Development of Thin-Film Fuel Cell Models for Degradation Studies

By: Pavan Bhargava
UMD
NIST SURF Colloquium 2011

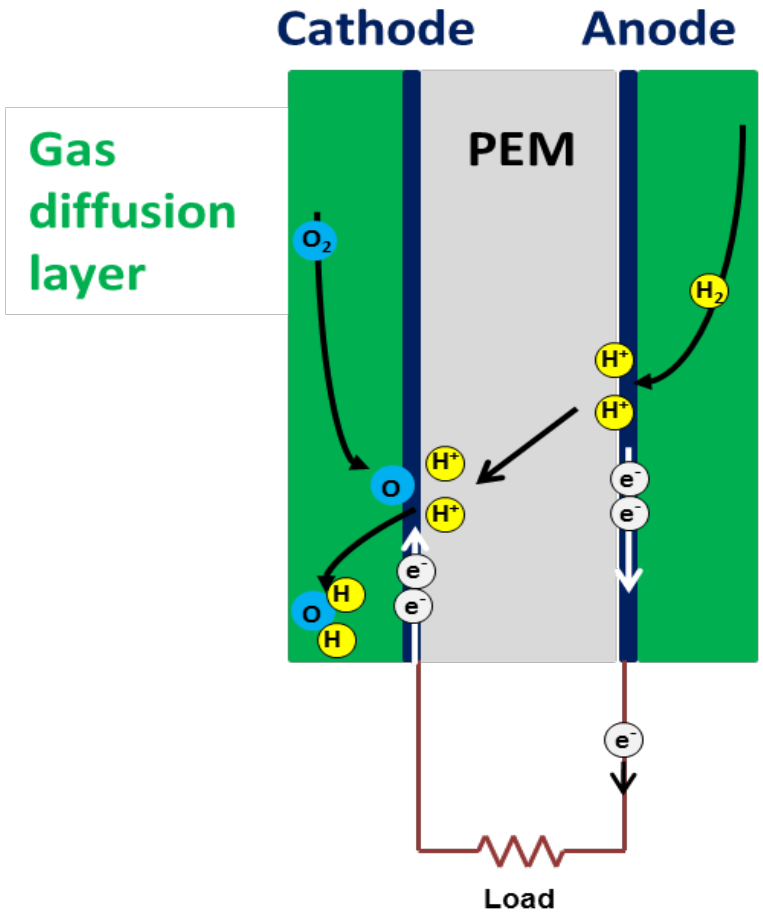
Outline

- Background
  - Fuel cell structure and mechanisms
  - X-Ray Reflectometry
  - Previous Attempts
- Goals, Methods, and Results
- Summary/Conclusion

