

Synthesis of Functionalized Mesoporous Silica Proton Exchange Membranes for Fuel Cells



Joe Selzler

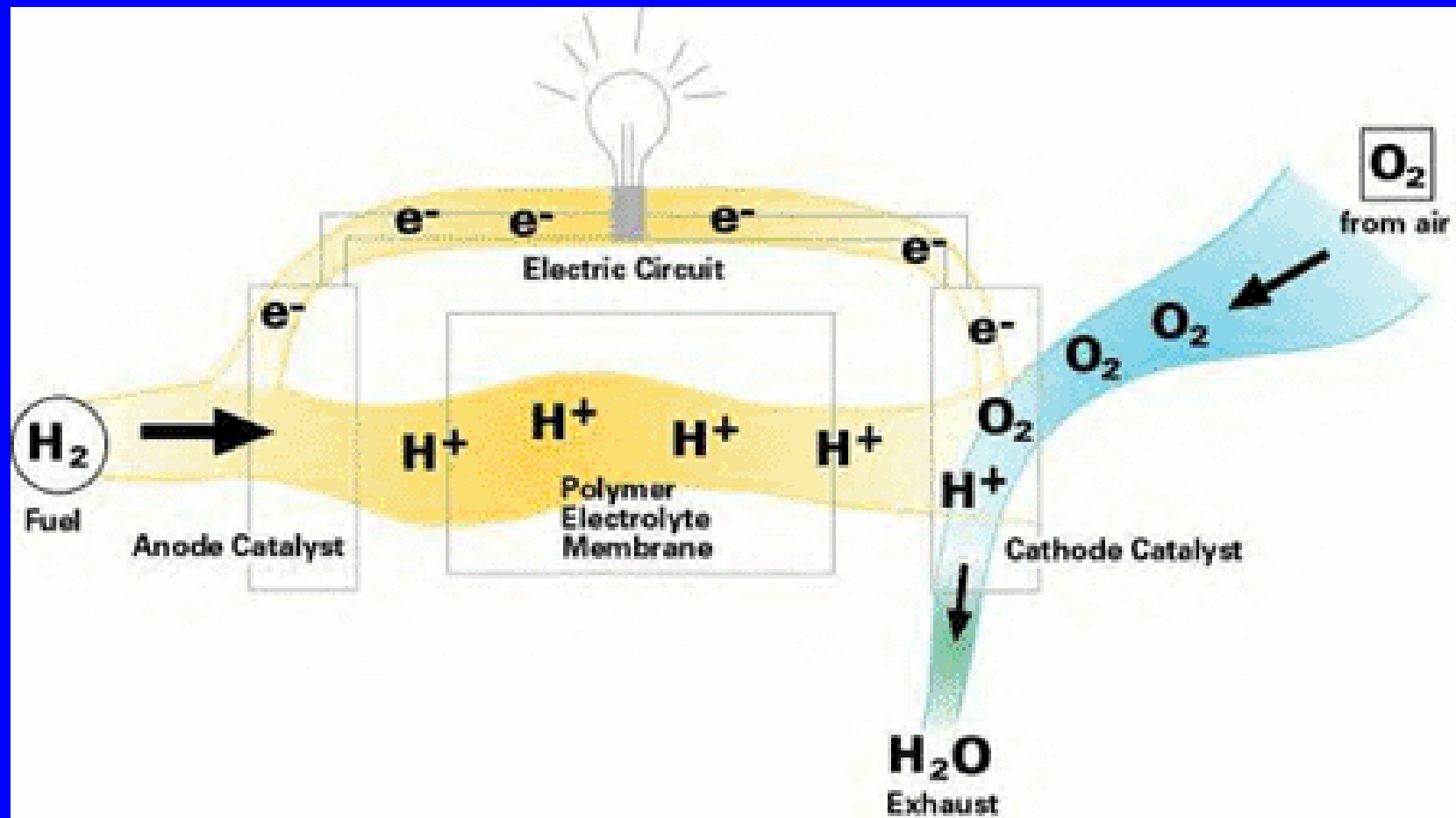


George Athens

Dr. Brad Chmelka

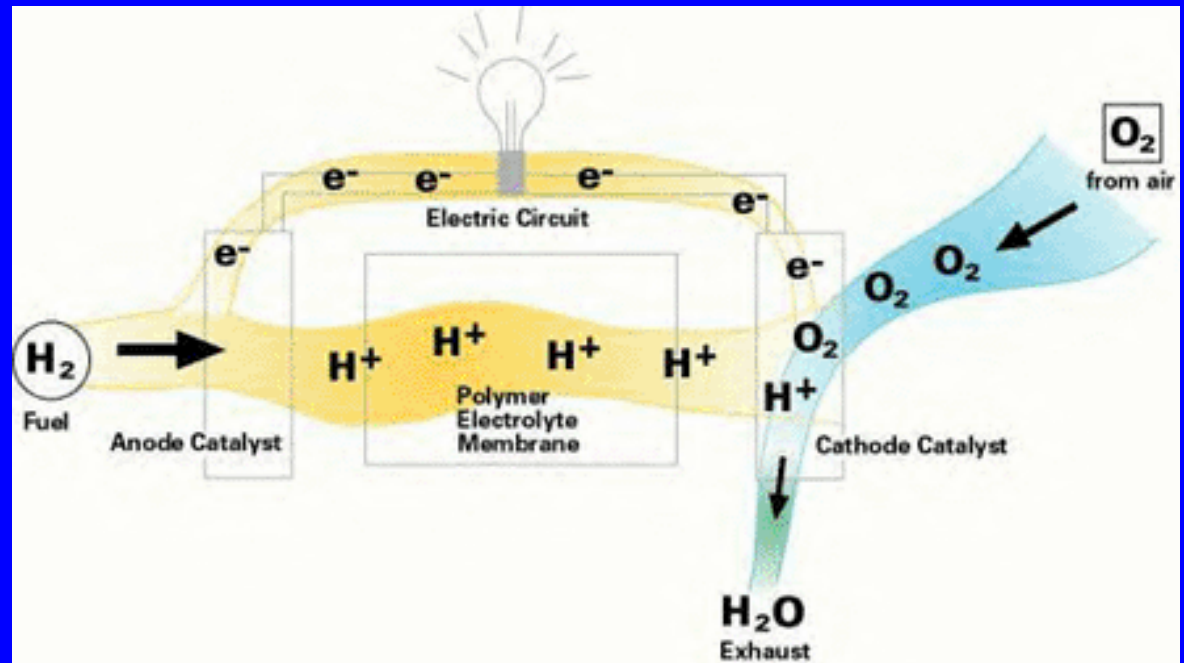


What is a fuel cell?



