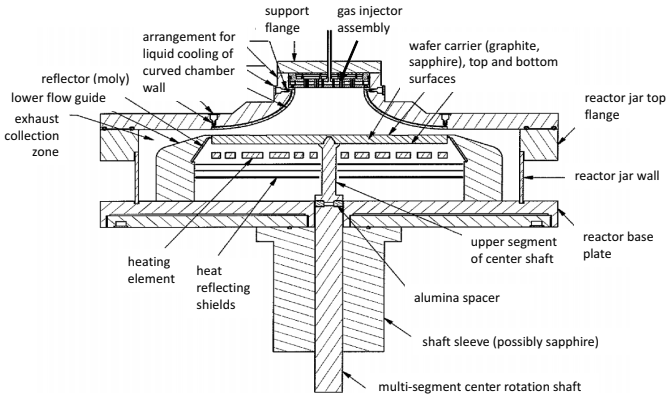
Temperature Control of Metal-Organic Chemical Vapor Deposition (MOCVD) Process

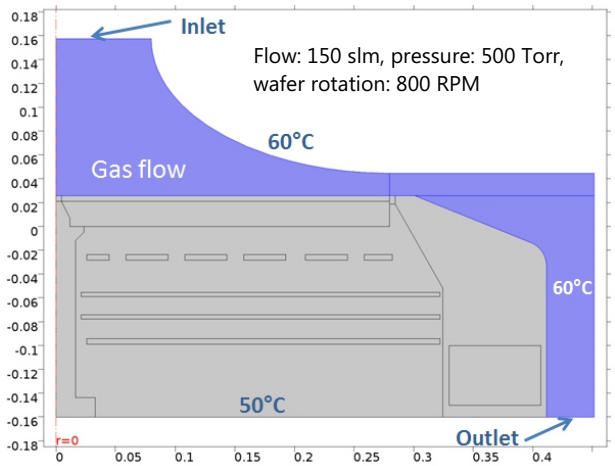
Thermal Model of MOCVD Chamber

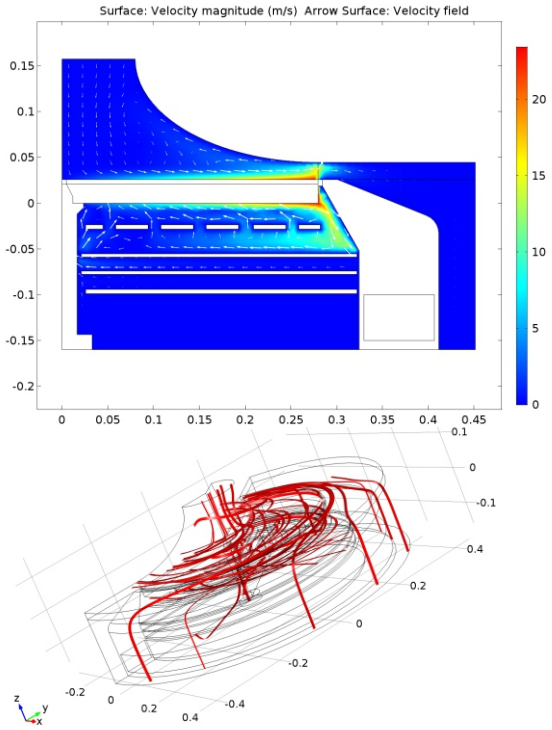
Physics-based MOCVD models are useful in many ways including model-based control, design of next-generation chambers, virtual sensing and process optimization. As a capability demonstration, we have developed a finite element (FEM) model of a chamber shown below with design features and geometry obtained from the literature. The model was developed using the popular commercial FEM software package, COMSOL.



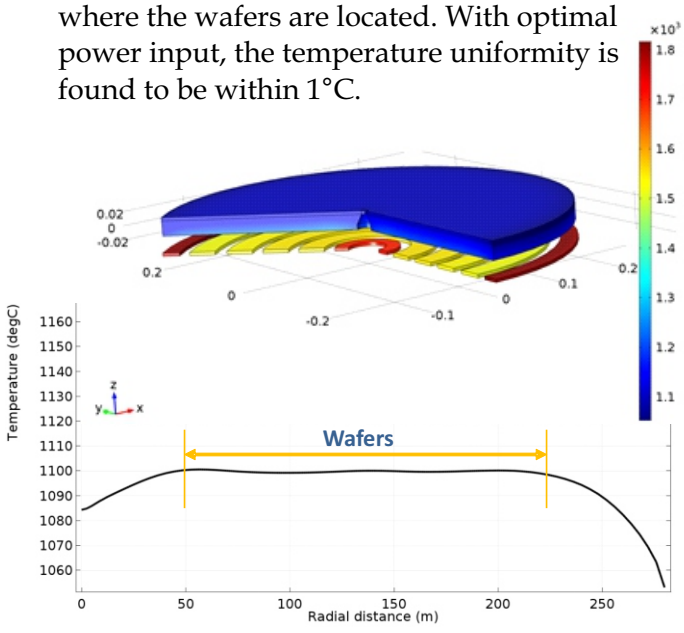
Details of a the MOCVD chamber geometry obtained from U.S. Patent 8778079.

