374a Real-Time Characterization of Ysz Film during Chemical Vapor Deposition Using an Extended Kalman Filter Based Soft Sensor

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Thin film deposition is a critical step in the production of advanced electronic and optical devices. It is highly desirable to develop real-time, structure-specific analytic tools for sensing film properties during thin film growth. As an alternative to the hardware sensor like RHEED which is expensive and requires stringent operation conditions, a soft sensor is a software-based sensing technique. It uses easily measured secondary variables and their interaction to infer values of interest.

This work utilized an emissivity correcting pyrometer and developed a extended Kalman filter based soft sensor to measure YSZ film growth rate, film thickness and film roughness in real time during chemical vapor deposition. The emissivity correcting pyrometer measures radiation and reflectance of film surface at two different wavelengths, for a total of four measurements. The radiation is the function of surface temperature and surface emissivity. Under the assumption of opaque substrate, emissivity can be obtained by measuring the reflectance at the same wavelength as the pyrometer. The reflectance of the film is determined by the interference between the beam reflected from the gas-YSZ interface and that from the YSZ-silicon substrate. It is also affected by roughness of YSZ film which causes the light scattering on the surface. The extended Kalman filter which consists of a process model of film growth and a sensor model took into account of all those interactions. Combined with limited sensor data, the extended Kalman filter gives the best estimate of the state of the system. Compared to widely used least squares fitting method, extended Kalman filter only needs the current measurements to update the state estimate and thus requires less on-line computation. The estimated film properties were compared against offline film characterization. The film thickness was measured by using ellipsometer and PANalytical X-ray reflectometer. The film roughness was measured by using atomic force microscope.