# Design of a MEMS Gas Chromatograph

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*A miniaturized gas chromatography system was developed with all components fabricated with MEMS technology. The low weight of the system makes it well suited for space applications but also for other applications, such as food quality control and explosive detection.*

A miniaturized gas chromatography (GC) system is being developed that consists of a pre-concentrator, a separation column, and a thermal conductivity detector (TCD). All three elements are fabricated with MEMS technology, which enables batch fabrication with very small feature sizes. When combined with gas handling and a vacuum pump, this system can be used to detect and identify different compounds in gases.

The pre-concentrator is a small chamber that is filled with an absorbing material. During the absorption phase, the chamber is cooled with an external Thermo-Electric Cooler (TEC) to temperatures below ambient, thus facilitating the absorption of the different gas compounds. Once sufficient compounds have been absorbed, the absorbing material is heated through the direct heating of pillars that are placed at regular intervals in the chamber. The heating is very rapid, resulting in a sharp desorption peak of the absorbing material. Tenax® has been selected as the absorbing material, because of its good absorption characteristics and its widespread use in GC applications. Small chambers were made and filled with Tenax®, as shown in Figure 1. The white material in the left and right thirds of the chamber is Tenax®. The center of the chamber could not be filled due to the asymmetric placement of the relatively large access hole (encircled in red). A re-design of the pre-concentrator is currently underway to improve the Tenax® filling characteristics.

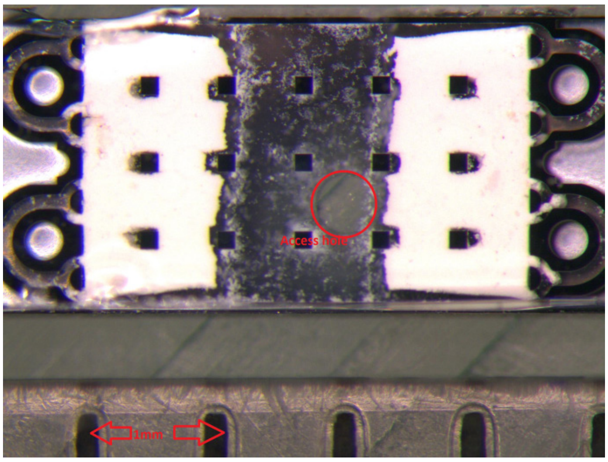


*Figure 1: A pre-concentrator chamber partially filled with Tenax® (white).*

The MEMS separation column was made by etching a long serpentine-shaped channel in silicon. A glass lid is anodically bonded to the silicon to form the column. The drawback of these columns so far, has been that it is very difficult to obtain a uniform coating of the stationary phase on the walls of these columns. The uniform thickness of the stationary phase is of paramount importance for the separation characteristics of the column. New techniques like Atomic Layer Deposition (ALD) and Molecular Vapor Deposition (MVD) allow the uniform coating of the columns, as they deposit the stationary phase one molecular layer at a time. The columns were fabricated, as depicted in Figure 2, and the deposition tests have begun.

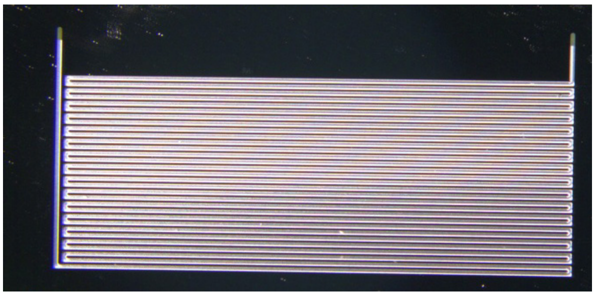

*Figure 2: Test column structures.*

The detection of the gases eluting from the column is done by a TCD. The TCD consists of four platinum resistors that are suspended two by two over two separate channels. A reference gas is led through one channel, and the gas eluting from the columns through the second channel. The temperature dependence of the platinum resistors is used to set their temperatures at a value slightly above the temperature of the gas. When particular compounds, having different thermal characteristics, elute from the column, the temperature of the resistors in that channel changes and, thus, so do their resistance values. This can be detected electrically by placing the four resistors in a Wheatstone bridge configuration.

The particularity of the TCD developed here is that it is designed to be flip-chip bonded to the end of the column, reducing the dead volume to an absolute minimum. As a result, there will be no peak broadening at the end of the columns. The fabrication of the TCD and its attachment to the columns is currently underway.

An easily overlooked aspect of the MEMS GC system is that it requires leak-tight gas connections of the silicon parts to conventional metal tubing. Therefore, multiple tests are underway to assure a reliable connection between silicon and the metal tubes. A first test result is shown in Figure 3, where a metal tube has successfully been inserted in a silicon chip.

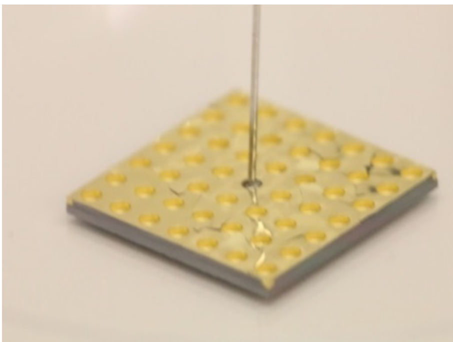

*Figure 3: A metal tube attached to a gold-covered silicon chip.*