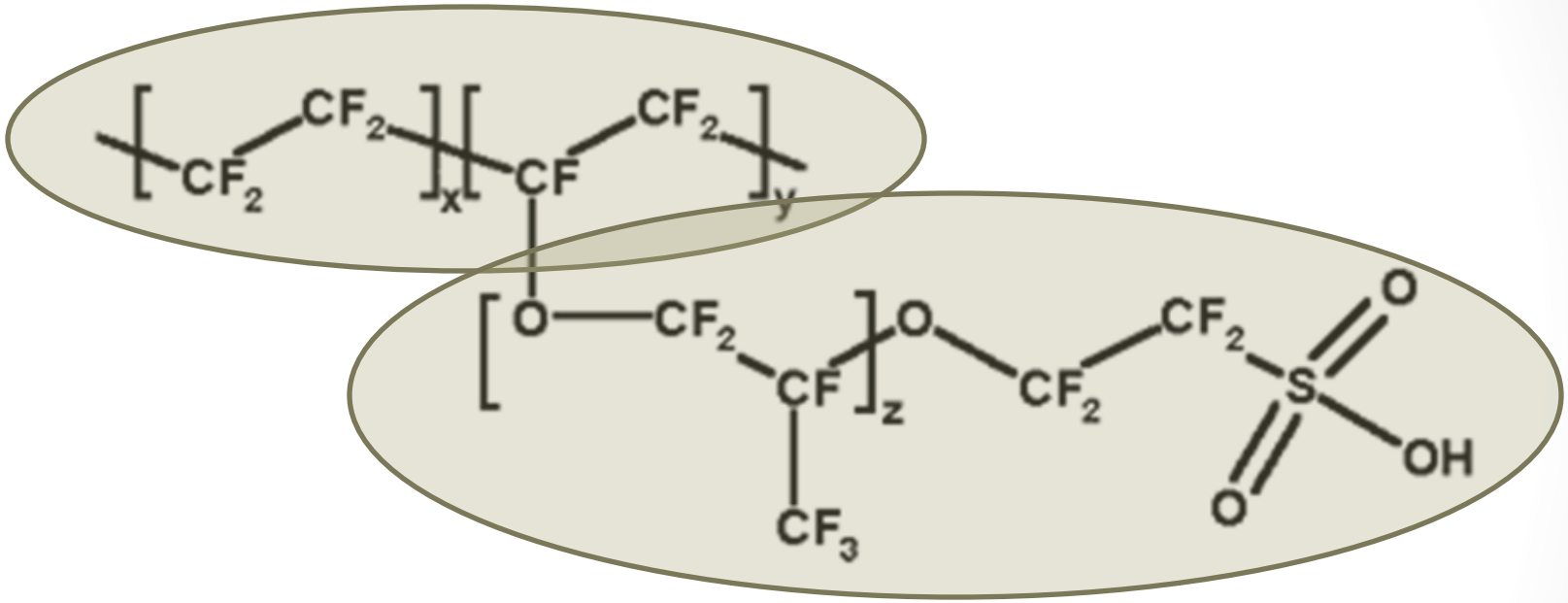
PEM fuel cells

- Proton Exchange Membranes (PEM) only allow the protons to pass through

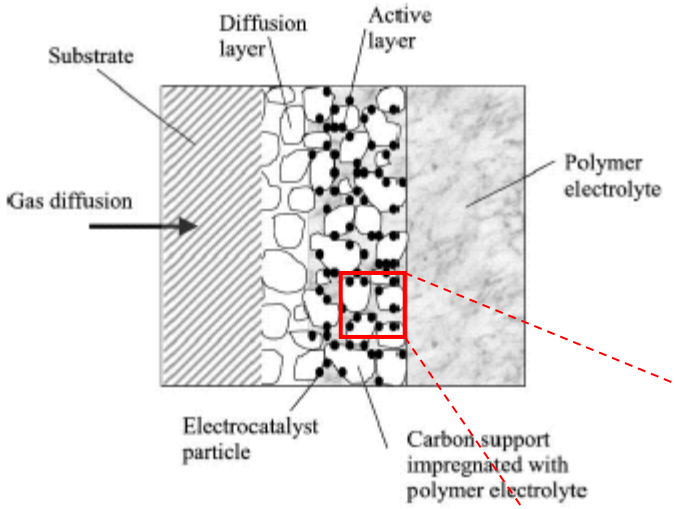
- Electrons are conducted across an alternate path to power the load



Nafion

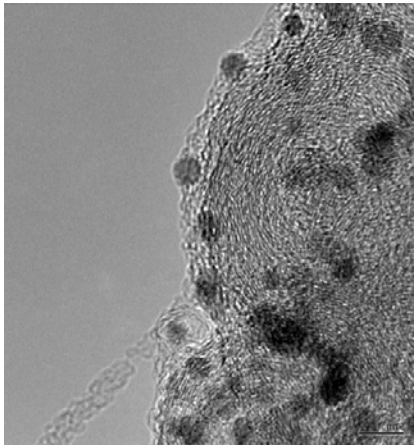


Fuel Cell Interfaces



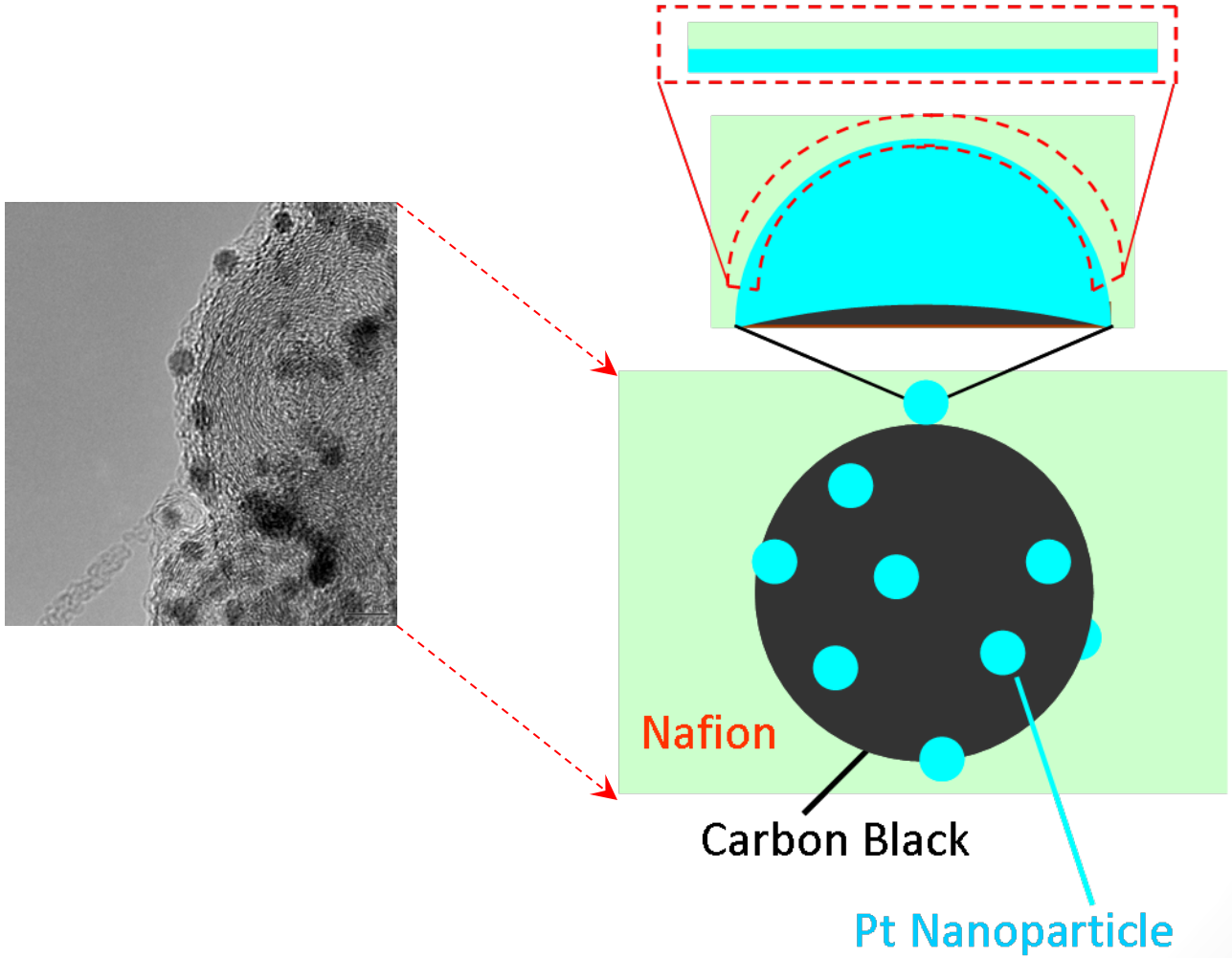
Three Phase Region

(where the gases, electrode, and PEM come together to allow the electrochemical reaction)



Identifying Contributing Degradation Phenomena in PEM Membrane Electrode Assemblies Via Electron Microscopy
K. L. More, R. Borup, and K. S. Reeves
ECS Transactions **3(1)** pp. 717-733 2006 [doi:10.1149/1.2356192]

