



## Using *in-situ* deposition of metallic thin films on Mars to monitor atmospheric H<sub>2</sub>O

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We describe the use of a novel sensor, designed to characterize the reactive nature of the Martian atmosphere, and to also characterize the instantaneous abundance of atmospheric H<sub>2</sub>O. The sensor deposits, *in situ*, a thin silver film onto a sapphire substrate and monitors oxidation by measuring resistance of the Ag film during both deposition and subsequent oxidation [1,2]. The evaporation source is placed in the center of an open-ended tube. On flash heating the source, evaporated metallic silver rapidly reacts with oxidizing gases in the tube, depositing on the tube walls as an insulating Ag oxide film. Unoxidized silver deposits over the Ag oxides, once the oxidizing gases in the vicinity of the source have been consumed. Since the ends of the tube are open, atmospheric gases in the tube cause a time delay as the evaporated silver initially reacts with the available O<sub>2</sub> and H<sub>2</sub>O; once oxidizing gases in the tube are significantly depleted, a silver film closes the chemiresistor circuit. In principle this operation mode provides a repeatable measure of the variable H<sub>2</sub>O abundance, since O<sub>2</sub> levels are constant in the atmosphere.

To explore the utility of the sensor for H<sub>2</sub>O detection, predict its behavior, and identify possible failure modes, we developed a numerical model of the laboratory experiments, and applied it to likely Mars conditions. The model predicts the behavior of the electrical circuit, the temperature dependence of resistivity for each component, and the resultant Joule heating. The model balances Joule heating against radiation, sensible heat loss to ambient CO<sub>2</sub> and, latent heat loss from sublimating Ag. The flux of Ag atoms from the source is tracked continuously. In the gas phase, the number density of Ag, O<sub>2</sub> and H<sub>2</sub>O is calculated, along with their reaction rates on collision

and deposition on the tube inner surface. The model suggests that Ag substantially depletes atmospheric H<sub>2</sub>O only near the center of the tube. The model supports the hypothesis that the onset of high conductivity is a function of the H<sub>2</sub>O abundance in the ambient gas, but only to a limit; when H<sub>2</sub>O abundances are buffered at or above 240K (an H<sub>2</sub>O abundance that would not have occurred on Mars), metallic Ag never deposits in excess of AgO, and the circuit does not close.

A significant difference in the Mars simulation is that the Ag source sublimates more quickly, primarily because of differences in sensible heat fluxes from the source. This allows subsequent heating of the W filament used to support the Ag source. Given the results of our model, to prevent possible melting of the filament on Mars, during ground operations the current pulse would be sequentially increased from a value below 650 msec until unoxidized silver deposits.

[1] Towner M.C., et al., The Beagle 2 environmental sensors: science goals and instrument description, *Planetary and Space Science* 52 (2004) 1141-1156

[2] Quinn, R. C., et al., An atmospheric oxidation monitor based on In-Situ thin-film deposition, Submitted to; *Sensors and Actuators*, 2005.