MicroChemical Systems for Separations

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Several unit operations are used on the macro scale to separate chemical species; examples include membrane separation, extraction, distillation, and chromatography. We have identified separation methods that take advantage of enhanced performance created by the small length scales of microfabricated chemical systems.

Palladium Micromembranes. High hydrogen purity is required in a variety of processes, from the microelectronics industry to PEM fuel cells. Microfabricated palladium membranes (see Figure 43) have been shown to enable hydrogen purification at high fluxes and high selectivity. We are investigating novel fabrication strategies to realize palladium microtubes. This approach reduces contact between silicon and metal, which limits interaction with silicon and membrane deactivation, and provides a higher surface-to-volume ratio than a flat membrane.

Extraction and Distillation. The production of fine chemical or pharmaceutical compounds requires multistep synthesis, including the mixing, reacting, and separating of chemical compounds. Since multistep syntheses typically involve reactive intermediates, it is desirable to run a separation immediately following reaction to reduce dead volume and increase safety. We have designed and are fabricating a first generation extractor that utilizes dielectrophoresis (DEP) to separate two immiscible liquids. DEP is advantageous because it is non-invasive, can readily be implemented in microfluidic devices, and does not require surfactants that could interfere with the process chemistry. Distillation processes are also useful for separating miscible compounds, but the strong surface forces in microsystems require new approached to creating distillation type process for small scale devices

Chromatography. This technique is widely used on the macroscale for highly selective separations such as those required for analytical chemistry and pharmaceutical production. A method for performing continuous chromatographic separations on the microscale would open the possibility of fabricating multistep designs requiring highly selective separations. The use of simulated moving bed chromatography as a separation tool on microscale is currently under investigation.

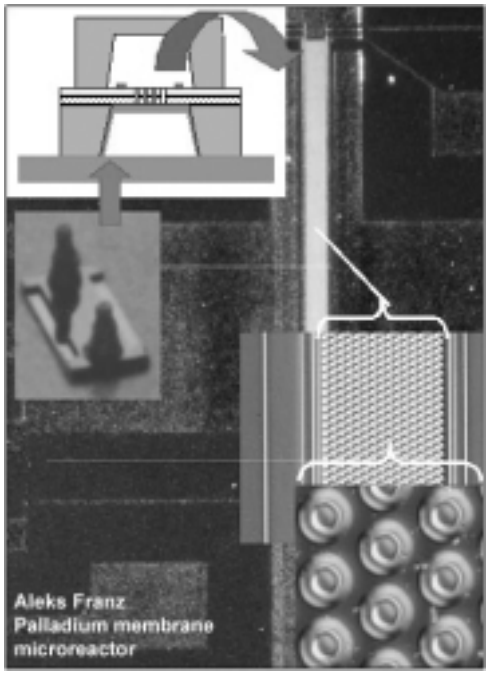

Fig. 43: Palladium micromembranes for hydrogen purification. Membrane device, 200 nm palladium film supported on silicon nitride and oxide membrane with 4 micron holes, image of membrane structure and integrated heater, actual device components.