Gasoline/methanol

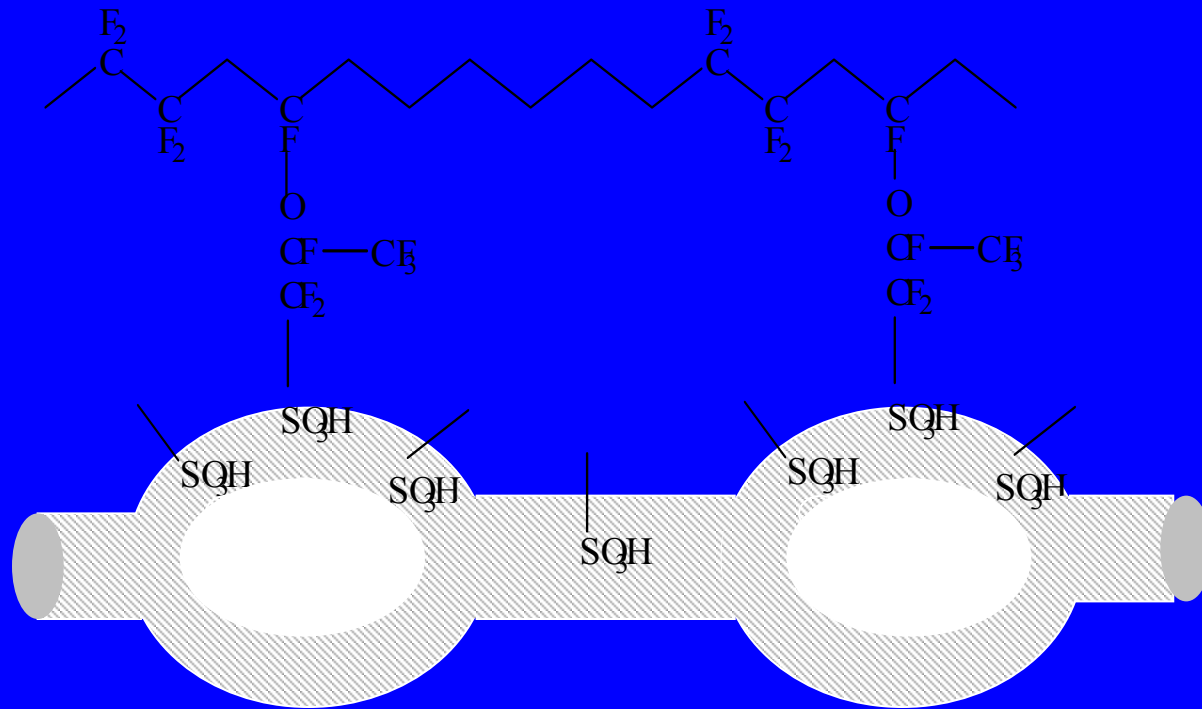
CO



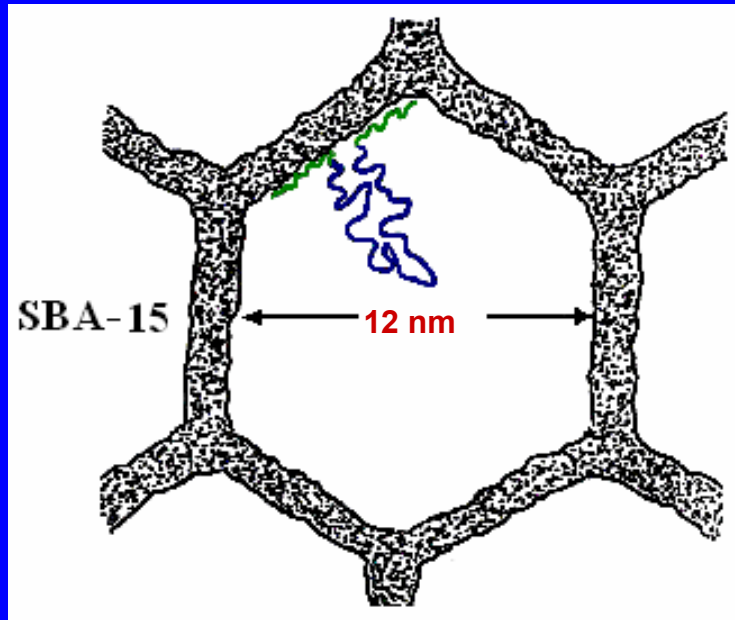
Current technology problems

- No hydrogen storage nor distribution network
- Catalyst poisoning due to CO in H₂ stream at low temperatures
- Poor PEM performance at high temperatures