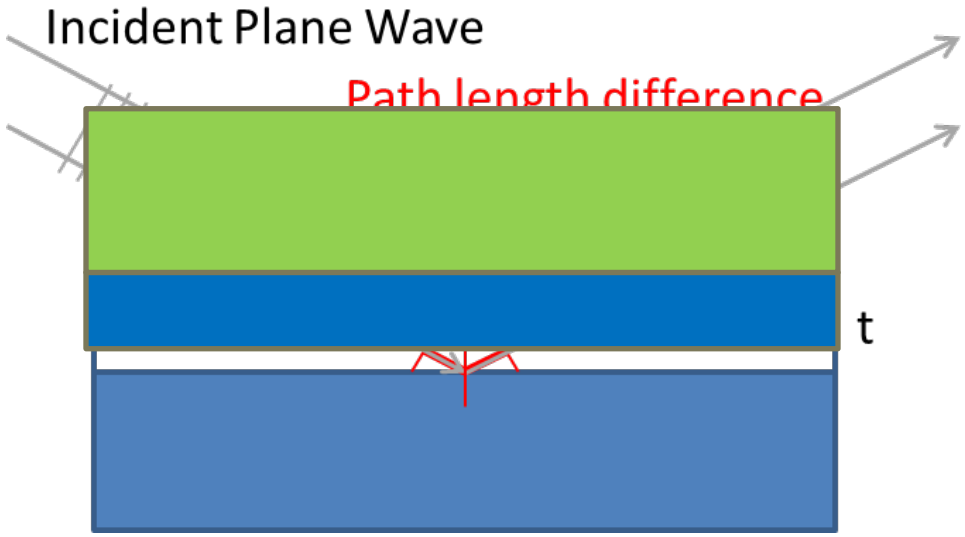
Fuel Cell Test Structures

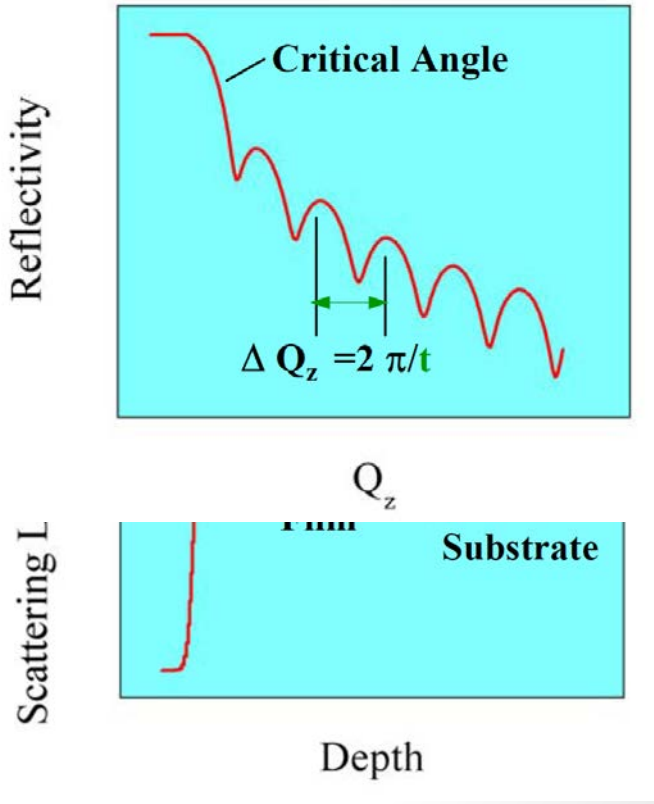


Outline

- Background
  - Fuel cell structure and mechanisms
  - X-Ray Reflectometry
  - Previous Attempts
- Goals, Methods, and Results
- Summary/Conclusion

