By: Peter Gu
PhD. Robert F. Klie
August 2nd,2007

Analysis of Au-CeO_2 Nano-particles using TEM

By: Peter Gu

Professor: Robert F. Klie, PhD

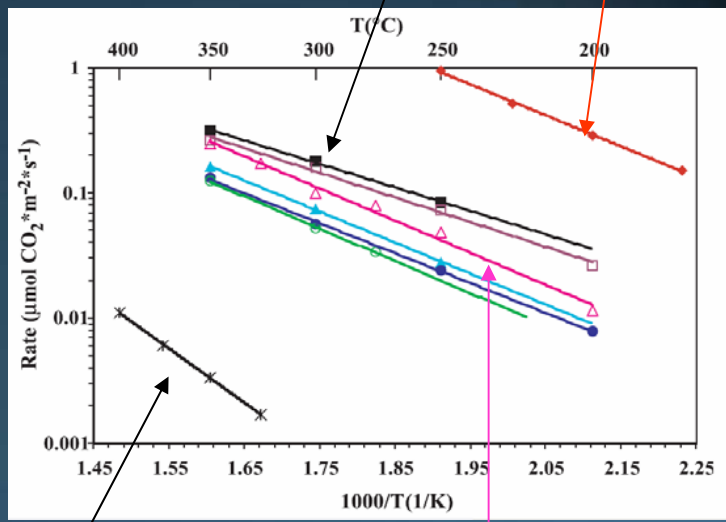
By: Peter Gu
PhD. Robert F. Klie
August 2nd,2007

Background

- Water Gas Shift Application
  - $CO + H_2O \rightarrow CO_2 + H_2$
  - Hydrogen production
  - Fuel cell power generation
- Drawback
  - Only occurs at high temperatures
  - Catalyst to lower activation energy
  - Previous studies
    - Pt and Cu-ZnO (costly / pyrophoric / instability)
    - CeO_2 (easily reduced and oxidized / stable / wide temperature range)
      - Addition of noble metals increase its ability to undergo reduction (Au)
      - Doping with rare earth metals (La / Gd) increases oxygen vacancies.

$CuO/ZnO/Al_2O_3$

4.4% $AuCeLa\ O_2$



Q. Fu, H. Saltsburg, M. Flytzani-Stephanopoulos, Science 301 (2003) 935, published online 3 July (10.1126/science.1085721).

$Ce\ La\ O_2$

0.7% $AuCe(La)O_2$ leached

By: Peter Gu
PhD. Robert F. Klie
August 2nd,2007

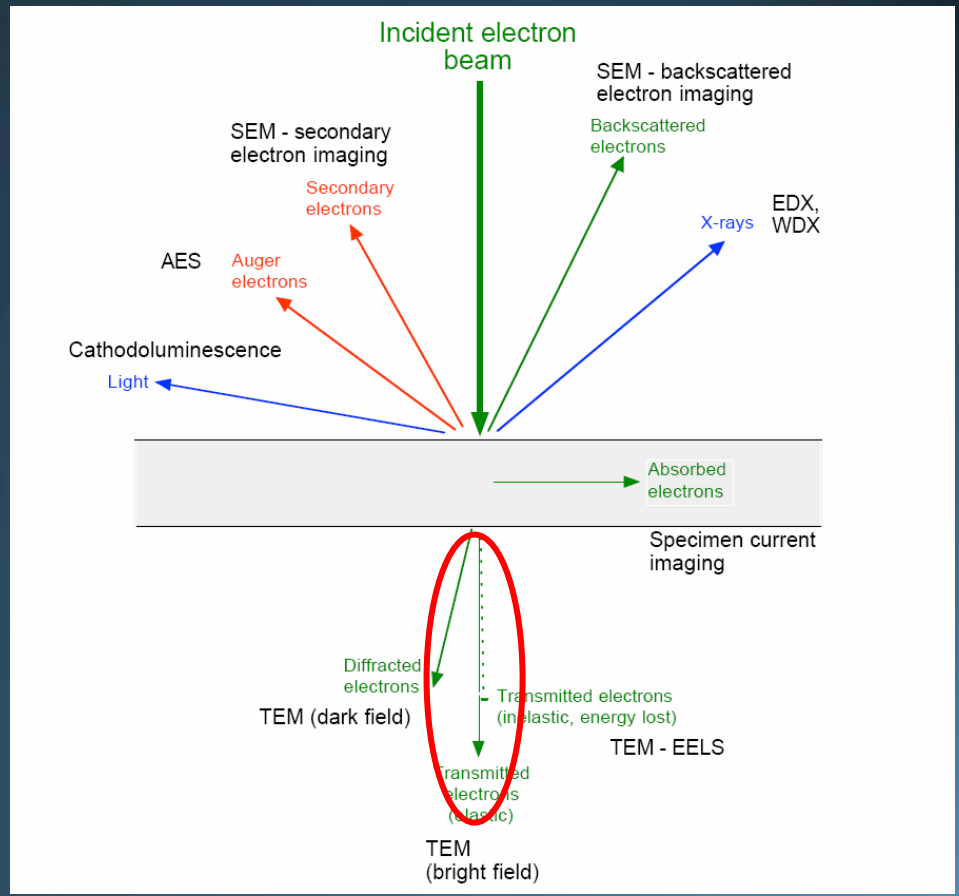
My Project Goals:

