Session [436] – Modeling and Design of Electronic Materials Processes

Control Strategies for the Programmable Chemical Vapor Deposition Reactor System [436e]

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Abstract

The Programmable Reactor System is a new approach to spatially controllable CVD under development at the University of Maryland. This reactor concept incorporates a number of novel design features, including a segmented showerhead with independently controllable feed gas injection in each segment, recirculation of residual gas up through the showerhead in each segment, and multi-segment residual gas sampling - features all aimed at improving 2-dimensional across-wafer controllability. A series of prototype reactors has been constructed based on this design, incorporating a relatively small number (e.g., three) segments; however, the basic operating principles have been successfully demonstrated through these prototype designs. This paper will discuss current control strategies for this complex CVD system including measurement based run-to-run optimum control and advanced process control for end-point detection in this multi-segmented reactor design.

An important goal in the proof of this reactor design is a demonstration of its capabilities in controlling film uniformity across the wafer surface and its unique ability to produce controlled non-uniformities, such as those that might be used in a single-wafer materials development combinatorial study. To this end, we will discuss implementation of measurement based optimum control, in which control variables are updated using a run-to-run optimization technique based on film property measurements such as across-wafer film thickness uniformity. To improve the optimization efficiency and reduce the experimental cost, this controller is tested using the object-oriented modular simulator developed for this system, which can be easily manipulated to test different assumptions with different transport models and reaction models. The simulation results then are used to guide the selection of experimental operating conditions. These simulation results and preliminary experimental testing of this controller will be discussed in this paper. We will also discuss relationship of controller performance with measurement accuracy, disturbances in precursor feed rate, and (experimentally measured) wafer temperature nonuniformities.

An advantage of the Programmable Reactor System is that it is designed to facilitate spatially resolved residual gas analysis: each segment is fitted with a sampling tube and all sampling tubes are connected to a mass spectrometer. In this paper, we will discuss this capability in terms of the challenges posed by this multi-segmented design in the context of spatially distributed end-point detection.