A thermal model of a reactor with a rotating susceptor was developed. The model incorporates gas flow, and conduction and radiation heat transfer throughout the chamber. The gas below the susceptor is nitrogen while the gas in the chamber above the susceptor is hydrogen. The six tungsten heaters below the carrier are connected to three power supplies, with middle four heaters grouped together.



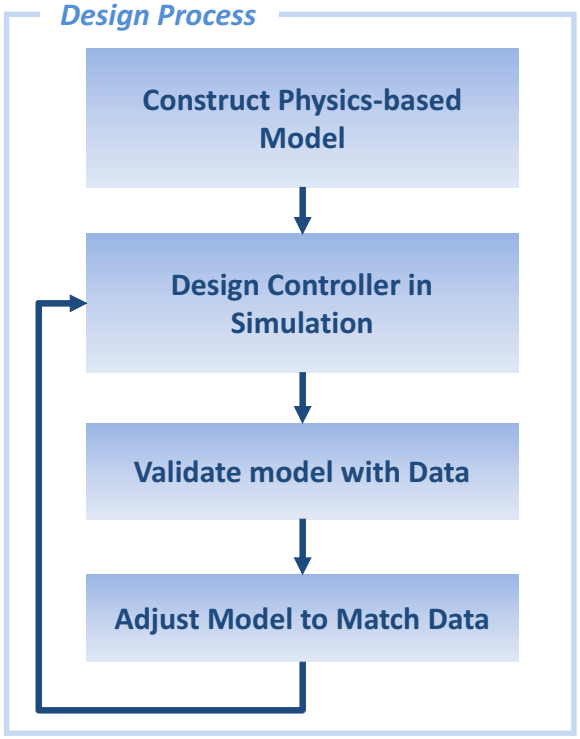


The above figures show the gas flow velocities, including the swirl flow due to susceptor rotation. The figure below shows the temperatures of susceptor and heaters. The graph at the bottom shows the temperature of the top surface of the susceptor *vs.* radial distance. Optimal power settings were determined for the three heater zones for maximizing temperature uniformity on the part of the susceptor where the wafers are located. With optimal power input, the temperature uniformity is found to be within 1°C.



Model-based Temperature Control

SC Solutions is a leading provider of high-performance temperature controllers for MOCVD chambers. The sequence of design steps for these model-based controllers is shown in the schematic below.



SC 's model-based approach has several advantages both for controller development as well as for design and operation of next-generation equipment. These advantages are summarized below.

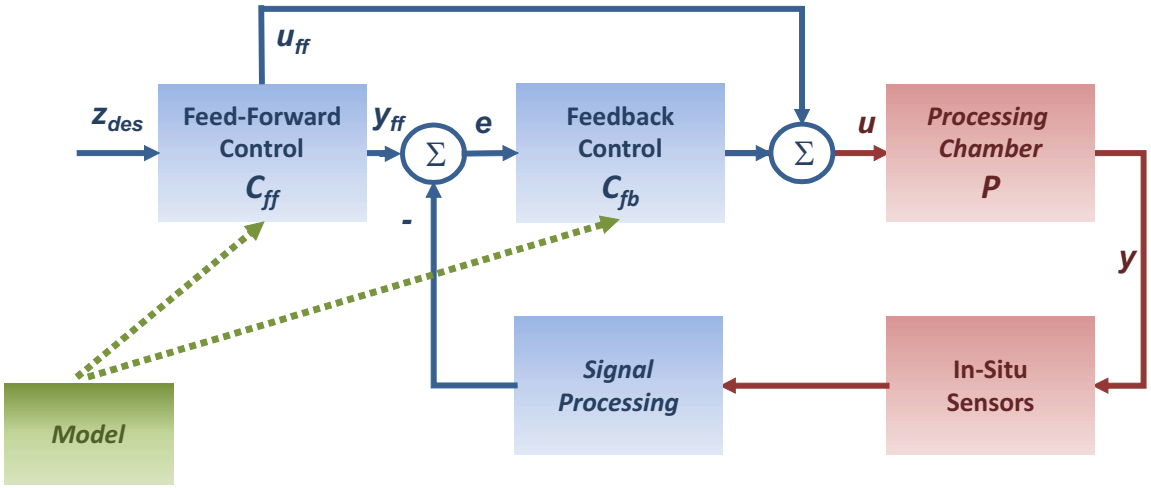
Advantages

Modeling for Control Design

- Controller is tested in simulation for wide range of conditions.
- Much of the control design can be done without access to equipment.
- Ability to do controller development in parallel with chamber development.

Modeling for Equipment Design

- A model of the system that can be modified for "what-if" studies.
- Provides a tool for troubleshooting.
- Path for continued improvement.



SC has developed techniques that allow high fidelity physics-based models to run much faster than real time. These dynamic models can be incorporated into real-time controllers to provide information that helps maximize controller performance.

For further information, please visit our website or contact us at the email and phone number given below.

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