Development of a Spatially Controllable Chemical Vapor Deposition System : Preliminary Experimental Evaluation

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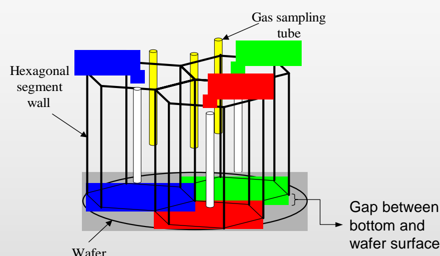
Spatially Controllable CVD Concepts

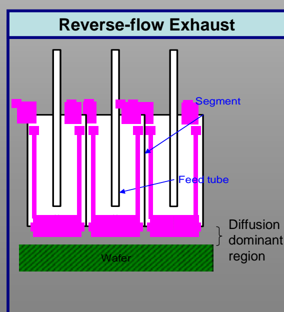
1. Gas delivery and sampling discretization

The hexagonal showerhead discretizes regions above the wafer surface into individually controllable regions.



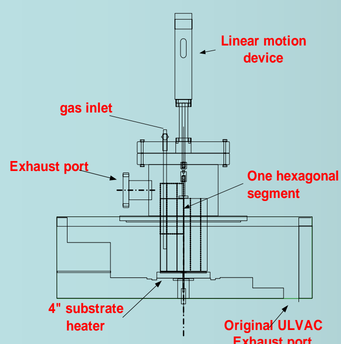
1. Segmented wall maintains the desirable gas concentrations in each segment.
2. Individual mass flow controllers allow individual segment recipes
3. Individual sampling tubes monitor each segment

2. Minimizes convective interaction

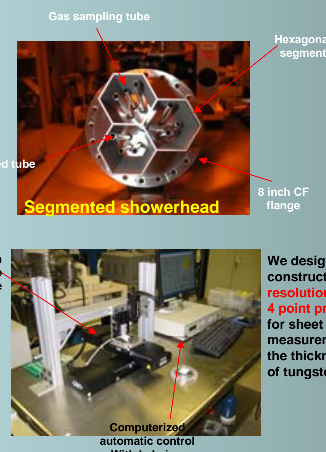


The reverse-flow gas exhaust minimizes convective interactions between segments under the segment wall.

Prototype Reactor 1.

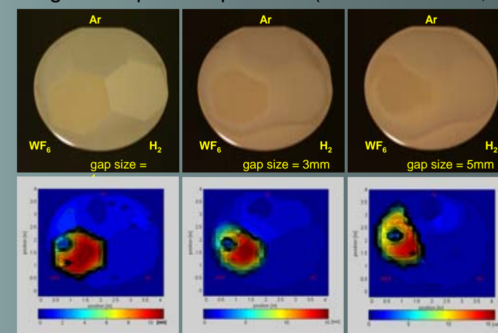


Prototype reactor 1. is the modification of commercial CVD cluster tool (Ulvac-ERA1000).



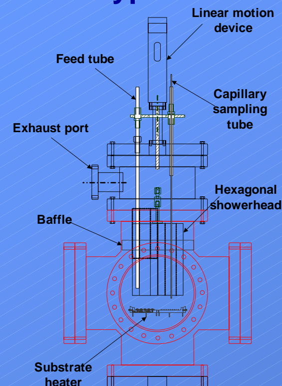
We designed and construct a high resolution automatic 4 point probe station for sheet resistance measurement to map the thickness pattern of tungsten film.

Film patterns on 4 inch silicon wafers after 10min tungsten deposition process. (at 350 °C and 0.5 torr)

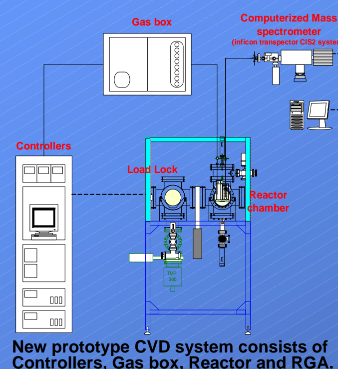


Sharp patterns are shown in thickness maps.

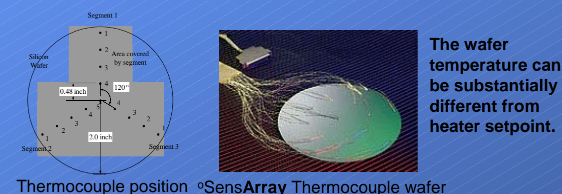
Prototype Reactor 2.



1. New clean reactor chamber reduces undesirable reaction (1.0E-8 torr)
2. Extendible reaction chamber (8inch 6-way cross CF) allows convenient modification of reactor structure.

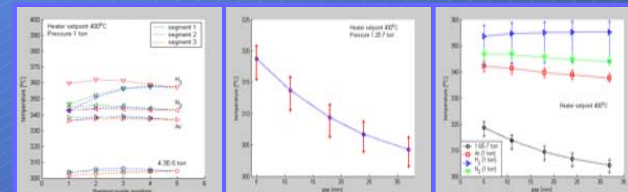


New prototype CVD system consists of Controllers, Gas box, Reactor and RGA.



Thermocouple position °SensArray Thermocouple wafer

The wafer temperature can be substantially different from heater setpoint.



Wafer temperature vs. gas composition

Average wafer temperature vs. segment position

Average wafer temperature vs. segment position varying gas composition

9 sets of valves, MFCs, regulators and gauges to control gas flow rate in each feed tube.

currently in Lamp lab, J.M.Patterson building, University of Maryland, College Park, MD

Summary

Prototype reactor 1 :

- Clear hexagonal deposition patterns prove the feasibility of this spatially controllable reactor concept.

Prototype reactor 2 :

- Flexible design and full controllability are the modifications.
- Temperature measurement experiments demonstrate that process conditions and reactor configuration significantly effect the wafer temperature.

Future work

- Tungsten film deposition with run-to-run control is planed to assess and demonstrate the ability of fast reprogramming of process conditions to compensate for undesirable effects such as non-uniform wafer temperature.