- Explain variations in catalytic activity
  - Size of Ceria Particles
  - Lattice Parameter
  - Structure of particle
  - Leaching
- Samples to be analyzed
  - 2.4% Au $(CeGd)O_2$
  - 1.8% Au $(CeLa)O_2$ Leached
  - 0.5% Au $(CeGd)O_2$ Leached
  - 0.75% Au CeO_2

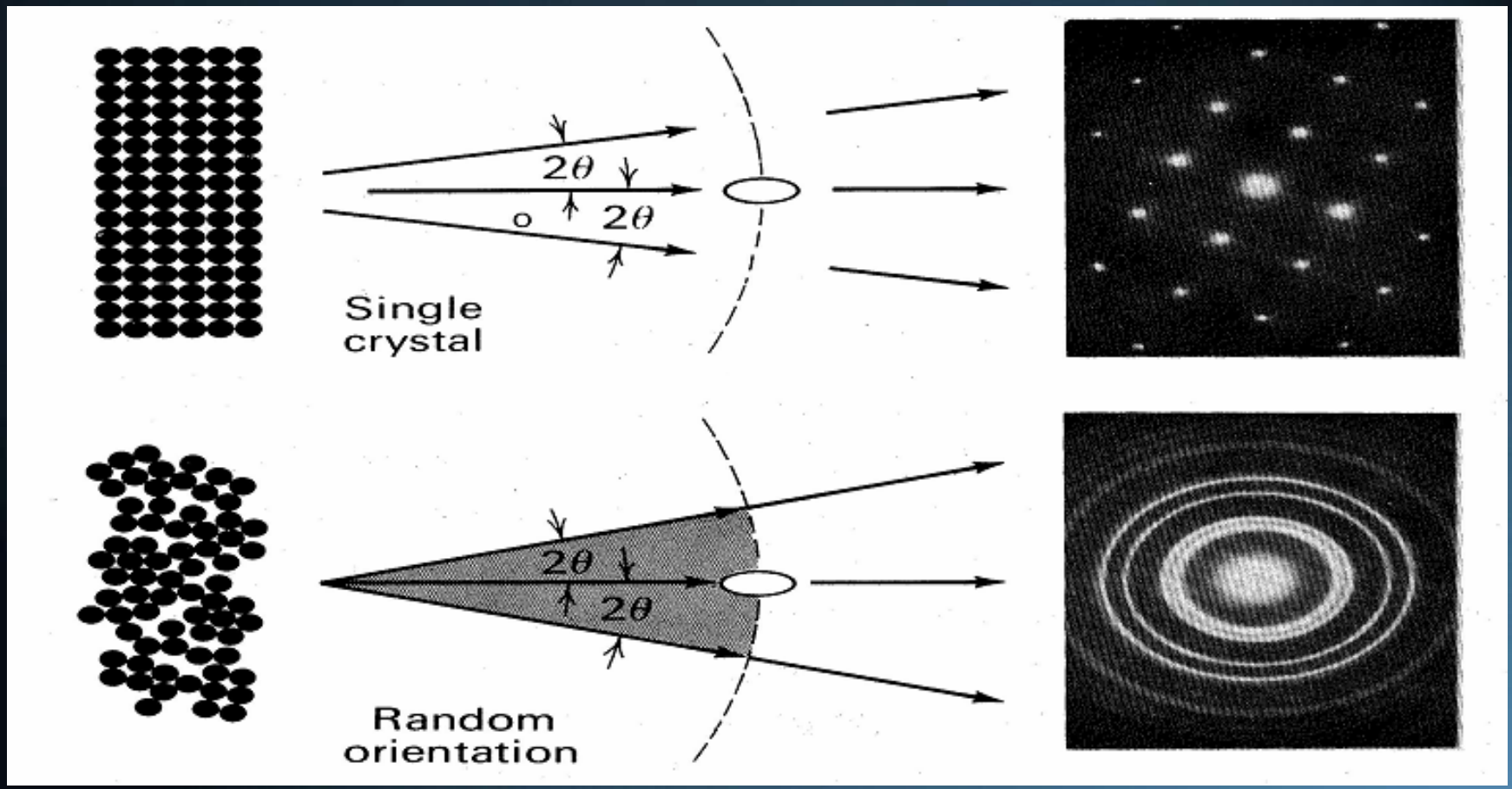
By: Peter Gu
PhD. Robert F. Klie
August 2nd,2007

