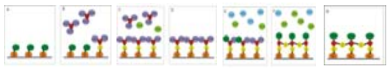
Thin Film Capabilities
Penn State Nanofabrication Facility

W Drawl, B Liu, A Mieckowski
Materials Research Institute , Pennsylvania State University

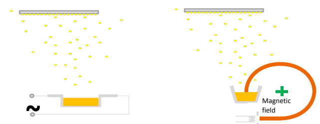
Introduction

Thin films are used through out the would today. Their applications range from optical coatings to cutting tools to microelectronic. Thin film deposition is the technique of applying a material on to a substrate with thicknesses on the order of nanometers to ten's of microns. The Penn State Nanofab has several techniques for growing thin films, these include: (ALD) Atomic Layer Deposition, Evaporation, Sputtering, (PECVD) Plasma Enhanced Chemical Vapor Deposition and (LPCVD) Low Pressure Chemical Vapor Deposition.

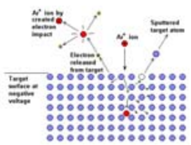
ALD is a thin film technique that is based on sequential introduction of gas phase precursors to deposit at film one atomic layer for each precursor cycle.



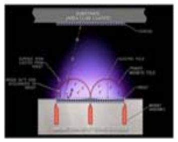
Evaporation as it pertains to thin films is a process where the deposited material is heated in high vacuum by thermal or a focused electron beam to the point at which sufficient kinetic energy is provided to over come the liquid-phase intermolecular forces so that the liquid at the surface becomes a vapor. The vapor is then directly transported to the substrate surface where the vapor then condenses as a growing film.



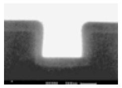
Sputtering is the removal of a material from a solid target by energetic ion bombardment in order to coat a substrate with the target material

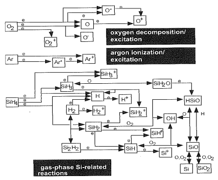


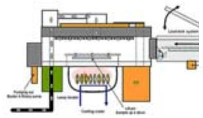
Ions penetrate the target and displace lattice atoms along the collision cascades
Momentum transfer is principally into the target: sputter ejection does not follow from a single binary event
Sputtered atoms can be ejected far from the initial collision site
S is proportional to Mi Mt/(Mi+Mt) (Mi+Mt) where S is the sputter yield
S is proportional to 1/U where U is the surface binding energy

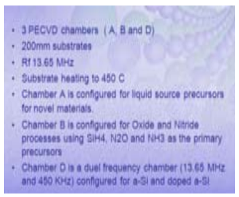


PECVD Plasma Enhanced Chemical Vapor Deposition is a process used to deposit thin films from a gas state to a solid state. Chemical reactions involving a precursor gas occur as a result of dissociation and ionization of the gas within a plasma with film growth occurring at the substrate surface.

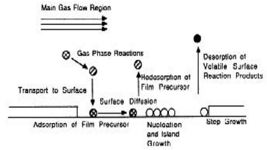








(LPCVD) Low Pressure Chemical Vapor Deposition is a process used to deposit thin films from a gas state to a solid state. Chemical reactions involving a gas or mixture of gases occur as a result of dissociation and/or reaction of the gases under reduced pressure and elevated temperature with film growth occurring at the substrate surface. Gases react at hot wafer surface to create solid films.



Silicon Nitride
 $3\ SiCl_2H_2 + 4\ NH_3 \rightarrow Si_3N_4 + 6\ HCl + 6\ H_2$
Polysilicon
 $SiH_4 \rightarrow Si + 2\ H_2$
Amorphous Silicon
 $SiH_4 \rightarrow Si + 2\ H_2$
LTO (Low Temperature Oxide)
 $SiH_4 + O_2 \rightarrow SiO_2 + 2\ H_2$

In Summary

Each tool and technique has its advantages and disadvantages. The details of the process and materials needed for the fabrication of the end product combine with the tool capabilities to ultimately determine which tool set would be optimal. In an effort to determine which tools best fit a particular fabrication process users are encouraged to interface with the staff.

There are several mechanisms currently in place to help facilitate these interactions:
 -New User Project Overviews
 -Tool trainings
 - Follow-up meeting with the staff as needed.

For more information on what tools are available or how to get started please visit:

http://www.mri.psu.edu/facilities/NNIN.asp