X-Ray Reflectometry

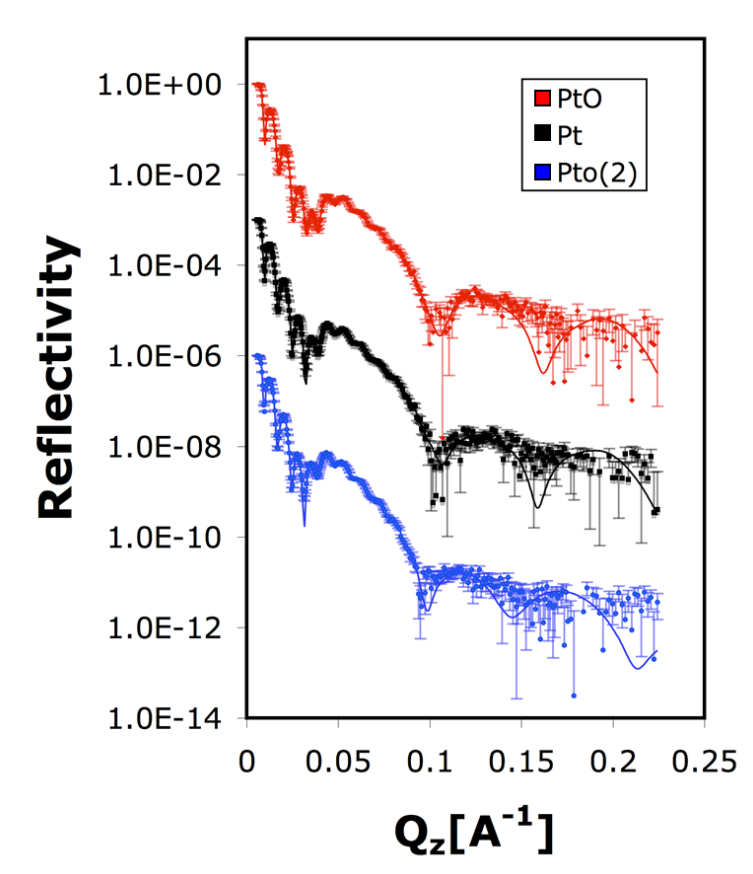


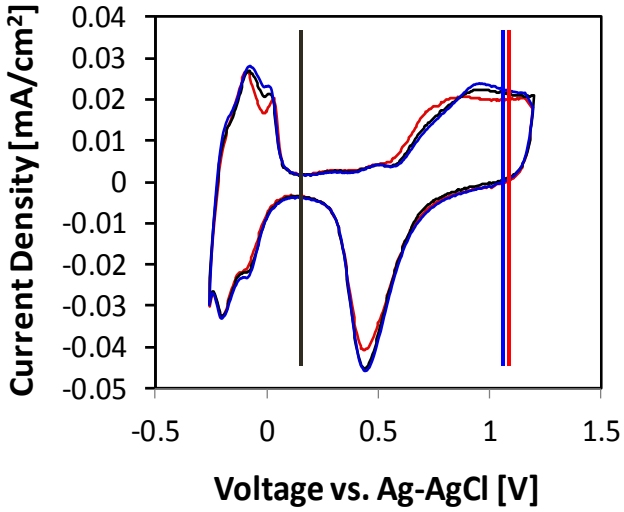


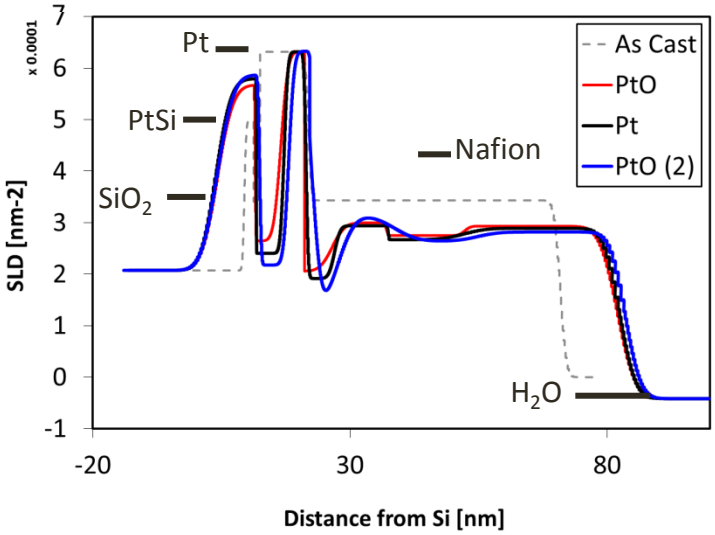
Outline

- Background
  - Fuel cell structure and mechanisms
  - X-Ray Reflectometry
  - Previous Attempts
- Goals, Methods, and Results
- Summary/Conclusion

Previous Attempts







Outline

- Background
  - Fuel cell structure and mechanisms
  - X-Ray Reflectometry
  - Previous Attempts
- Goals, Methods, and Results
- Summary/Conclusion