Transmission Electron Microscope

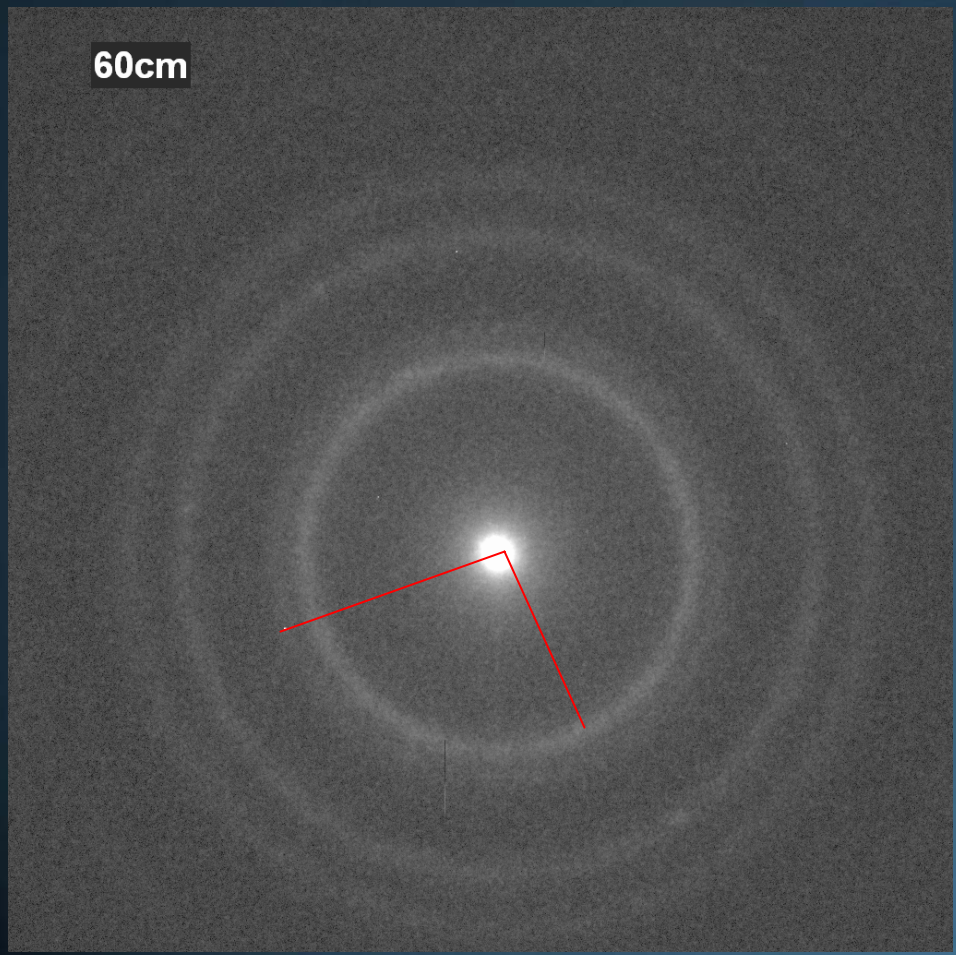
- Beams of electrons transmitted
- Wavelength of electrons are smaller than atoms
- Electron transparent specimen