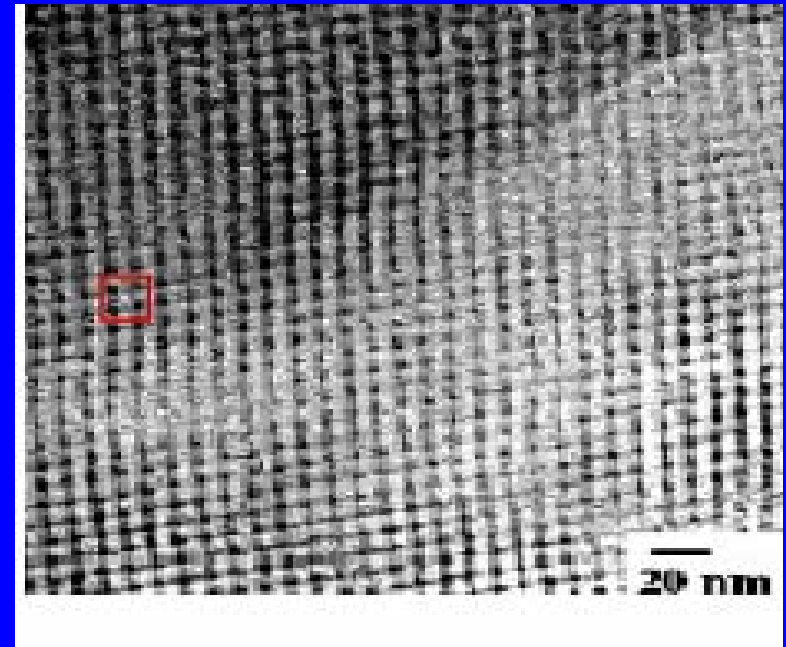
Current PEM Material: Nafion™



Our Solution: Block-Copolymer-Templated Inorganic Materials

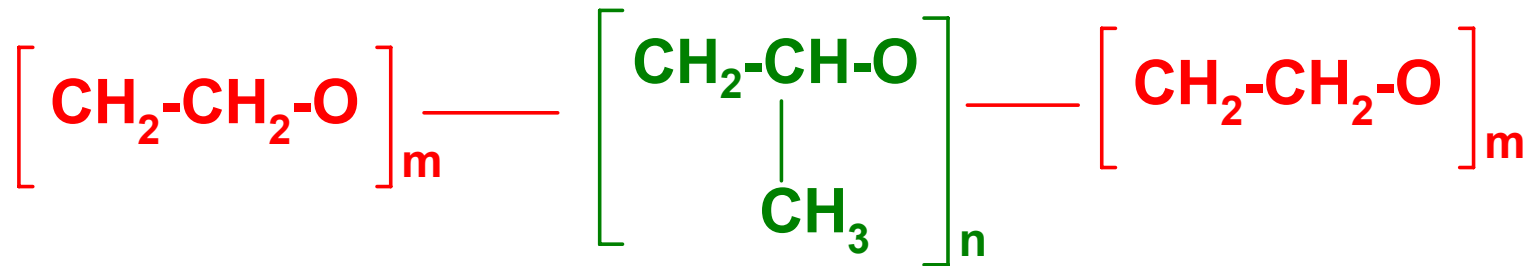


Chmelka, Stucky *et al.*, *Science*, 279, 548 (1998)
Stucky, Chmelka *et al.*, *Nature*, 396, 152 (1998)

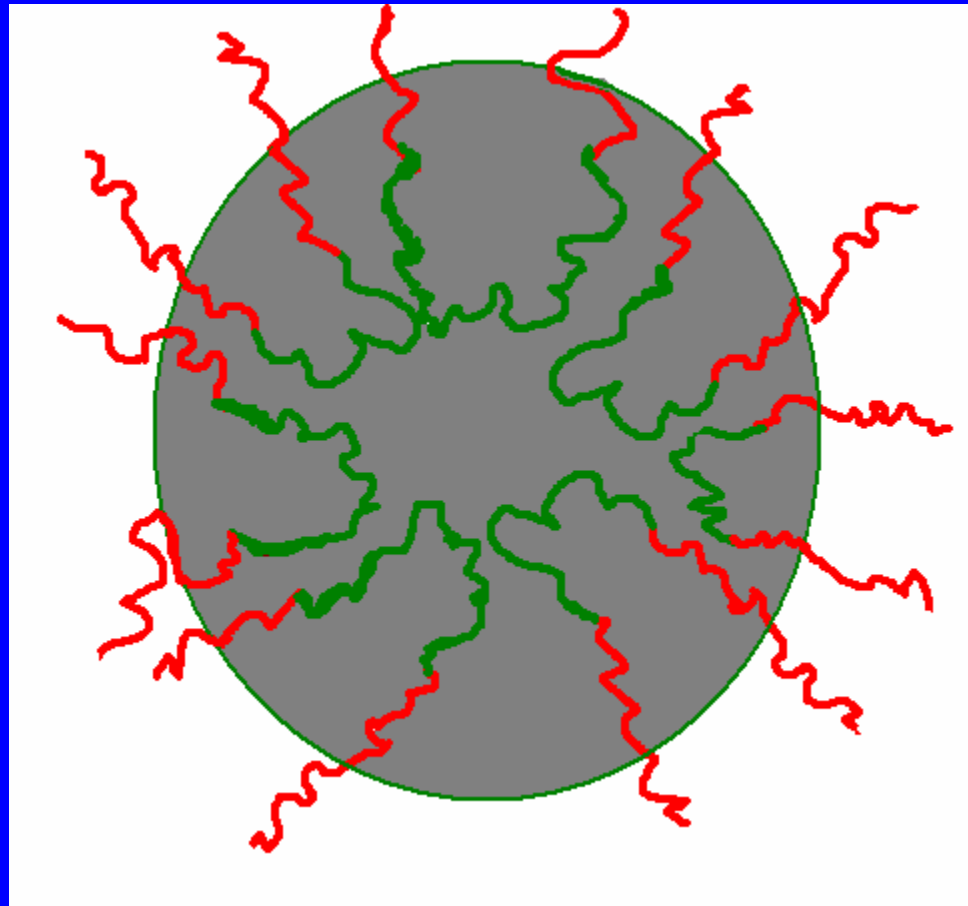
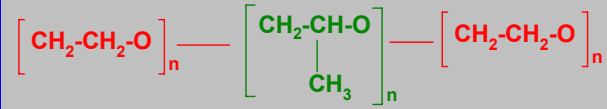


Stucky, Chmelka *et al.*, *Chem. Mater.*, 14, 3284 (2002)

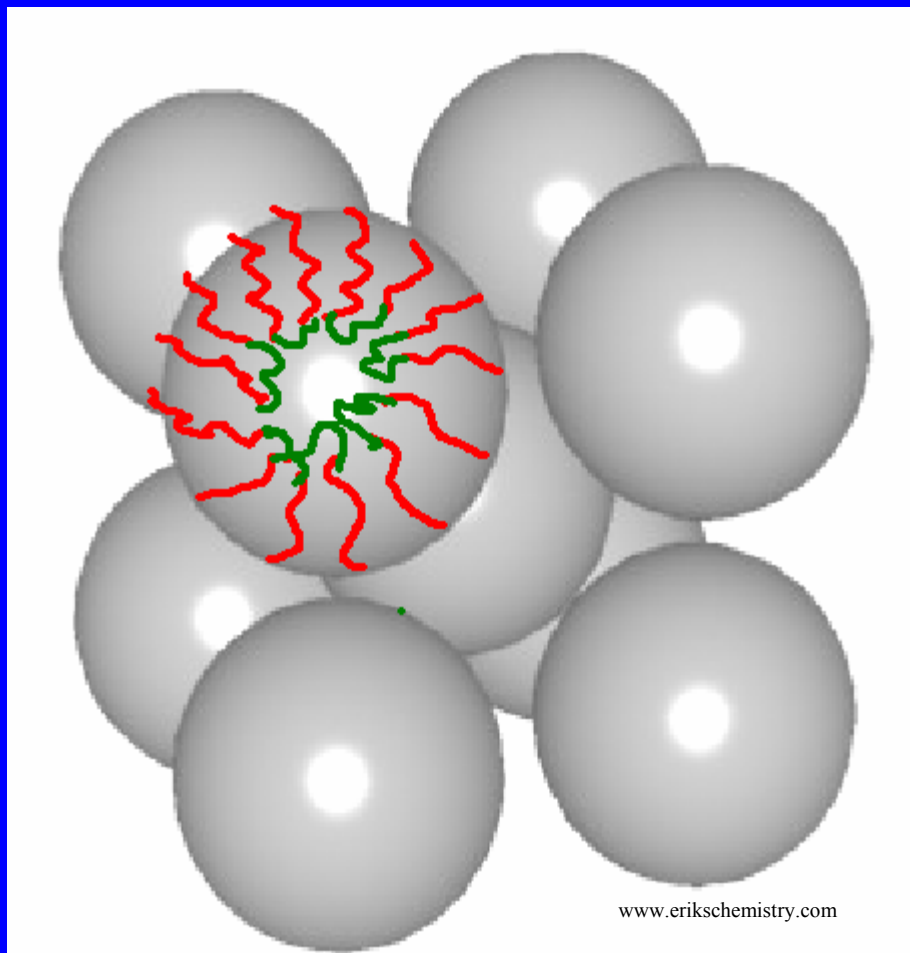
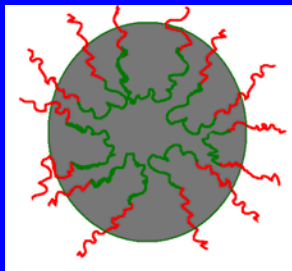
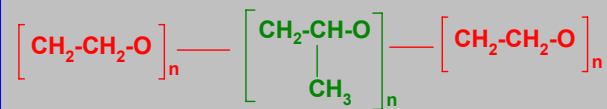
Block-copolymer Self Assembly



