

Five digit Project ID number: 60197

Project Title: Microsensors for In-Situ Chemical, Physical, and Radiological Characterization of Mixed Waste

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Number of graduate students and post-docs : 5

Specific DOE problems:

A widespread need exists for a portable, real-time, in-situ chemical, physical, and radiological sensors in the characterization and monitoring of mixed waste, ground water, contaminated soil and process streams. A number of environmental monitoring scenarios could benefit from miniature, low-power instrumentation that provides multicomponent analysis and information in an autonomous fashion. For example characterization of ground water is important for plume containment and remediation efforts. Urgent need also exists for sensors for determination of location, chemical composition, and level of Dense Non-Aqueous Phase Liquids (DNAPLs).

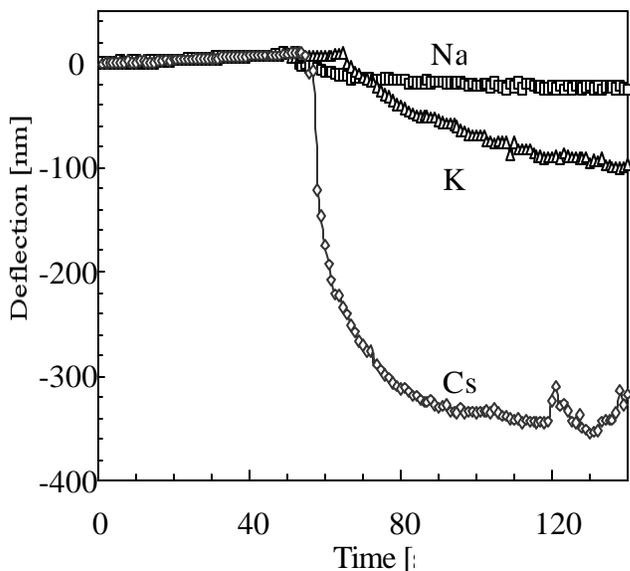
Research Objective:

The objective of this research program is to conduct the fundamental research to develop extremely sensitive and highly selective for chemical, physical, and radiological characterization of mixed waste and ground water using microcantilever platform. The microcantilever sensors have sensitivity in the range of parts-per-trillion. These sensors will be of great value to DOE for the safe and cost-effective in situ, real-time characterization of contaminated sites. The ability to detect and measure specific chemicals and radionuclides in real-time using miniature and inexpensive sensing device could result in considerable benefits with regard to both cost savings and safety issues. In addition, this approach can also lead to multi-element/multi target sensors using array approach. The selectivity of the sensor results from chemical modification of cantilevers using selective molecular recognition agents.

Research Progress and Implications:

As of mid-third year great progress has been made toward demonstrating many chemical, physical, and radiological sensors with unprecedented sensitivity and selectivity. The demonstrated examples include detection of Cs ions with 10^{-12} M sensitivity in presence of high concentrations of Na⁺ and K⁺ ions. To make the microcantilevers selective for Cs, the cantilevers were coated with cesium-selective ionophores (which have selectivities for cesium over sodium in the range of 20,000 to 50,000). We have used chemically modified 1,3-alternate 25,27-dialkoxy -26,28-

calix[4]-benzo-crown-6 ionophores, for attachment to the microcantilever. The ionophores for cesium ion detection were synthetically modified with long-chain alkanethiols for attachment to a gold-coated microcantilever. The octyl chains were



derivatized with terminal thiols for adsorption onto gold. In order to form a compact monolayer, a shorter chain amphiphile 1-decanethiol was co-adsorbed onto the gold surface to fill the gaps present between the two alkyl thiol arms of the ion selective ionophores and the adjacent molecules.

Figure above shows the selective response of a modified cantilever for

detection of Cs^+ , K^+ , and Na^+ ions.

Another great successful demonstration was detection of Cs ions in a tank waste simulant with high concentrations of sodium nitrate and NaOH (pH 14). In addition we have demonstrated selective and sensitive sensors for Na, K, and CrO_4 . We have also developed extremely sensitive pH sensors with sensitivity of 10^{-3} pH units. Examples in chemical sensing include detection of benzene, toluene, and hydrogen. We have demonstrated a novel micromechanical detector for alpha particle detector using microcantilevers.

Planned Activities:

During the remainder of this fiscal year, we will focus our attention on the development of modified cantilevers for characterization of selected inorganic species (Pb, Hg, Cr, and Sr) in ground water. Experiments are presently underway evaluate and optimize microcantilever radiation detector for alpha particles.

Information Access:

T. Thundat, E. Finot, H-F. Ji, R. Dabestani, P.F. Britt, P.V. Bonnesen, G.M. Brown, and R.J. Warmack, "Highly selective microcantilever sensor for Cs ion detection" *Electro. Chem. Soc. Pro.* 99-23, pp 314-319 (1999).

T. Thundat and L. Maya, "Monitoring chemical and physical changes on sub-nanogram quantities of platinum oxide" *Surf. Sci. Lett.* **430** L546 (1999).

H-F. Ji, E. Finot, R. Dabestani, T. Thundat, P.F. Britt, and G.M. Brown," *Chem. Comm.* (in press).