

**Next Generation Electrochemical Sensors for In Situ and Laboratory Sample Analysis** R. C. Quinn<sup>1,2</sup> and A. C. Noell<sup>3</sup>, <sup>1</sup>SETI Institute/NASA Ames Research Center (Moffett Field, CA), <sup>2</sup>Leiden Measurement Technology (San Carlos, CA), <sup>3</sup>NASA Jet Propulsion Laboratory (Pasadena, CA)

**Introduction:** The trajectory of technology development for space and planetary exploration typically follows a path of increasing analytical spatial resolution. This trajectory is driven by our growing understanding of solar system objects and our ability to develop hypotheses which can only be tested through fine-scale measurements. Nowhere is this more evident than in our exploration of Mars, where the ability to perform measurements with fine-scale spatial resolution is essential for future in situ exploration and for laboratory analysis of returned samples. Microsensor arrays offer a number of promising approaches to achieve fine-scale spatial resolution through their use as direct in situ chemical probes or through the use of integrated microsampling interfaces. Sensor arrays can provide high sensitivity with limited power, mass, and volume requirements making them a logical choice for small payload implementation and an attractive alternative to traditional laboratory analytical instrument approaches. The Wet Chemistry Laboratory (WCL), which was part of the Mars Microscopy, Electrochemistry, and Conductivity Analyzer (MECA) on the Phoenix Lander is an example of a highly successful sensor based approach to planetary exploration. The WCL contained an array of electrochemical sensors that were used to measure the soluble components, including perchlorate, present in martian surface material [1].

**Next-Generation Sensor Arrays:** Key indicators of biosignature preservation as well as past and present habitability, including physicochemical conditions and the distribution of chemical energy and nutrients sources, can be evaluated using electrochemical sensors. The presence of electron acceptors such as  $\text{ClO}_4^-$  and  $\text{SO}_4^{2-}$ , sources of bioessential nutrients (H, C, N, O, S), and physicochemical factors such as pH, Eh, and conductivity were characterized at the Phoenix landing site with the WCL. However, the WCL sensors were specifically packaged for deck accommodation and required a large bulk (~1 cc) sample delivery from the lander sample acquisition and handling system. In the Phoenix WCL packaging configuration, spatial resolution is defined by the sampling capabilities of a lander or rover robotic arm.

Since the time of the Phoenix mission, we have been developing new electrochemical sensing approaches to fill WCL technology gaps, including the development of microsensors for the direct and im-

proved detection of nitrate, sulfate, perchlorate and oxidants. These new technologies have been demonstrated for lab-on-chip platforms, with consideration of packaging approaches to allow both laboratory-based and in situ spatially resolved chemical measurements. Using microfabrication technologies, the goal is to develop microdevices for direct contact measurement of samples in the size range of sand, clay, and below to allowing spatial chemical profiling of sedimentary deposits, regolith, and samples generated through drilling or coring.

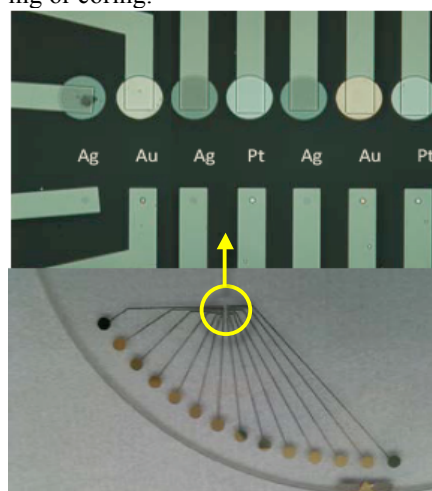


Fig. 1. A microelectrode array. a) Detail of upper 250  $\mu\text{m}$  electrode and lower 25  $\mu\text{m}$  electrode arrays. b) Passivated metal traces for electrical contact run from the arrays to the wafer edge.

**References:** [1] Hecht, M. H. et al. (2009) Science 325, 64–67.

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