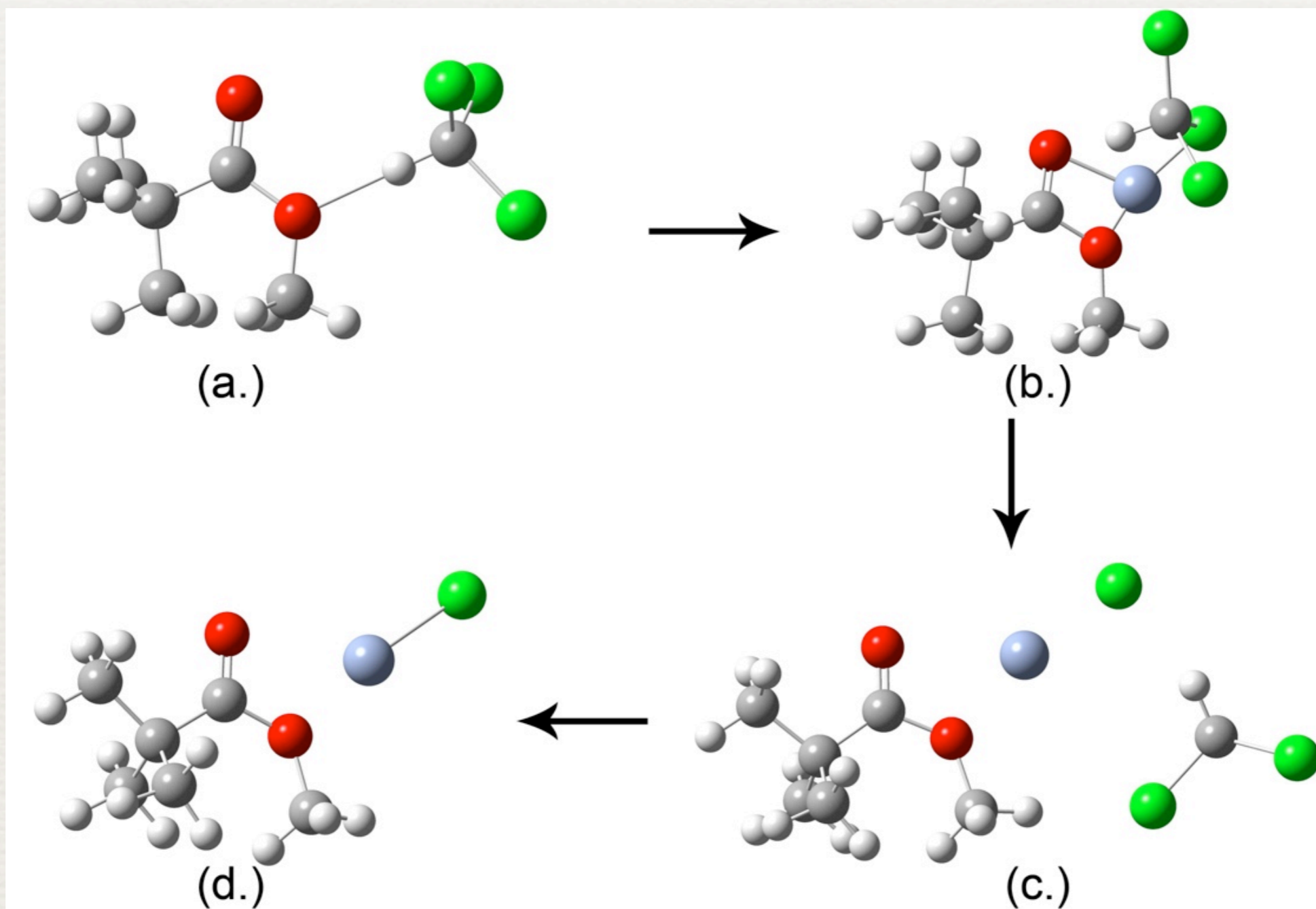
- ♦ Halogenated solvents are “complexing solvents” for PMMA.
- ♦ Form complexes with oxygens in PMMA backbone.
- ♦ Remain behind in polymer afterwards and can act as sites for metal adhesion.