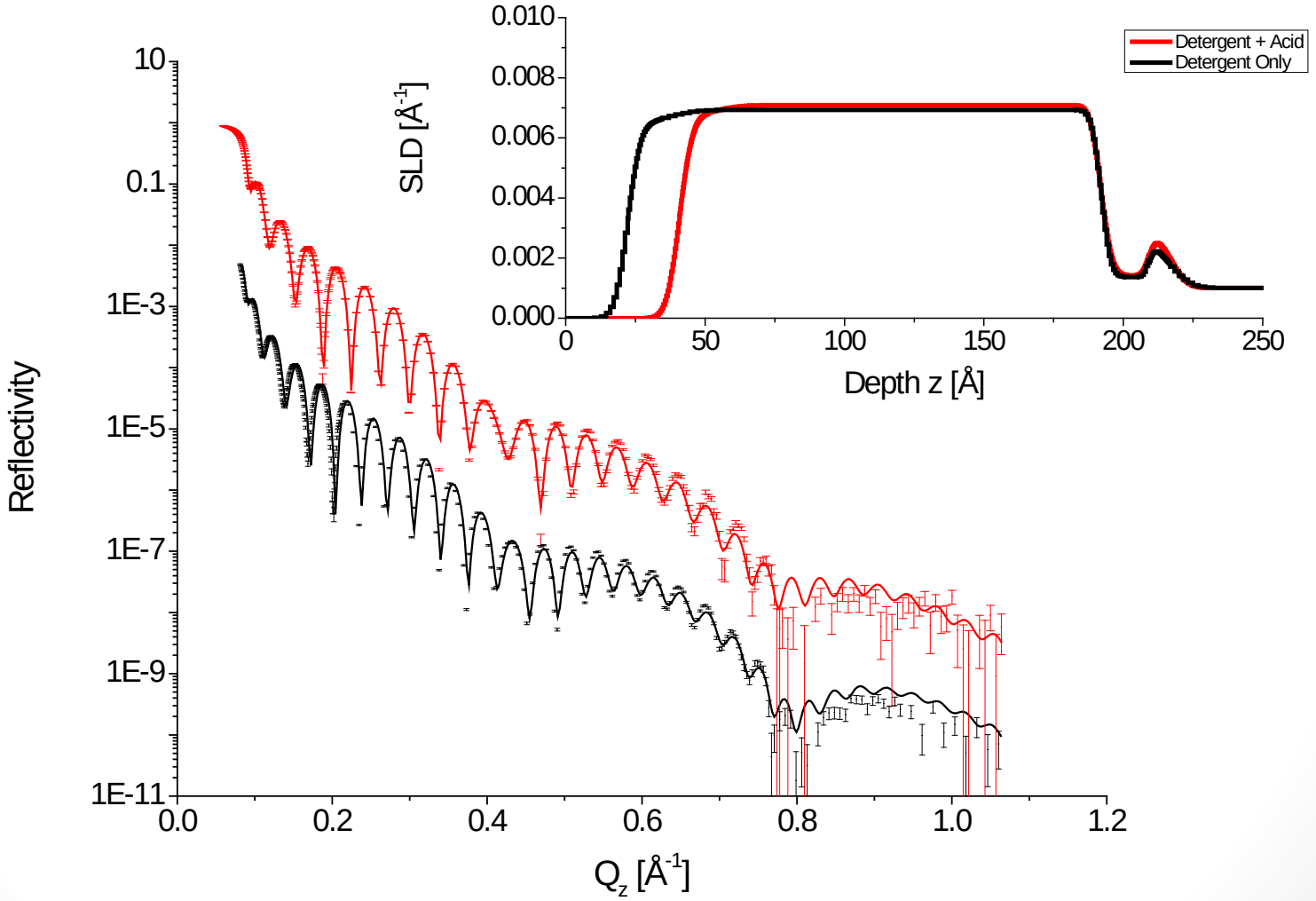
Fundamental Question

- Do different substrate treatment methods affect the structure of the deposited catalyst?