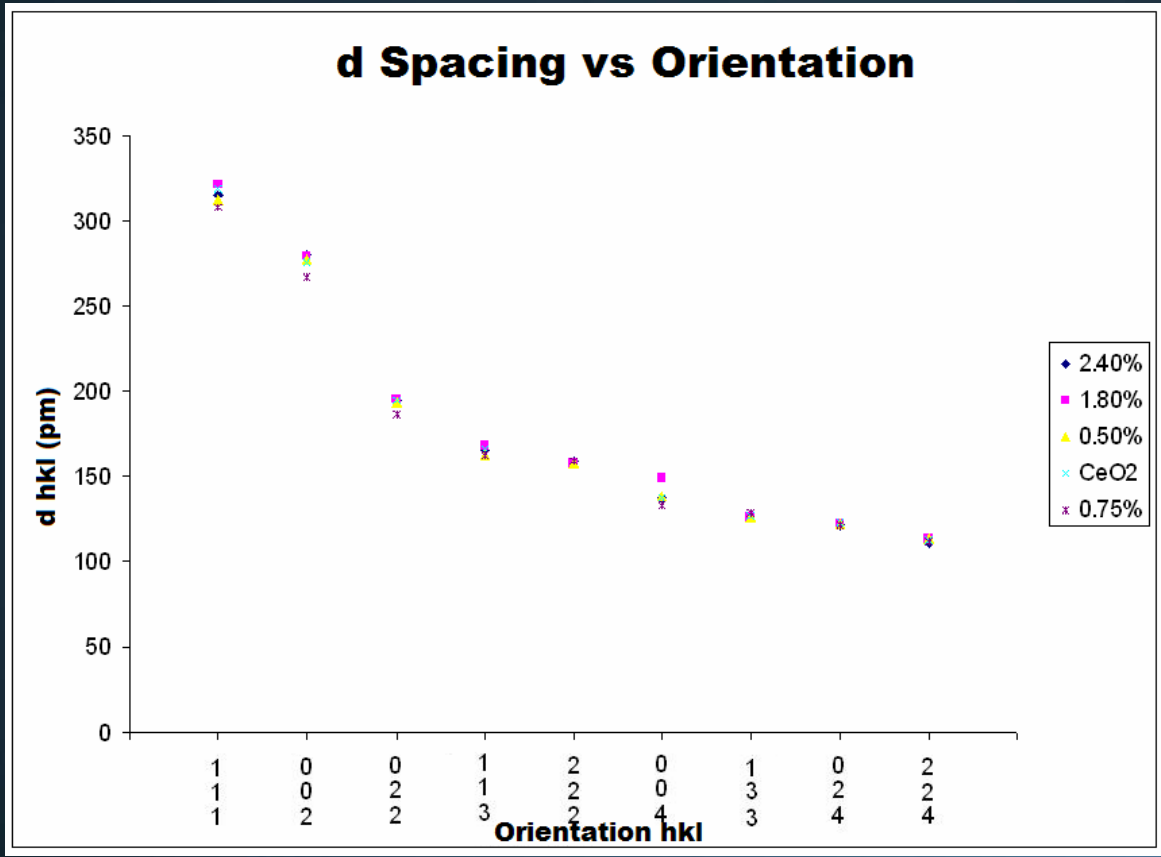
By: Peter Gu
PhD. Robert F. Klie
August 2nd,2007