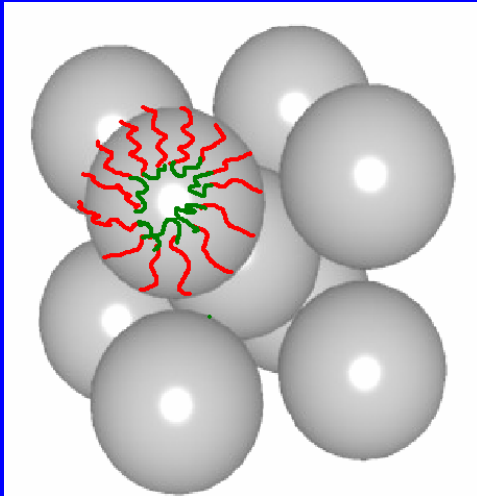
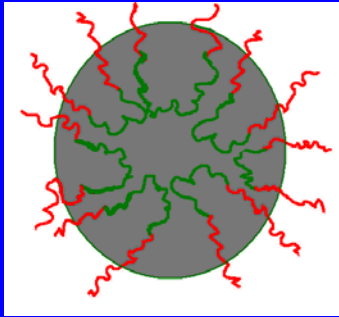
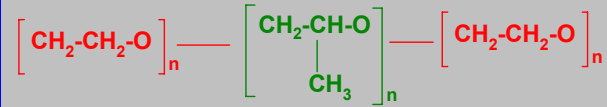
Block-copolymer Self Assembly



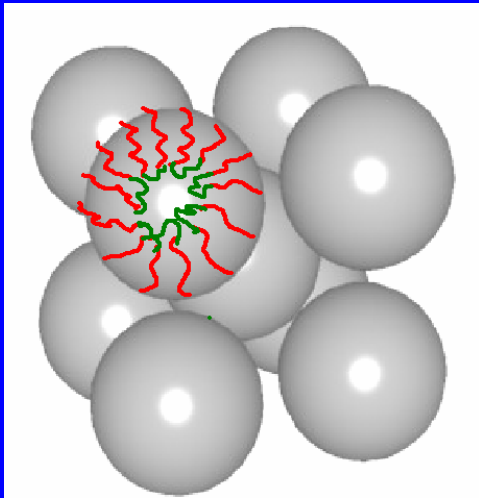
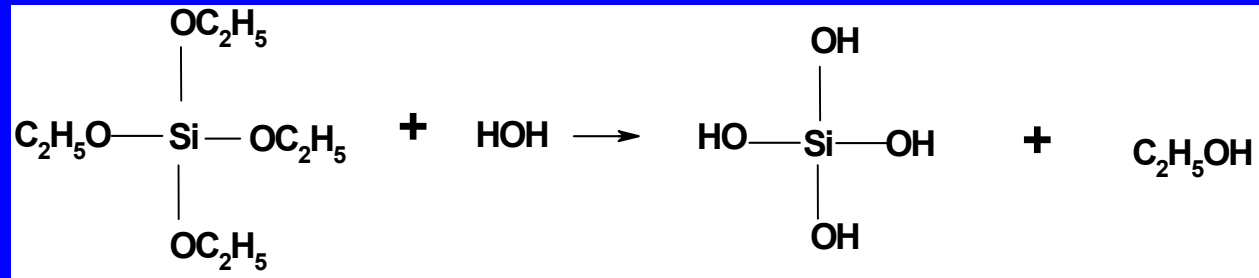
Block-copolymer Self Assembly



