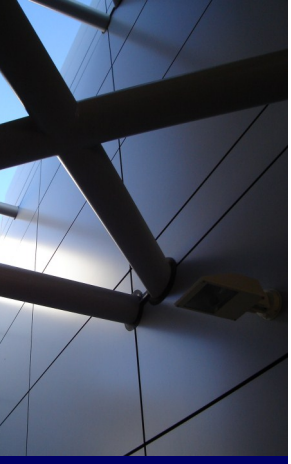

COLLOQUIUM
MECHANICAL ENGINEERING

The Department of Mechanical Engineering presents:

Student Presentations:

Thomas Lopez, Ph.D Student
Mechanical Engineering, University of California Riverside

Friday, October 26, 2012
11:10AM-12:00PM
Bourns Hall A265

Crystallization of non-thermal plasma – produced amorphous silicon nanopowder

The use of a continuous flow non-thermal plasma reactor for the formation of silicon nanoparticles has attracted great interest because of the advantageous properties of the process [1]. Despite the short residence time in the plasma (around 10 milliseconds), a significant fraction of the precursor, silane, is converted and collected in the form of nanopowder. The structure of the produced powder can be tuned between amorphous and crystalline by adjusting the power of the radio-frequency excitation source, with higher power leading to the formation of crystalline particles. Numerical modeling suggests that higher excitation power results in a higher plasma density, which in turn increases the nanoparticle heating rate due to the interaction between ions, free radicals and the nanopowder suspended in the plasma [2]. While the experimental evidence suggests that plasma heating may be responsible for the formation of crystalline powder, an understanding of the mechanism that lead to the crystallization of the powder while in the plasma is lacking. In this work, we present an experimental investigation on the crystallization kinetic of plasma-produced amorphous powder. Silicon nanoparticles are nucleated and grown using a non-thermal plasma reactor similar to the one described in [1], but operated at low power to give amorphous nanoparticles in a 5-10 nm size range. The particles are then extracted from the reactor using an orifice and aerodynamically dragged into a low pressure reactor placed in a tube furnace capable of reaching temperatures up to 1000°C. Raman and TEM have been used to monitor the crystalline fraction of the material as a function of the residence time in the tube furnace and as a function of furnace temperature. We find that for a residence time in the annealing region of approximately 10 milliseconds, a temperature of at least 700°C is needed to observe the onset of crystallization. Further data analysis allows extrapolating the crystallization rate for the case of this simple, purely thermal system. We conclude that thermal effects alone are not sufficient to explain the formation of crystalline powder in non-thermal plasma reactors. In addition, we have also used *in-situ* FTIR to monitor the role of hydrogen on the crystallization kinetic. Hydrogen-induced crystallization has been proposed as the mechanism leading to deposition of micro-crystalline silicon thin films at low temperature in PECVD reactors run with at high H2/SiH4 concentration ratio [3]. We find that the plasma-produced amorphous silicon powder is rich with surface SiHx species, but no detectable signature from bulk Si-H bonds has been observed.

1. Mangolini, L., et al., Nano Letters, 2005. 5(4): p. 655-659.
2. Mangolini, L. and U. Kortshagen, Physical review E, 2009. 79: p. 026405 1-8.
3. Sriraman, S., et al., Nature, 2002. 418: p. 62-65.

Bio: Tom is originally from Saint Paul, Minnesota; He received a B.S. in Physics and Mathematics from Augsburg College in 2011; He is currently a 2nd year PhD student working in Dr. Lorenzo Mangolini's Lab.