Cleaned with Detergent

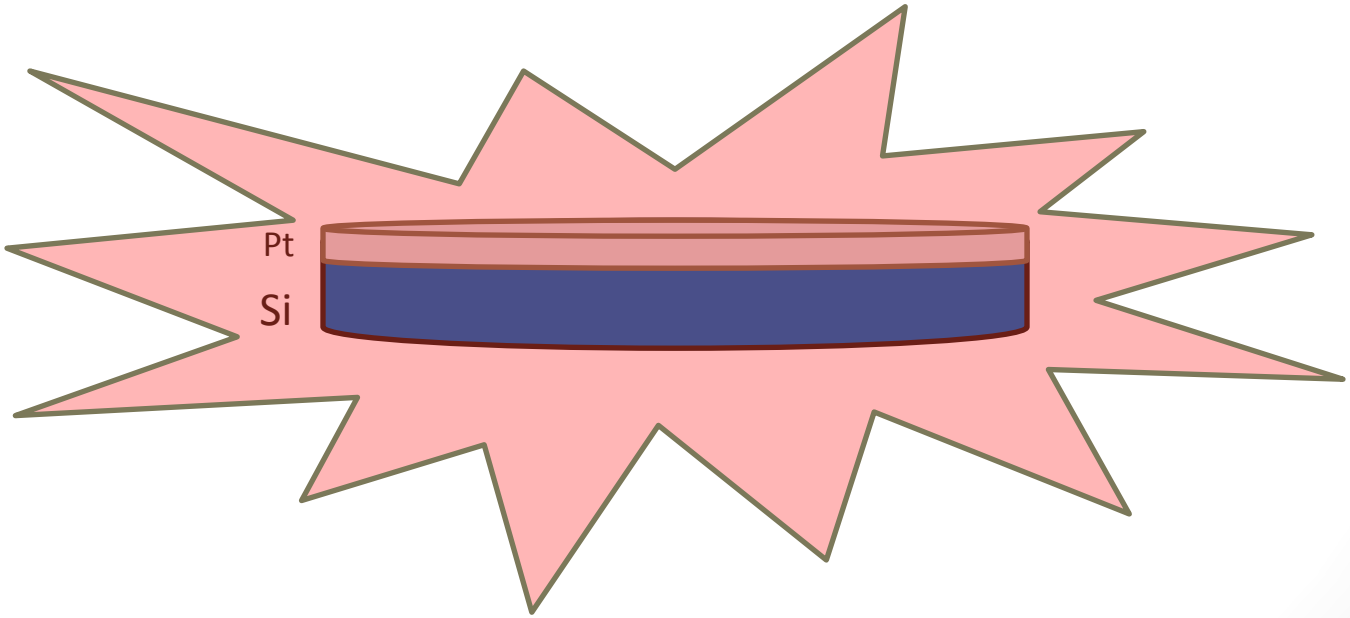
Cleaned with Detergent and Acid

Substrate Treatment

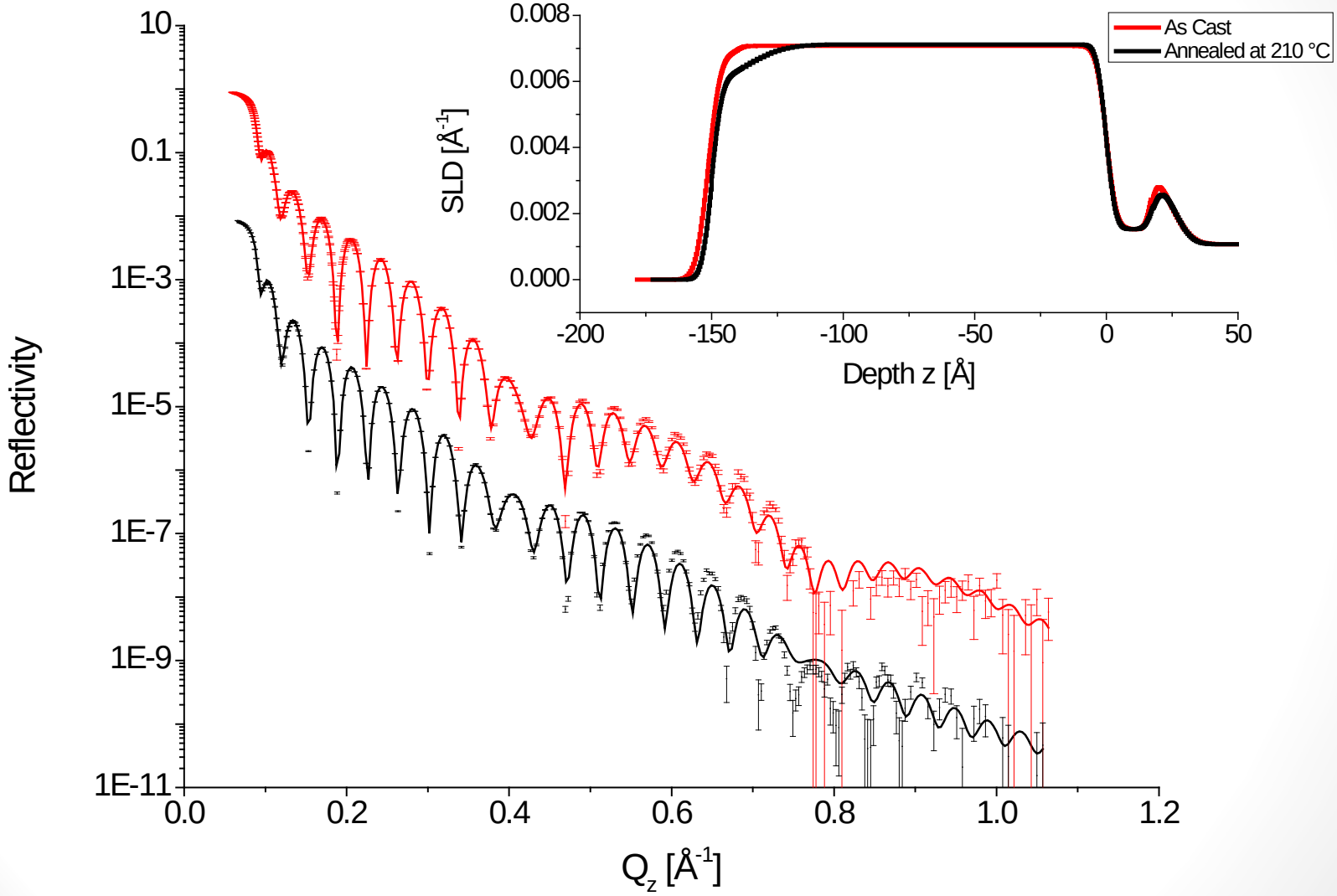


Fundamental Question

- How do varying annealing situations affect catalyst structure?
  - Can annealing the test structure before the addition of Nafion promote the growth of unwanted structures?

