Advances in Microsystems Engineering Sciences
Sandia National Laboratories • August 2003

A Monolithically Integrated MicroChemLab™ for Gas-Phase Chemical Analysis

Recent collaborations among SNL fabrication facilities have produced a monolithically integrated version of the MicroChemLab™ (Figure 1). The gas-phase MicroChemLab™ is a complete chemical analysis system that mimics a laboratory-scale chromatography instrument. Previous versions of this technology used three microfabricated components: membrane preconcentrators (PC), etched gas chromatography (GC) channels, and integrated surface acoustic wave (SAW) modules. The components were fluidically linked and integrated using macroscale technology. As a result of recent advances, the parts and all of their links can now be cofabricated on a single substrate (chip). The new chip contains a PC, one GC channel, and two magnetically actuated flexural plate wave (FPW) sensors. Gas dead volume between components, a potential degradation factor in the earlier MicroChemLab™, is significantly reduced in this new system.

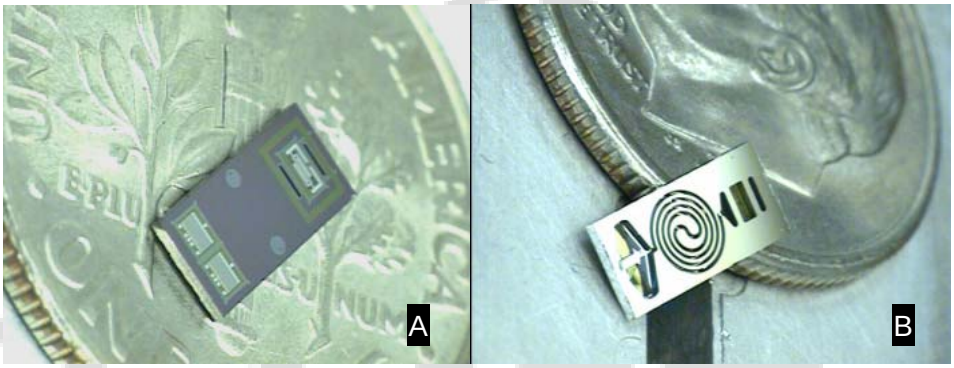

Figure 1. Monolithically integrated MicroChemLab™ on a US dime. (A) The front side is surface micromachined to create a preconcentrator, two gas chromatography coating ports, and the two flexural plate wave detectors. (B) The reverse side is Bosch etched to define release holes, the fluidic channels, and the spiral gas chromatographic column.

The monolithic version of the chip is fabricated entirely of silicon (rather than mixed and diverse materials), ensuring that standard SNL microelectronic and micromachining processes can be used. Microfabrication uses front-side micromachining to define the silicon-nitride membranes used for the PC and the two FPWs. This process also creates access ports for the GC channel, which must eventually be coated with a stationary phase. Back-side Bosch etching creates the spiral GC column and the fluidic links between the components and defines release holes for wet etching the sacrificial oxides to release the device membranes. The length of the GC column (Figure 2) was intentionally shortened to fit it on one module while allowing proof of concept of the fabrication methodology. A forthcoming design has a longer GC column, which is more suitable for field analysis.

Two SNL facilities collaborated to produce this system: front-end processing ocurred in the MESA Microelectronics Development Laboratory (MDL), and Bosch-etching was performed in the Compound Semiconductor Research Laboratory (CSRL) (future MESA MicroFab). This product is technologically important because it represents system integration and fabrication of macroscale modules on a single microscale substrate. It also demonstrates the cross-lab coordination that will occur in the future MESA complex. Production of this monolithically integrated MicroChemLab™ advances the concept of integrated microsystems.

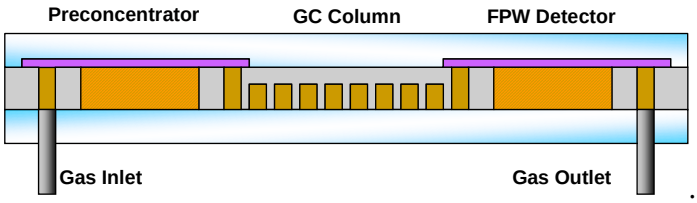

Figure 2. Schematic cross-section showing the three monolithically integrated components in a sealed package with gas inlet and outlet ports

For more information, contact: Ron Manginell, 505-845-8223, rpmangi@sandia.gov

Contributors include: Doug Adkins (1764), Richard Kottenstette (1764), Dave Wheeler (1764), Pat Lewis (1764), Joe Bauer (1764), Sara Sokolowski (1764), Rob Manley (RIT, 1764 student), Darin Graf (2614), Murat Okandan (1749), Sita Mani, (1749), Kent Schubert (1763), Randy Shul (1763), and Peggy Clews (1746).