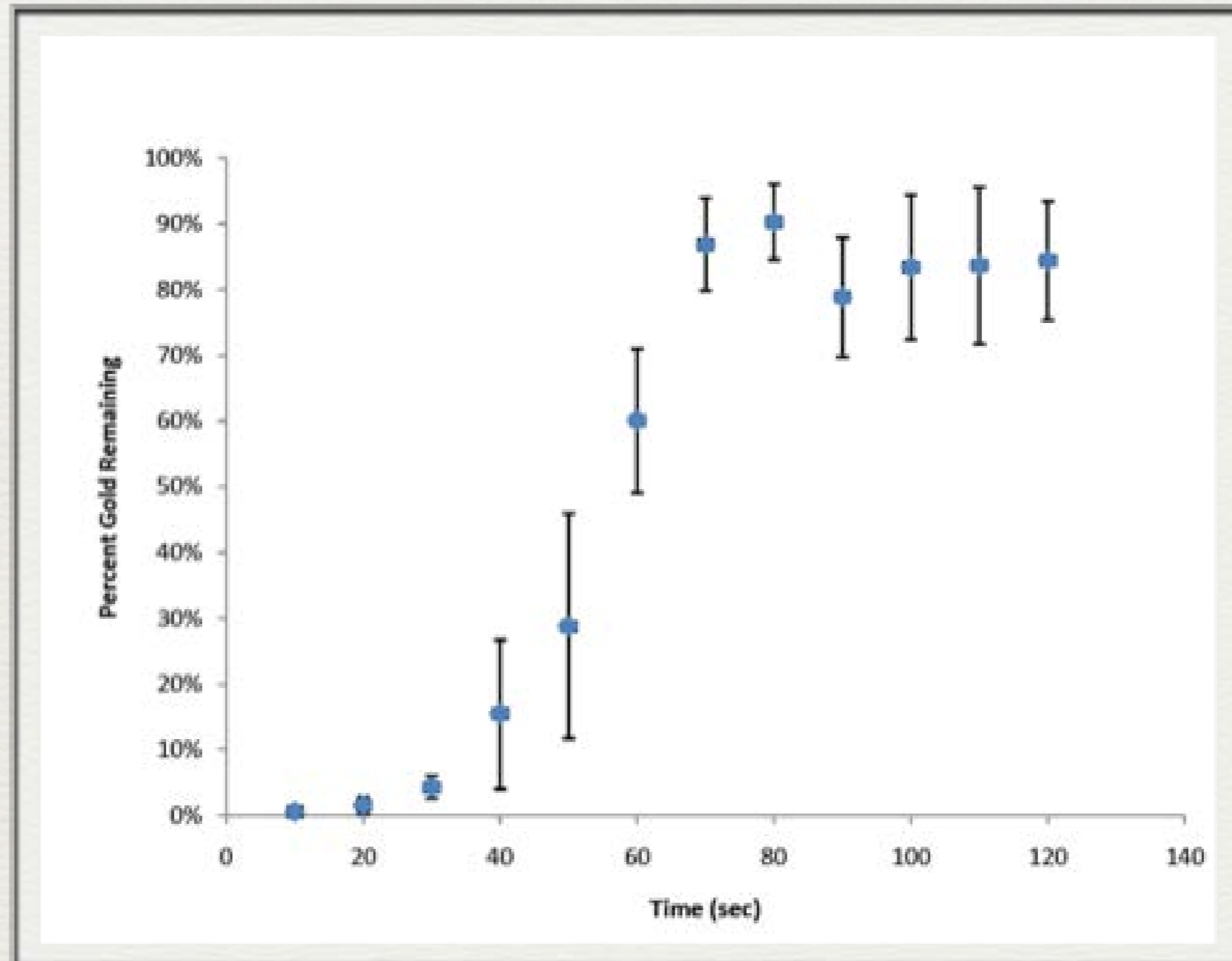
Chlorine XPS



DFT Modeling



Using Vapor Exposure to Introduce Chloroform



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