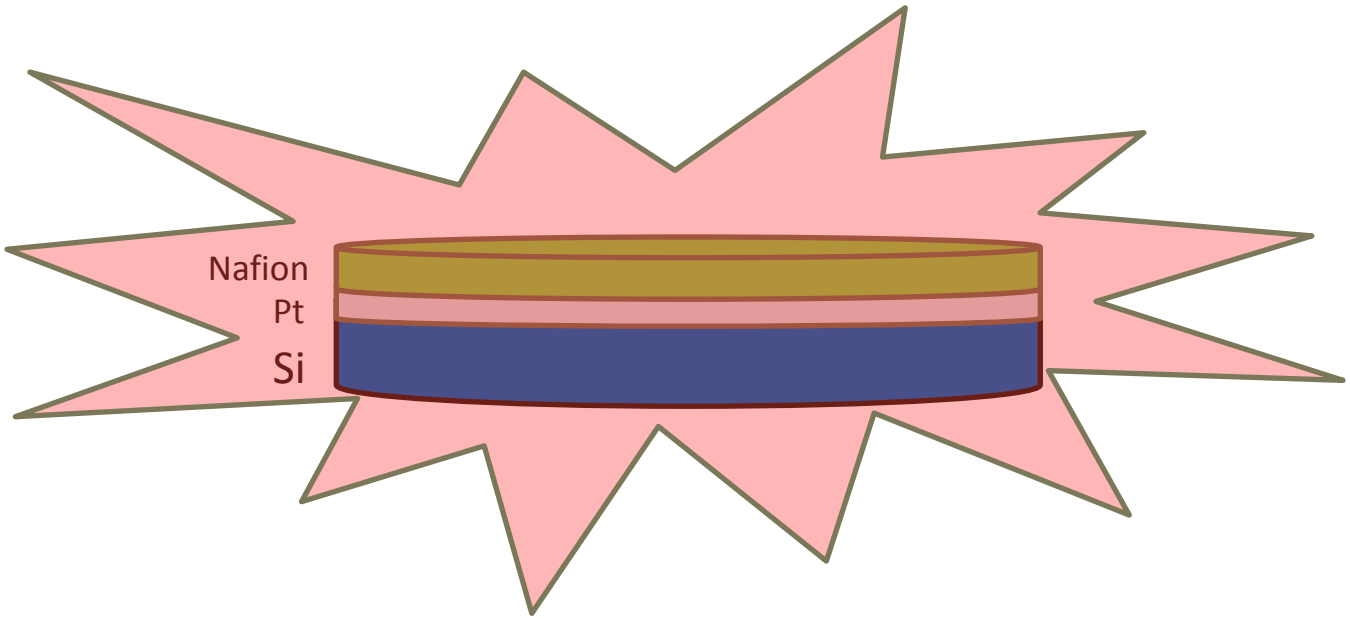


Effects of Annealing

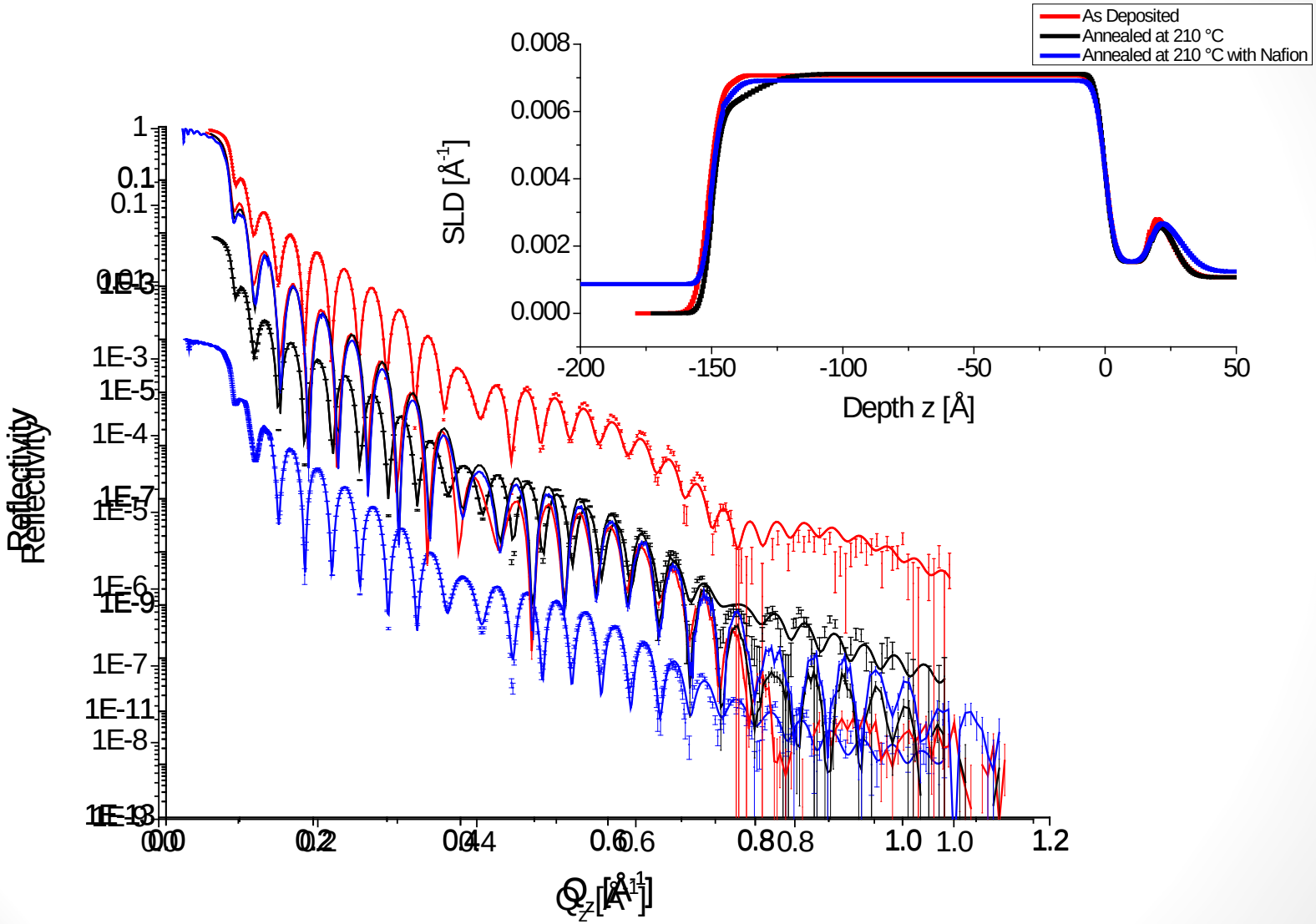


Effects of Annealing

- Does the addition of Nafion amplify structural changes under annealing?