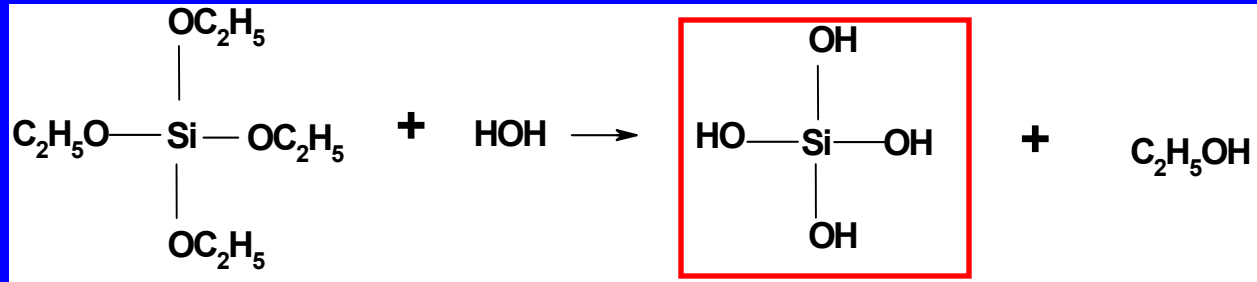
Block-copolymer Self Assembly



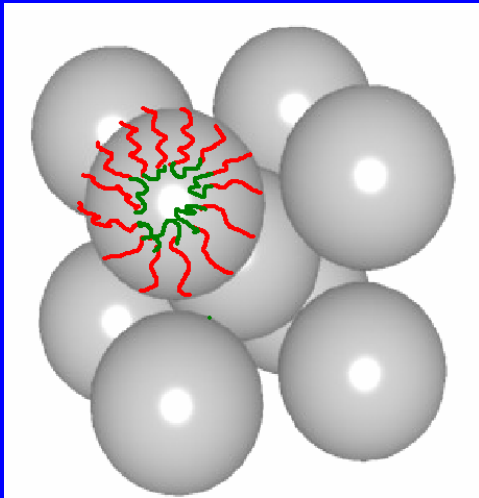
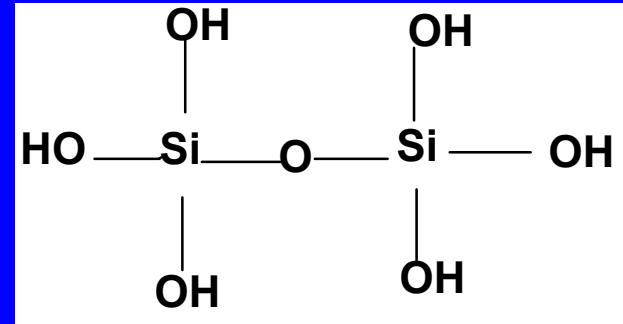
Silica Network Formation



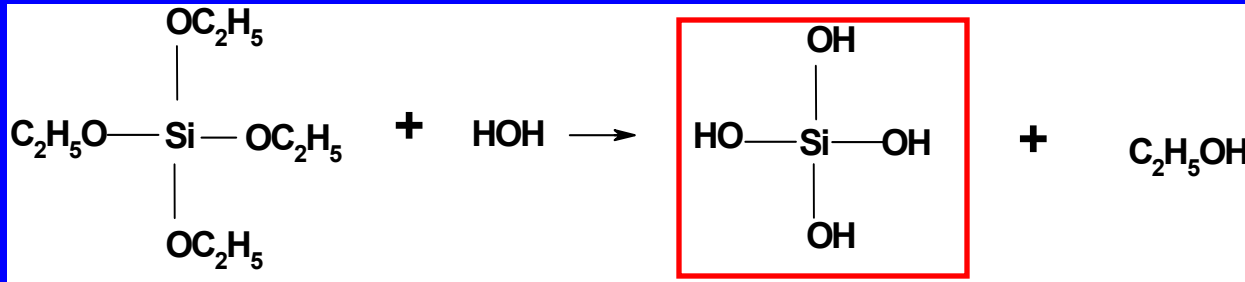
Silica Network Formation



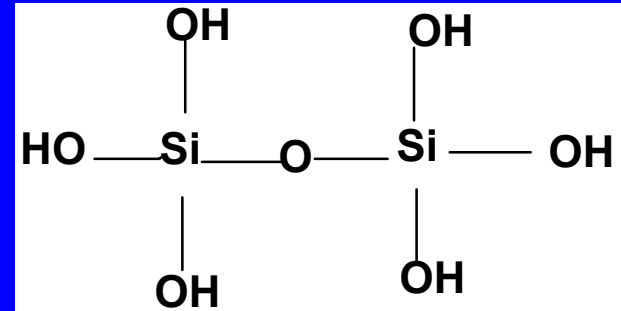
Crosslink



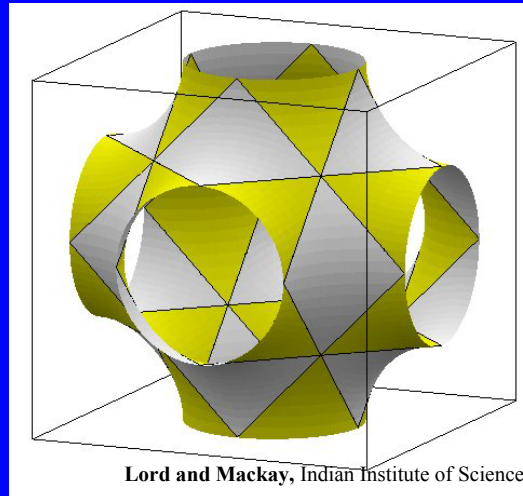
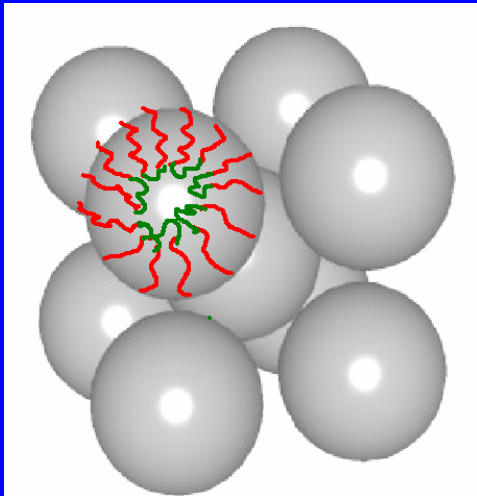
Silica Network Formation