By: Peter Gu
PhD. Robert F. Klie
August 2nd,2007



By: Peter Gu
PhD. Robert F. Klie
August 2nd,2007



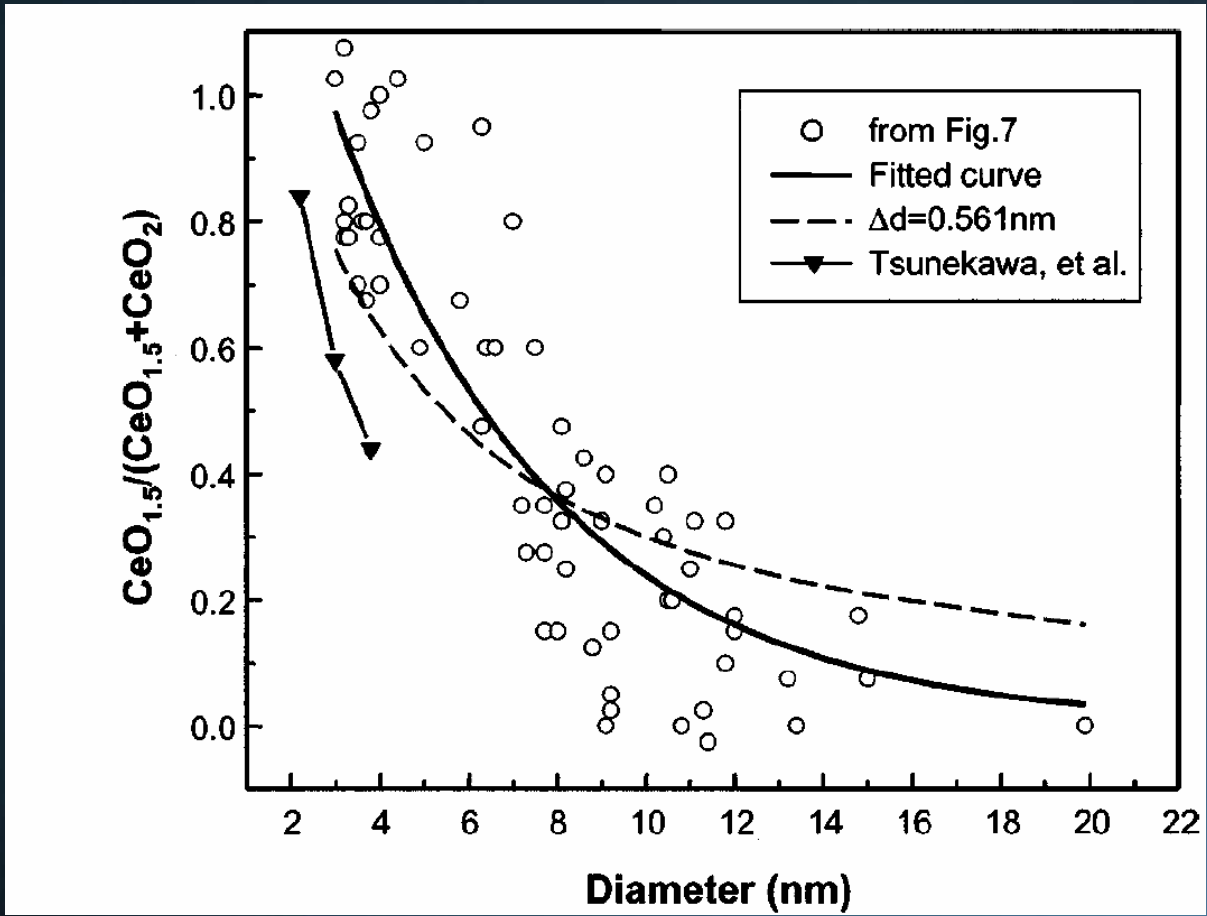
*J.M. Zuo and J.C. Mabon, Web-based Electron Microscopy Application Software: Web-EMAPS, Microsc Microanal 10(Suppl 2), 2004; URL: http://emaps.mrl.uiuc.edu/

By: Peter Gu
PhD. Robert F. Klie
August 2nd,2007

Lattice Parameter Comparison		
Particle	Leached	Lattice (pm) ± 10
CeO_2*	N/A	551.3
0.75% Au CeO_2	No	548.0
1.8% Au (CeLa) O_2	Yes	557.5
2.4% Au (CeGd)O_2	No	550.9
0.5% Au (CeGd)O_2	Yes	540.9