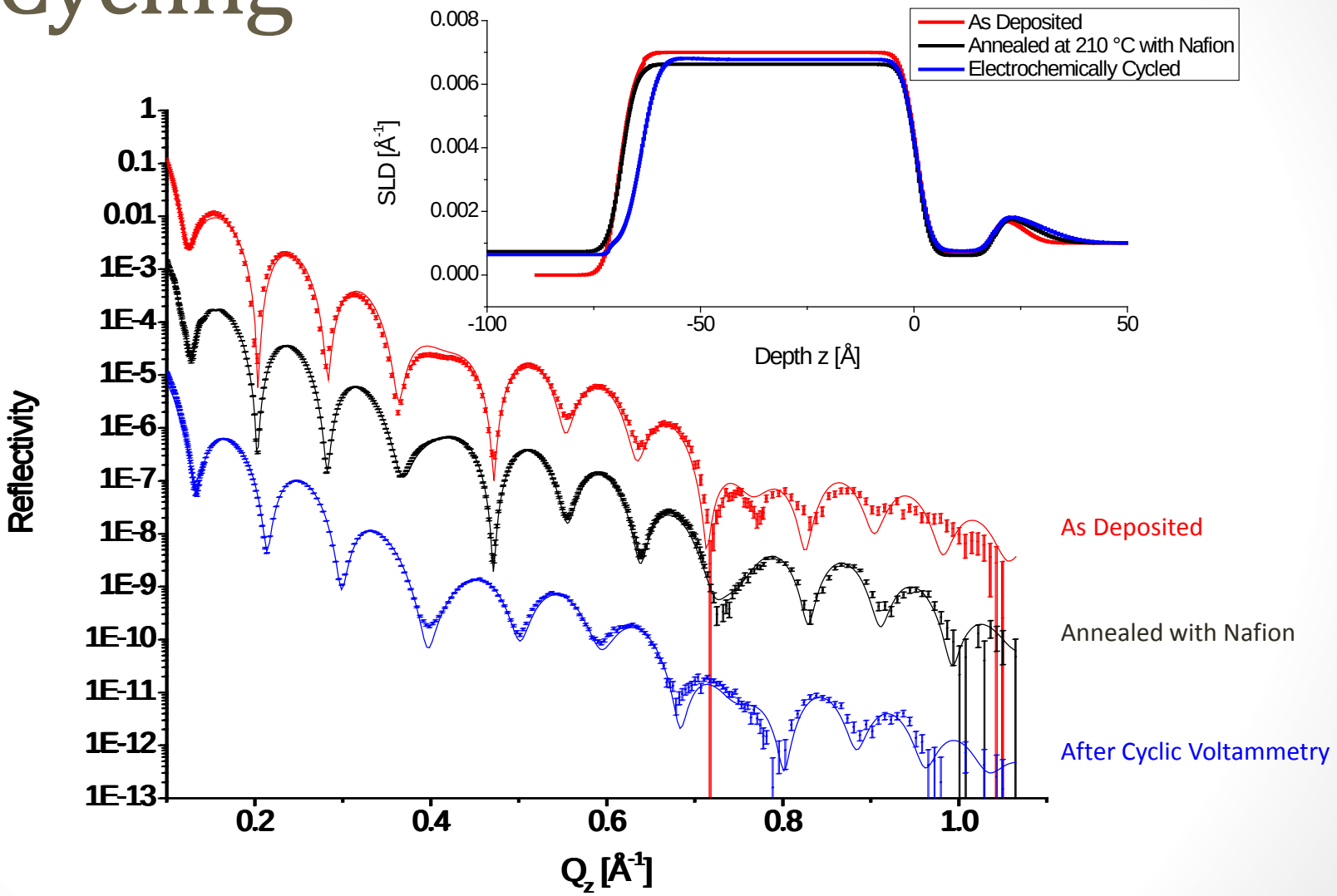
Effects of Annealing



Fundamental Question

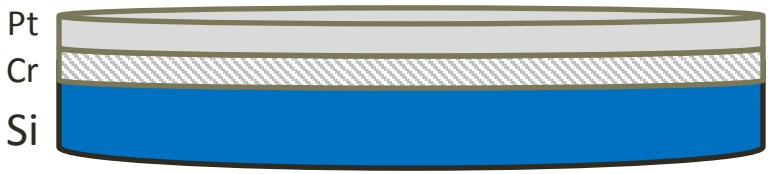
- How does electrochemical cycling affect PtSi and Platinum in the test structure?

Effects of Electrochemical Cycling

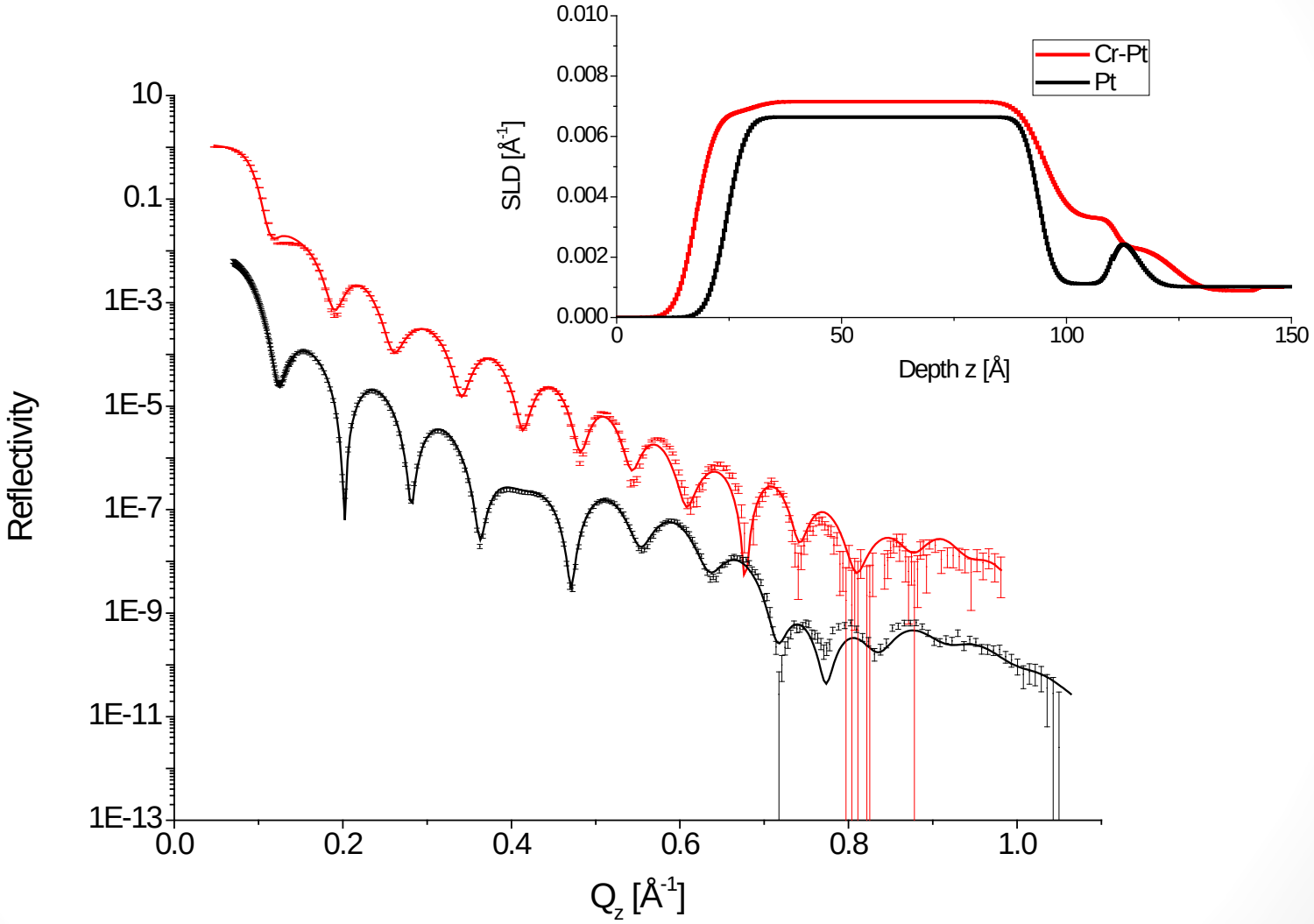


Fundamental Question

- Can adding Cr before Pt prevent unwanted structure complexity?



Addition of Cr



Conclusions

- The substrate can be treated with just detergent; more aggressive cleaning methods do not improve roughness
- Annealing the test structure with Nafion promotes the growth of the PtSi layer.
- Electrochemically cycling the test structure increases PtSi thickness and degrades the Pt layer.
- The addition of Cr before sputtering Pt does prevent the development of a PtSi layer.

Acknowledgements

Steven DeCaluwe

Joe Dura

Julie Borchers

SURF Program