Crosslink

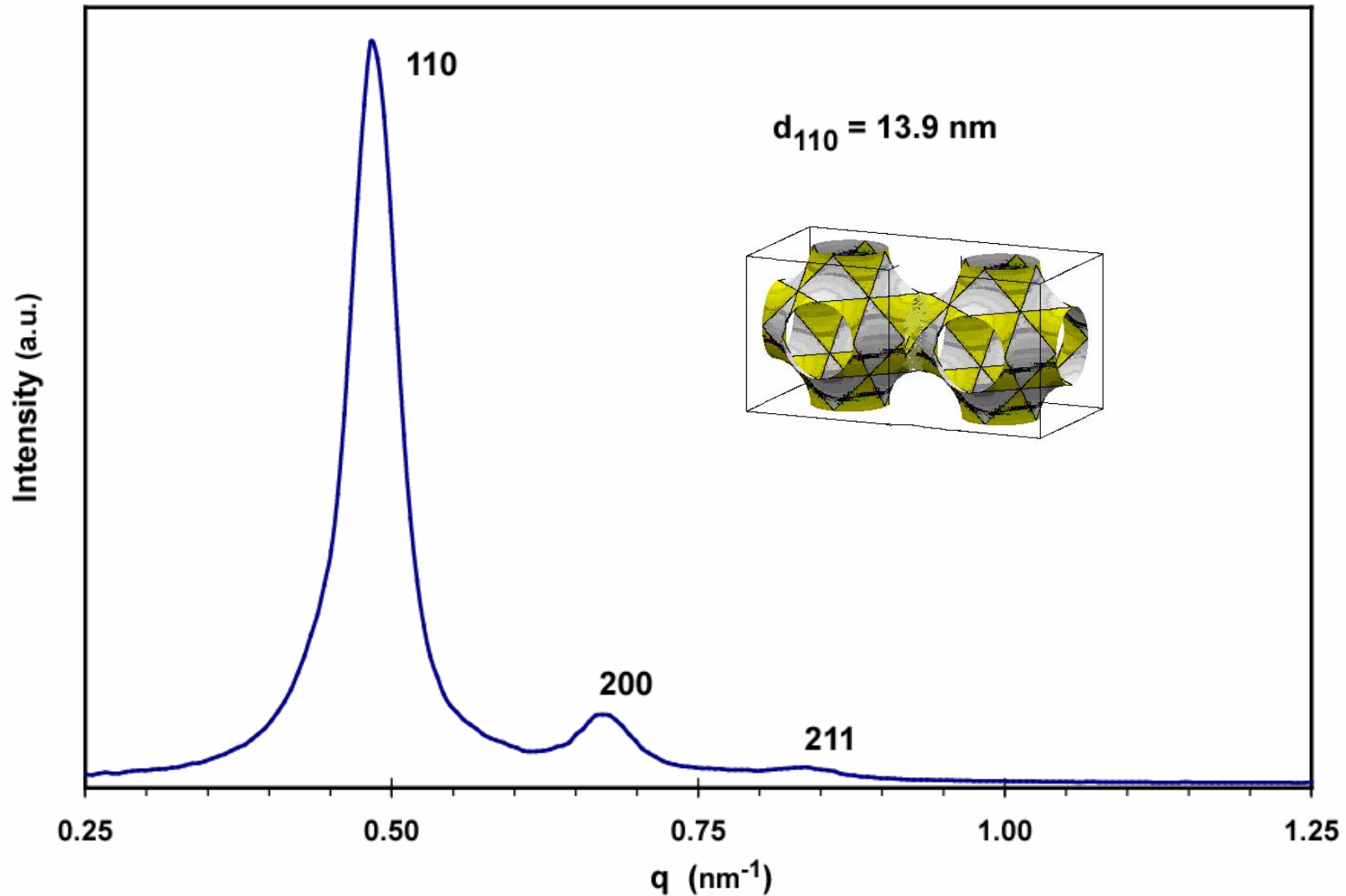


Remove polymer

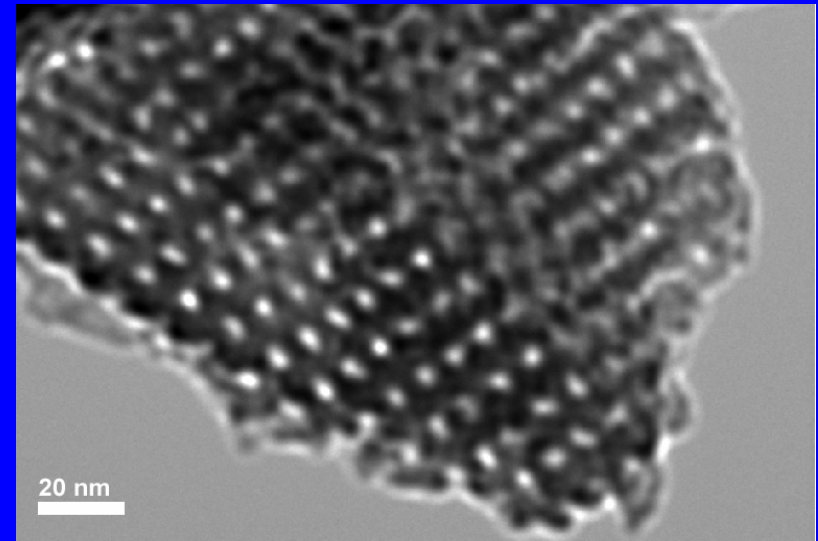
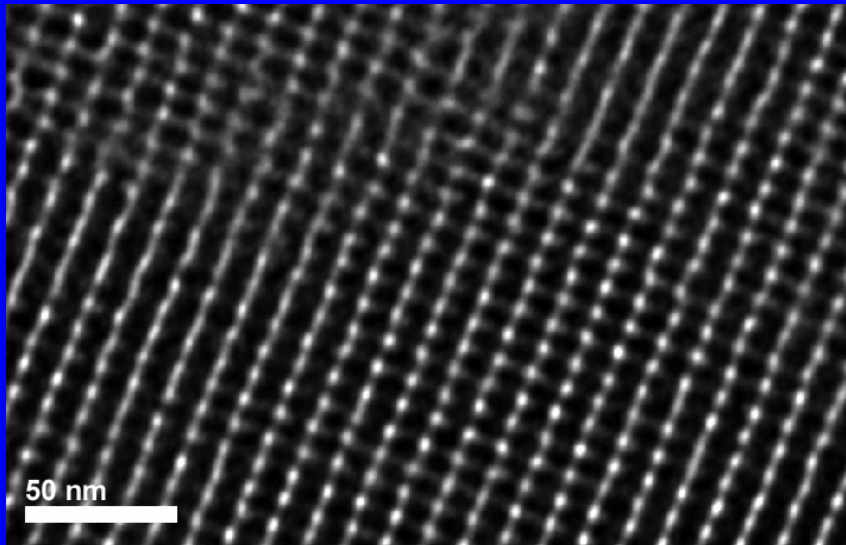
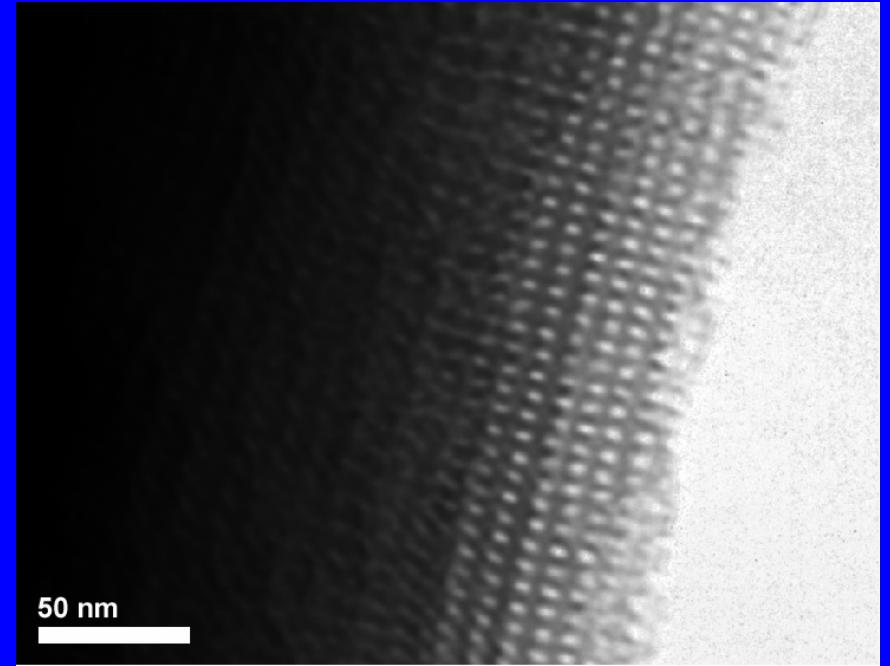
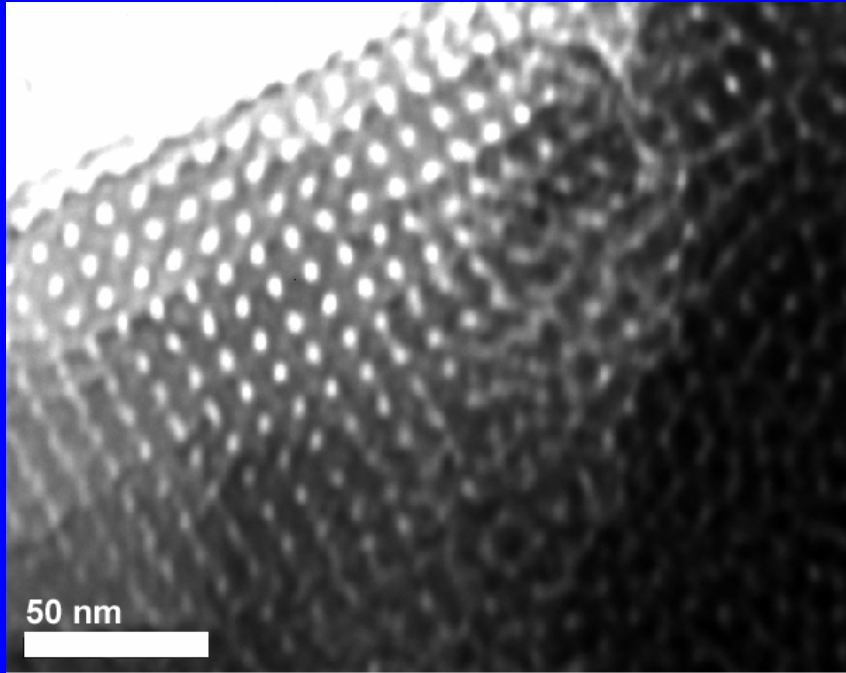