*J.M. Zuo and J.C. Mabon, Web-based Electron Microscopy Application Software: Web-EMAPS, Microsc Microanal 10(Suppl 2), 2004;
URL: http://emaps.mrl.uiuc.edu/

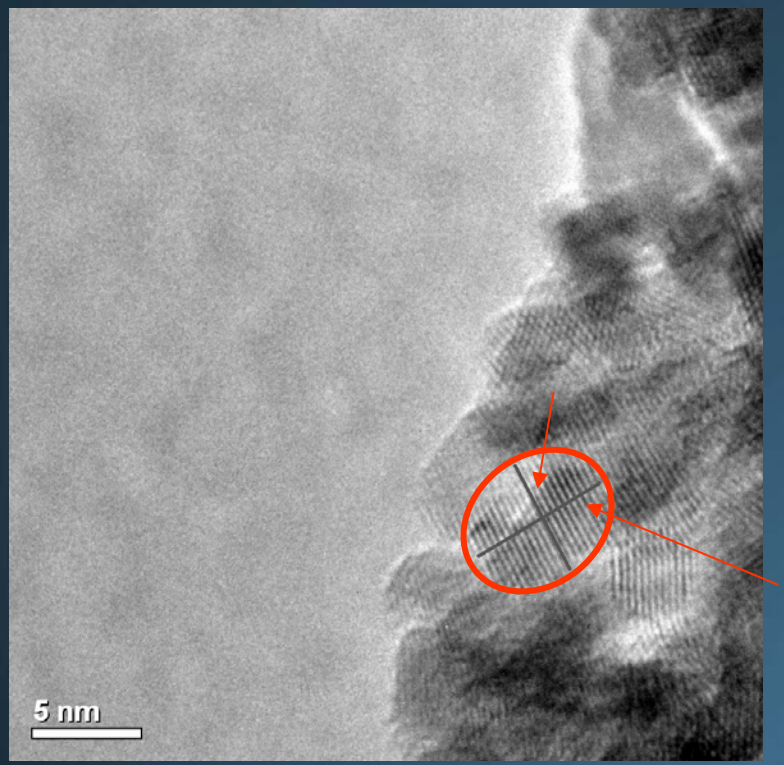
By: Peter Gu
PhD. Robert F. Klie
August 2nd,2007



L. Wu, H. Wiesmann, A. Moodenbaugh, R. Klie, Y Zhu,
D. Welch, M. Suenaga, Physical Review B 69 (2004)

By: Peter Gu
PhD. Robert F. Klie
August 2nd,2007

Particle Size Analysis



By: Peter Gu
PhD. Robert F. Klie
August 2nd,2007

Summary

Sample	d spacing (pm)	Perpendicular to Atomic Fringe (nm)	Along Atomic Fringe (nm)
2.4% Au CeGd O_2	550.9	3.7	3.6
1.8% Au CeLa O_2 Leached	557.5	5.3	5.3
0.75% Au CeO_2	548	4.4	4.6
0.5% Au CeGd O_2 Leached	540.9	4.1	3.7

By: Peter Gu
PhD. Robert F. Klie
August 2nd,2007

Conclusion

- There were no significant deviations in lattice parameter; however there are some trend speculations
- Particle size analysis indicates the 1.8% is somewhat larger and the 2.4% is slightly smaller compared with the remainder of the samples.
  - Could be due to the Leaching process
  - Not enough difference to be attributed to catalytic activity variations

By: Peter Gu
PhD. Robert F. Klie
August 2nd,2007

Future Work

- Collect more particle size and diffraction pattern data
- Measure gold particle size
- EDS mapping on each sample
- TEM in situ at high temperatures

By: Peter Gu
PhD. Robert F. Klie
August 2nd,2007

Acknowledgements

- The financial support of the Department of Defense and the National Science Foundation under:
  - Grant NSF EEC 0453432.
  - Grant NSF CTS 0706699
- PhD Takoudis and Prodyut for organizing the program
- PhD Klie for allowing me to conduct research under his guidance.
- PhD Guang Yang for volunteering many of his hours helping me with the project
- PhD Roth for teaching me how to obtain remarkable images using the TEM

By: Peter Gu
PhD. Robert F. Klie
August 2nd,2007

Thank you for listening!
Any questions?