A New and Unique Instrument for Characterizing Reactions between Thin Films and Gases: Simultaneous Measurements of Heat Flow, Mass Change and Viscoelastic Changes in Thin Film Samples

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ABSTRACT

Many chemical processes occur in a thin solid film exposed to a gas when the gas either adsorbs on the surface or dissolves in the film. These processes can be characterized using the patented combination of a quartz crystal microbalance with an ultra-sensitive heat conduction calorimeter. A new measurement technique has been developed that simultaneously and continuously measures the small mass changes, heats of reaction, and changes in film viscoelasticity during the interaction of gases with thin films.

The Masscal G1™ microbalance/microcalorimeter incorporates a quartz crystal resonator oscillating in shear mode and direct heat flow sensors within a precisely controlled sample chamber and gas flow system. The quartz resonator can be coated with a thin film sample (0.001-10 μm) and exposed to a program-controlled active probe gas under precise isothermal control. Three quantities are monitored simultaneously as the concentration of probe gas is varied: (a) the mass change m(t) (to ± 2 ng), (b) the thermal power P(t) (to ± 50 nW), and (c) the change in loss compliance J"(t) of the film when it absorbs, releases, or reacts with the probe gas.

Major areas of application for the Masscal G1 include 1) surface reactions and catalysis; 2) biological processes in thin films; 3) film deposition, properties, and their interactions with substrates; and 4) adsorption and desorption phenomena in pharmaceutical and industrial coatings.