Structure Characterization

Small Angle X-Ray Diffraction

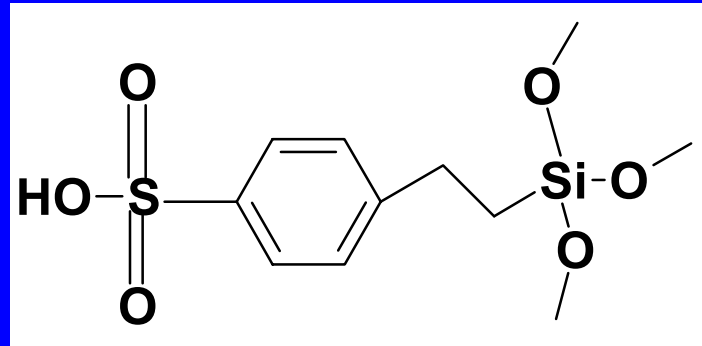


Transmission Electron Microscopy (TEM)

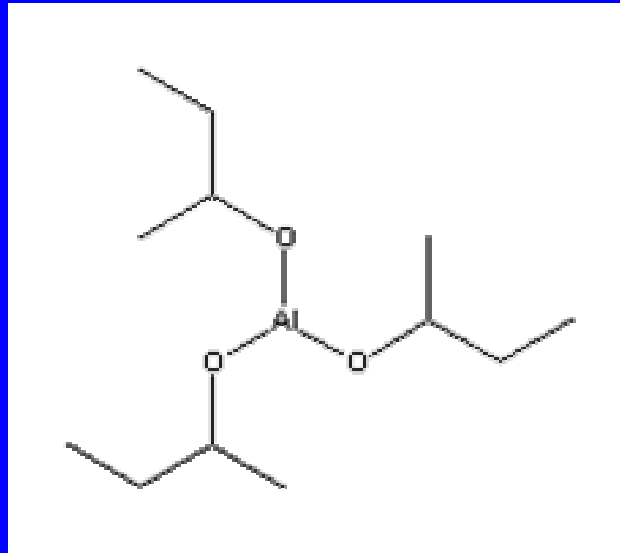


Current Work

- Incorporate functional groups into silica thin films



- Synthesize aluminosilica thin films including functional groups



Acknowledgements

Chmelka Group:

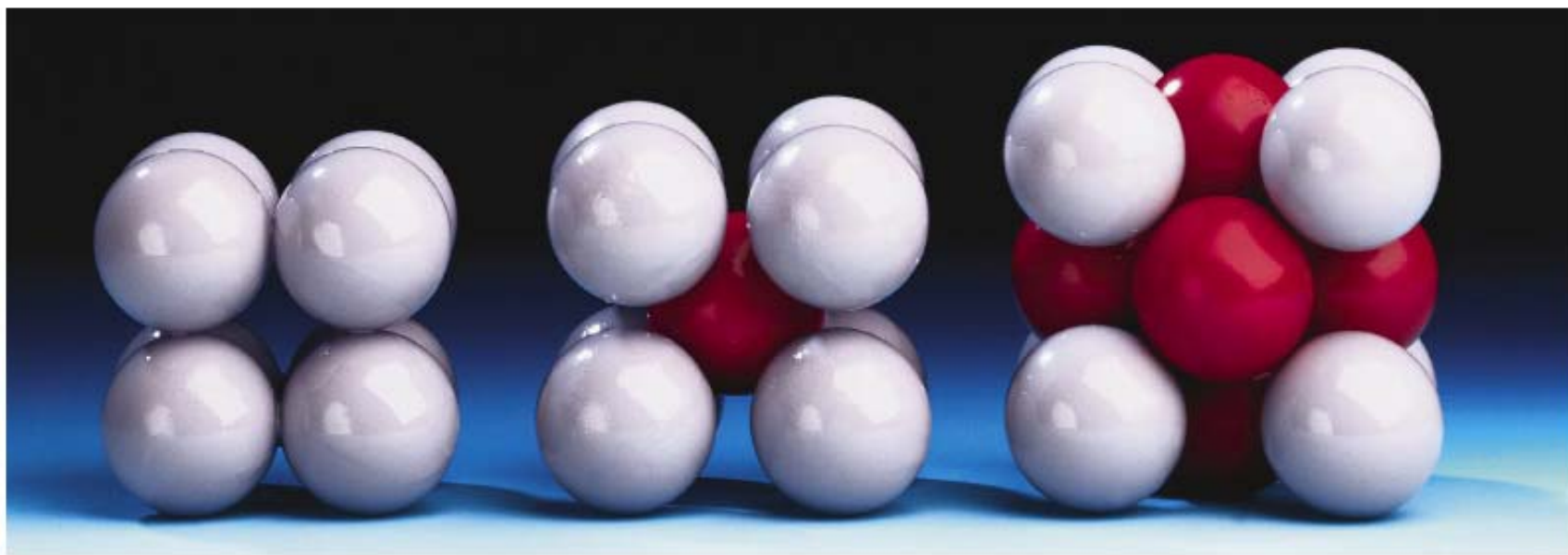
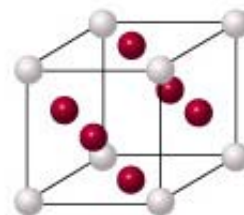
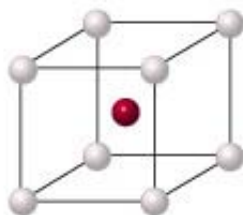
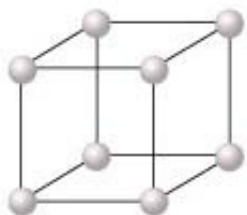
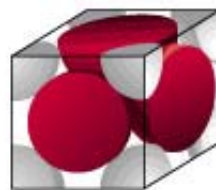
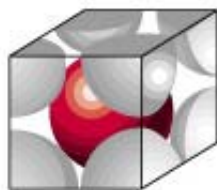
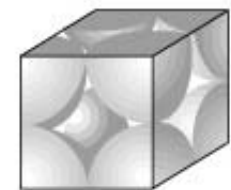
- George Athens (mentor)
- Dr. Brad Chmelka (advisor)

INSET program:

- Trevor Hirst
- Liu-Yen Kramer
- Nick Arnold
- Mike Northern

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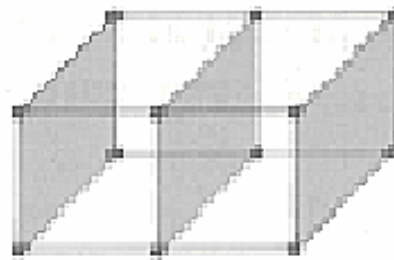


(a)

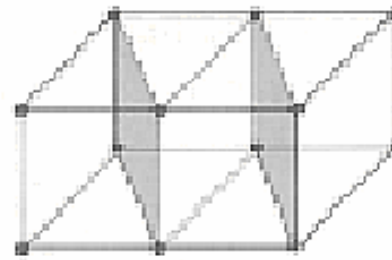
(b)

(c)

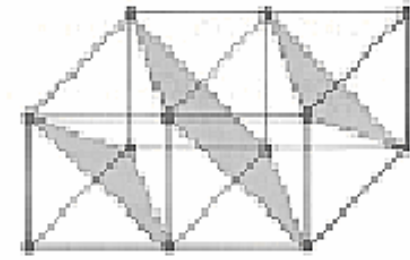
**Primitive
cubic lattice**



100 planes

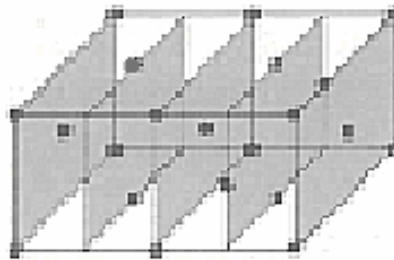


110 planes

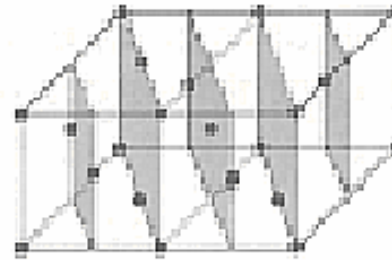


111 planes

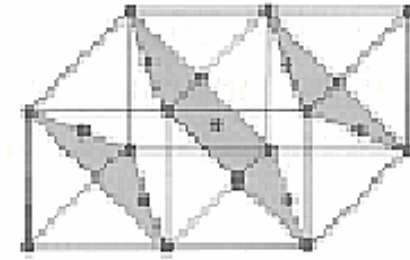
**Face-centred
cubic lattice**



200 planes

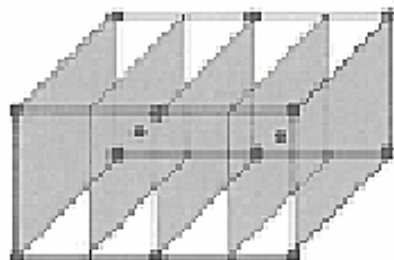


220 planes

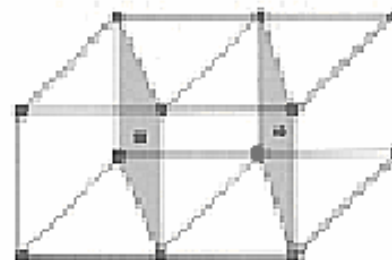


111 planes

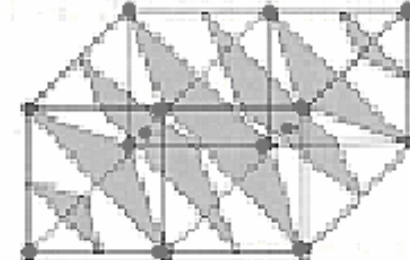
**Body-centred
cubic lattice**



200 planes



110 planes



222 planes

Miller indices for three types of cubic lattices.

Table 1: Miller indices for the different cubic unit cells

reflection*	cubic		
	simple	Face-centered	Body- centered
1	100
2	110	...	110
3	111	111	...
4	200 [2(100)]	200	200
5	210
6	211	...	211
7			
8	220 [2(110)]	220	220 [2(110)]
9	300, 221 [3(100)]
10	310	...	310
11	311	311	...
12	222 [2(111)]	222 [2(111)]	222
13	320

*reflection = $h^2 + k^2 + l^2$

Second and third order reflections are indicated by the orange label as $n(hkl)$.