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MICROREACTOR INTEGRATED ON SILICON FOR CATALYTIC APPLICATIONS

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Abstract

In the recent years, several applications have clearly demonstrate the interest to develop miniaturized analysis systems compared to the equipments used at the laboratory scale. The well known advantages of the microreactors can be resumed as follows: reduction of the dimensions, increase of the surface/volume ratio, a reduced volume of products inducing an improved safety.

In this context, we have developed a microreactor integrated on silicon for catalytic applications. The choice of silicon as base material allows not only a precise fabrication at a low cost with well controlled technological processes, but also a good thermal conductivity to favour the insertion of the heat control inside the microreactor.

The proposed microreactor is constituted of the stack of 3 x 3 cm² silicon platelets, each one including the reaction chambers that are defined by a network of parallel microchannels structured by deep reactive ion etching (DRIE) according to the Bosch process[®]. The principal advantages of this technique concern higher etching rates, the ability to achieve vertical sidewalls and high aspect ratio structures on silicon.

Each elementary platelet includes the fluidic connections towards the microchannels and the bordering platelets, these connections being structured by through silicon etching with DRIE. The precise micromachining of silicon induces an assembly without soldering, thus authorizing an easy replacement of the platelets, particularly for catalyst coating control.

Standard metallization technologies developed in microelectronics processes are used to deposit the catalyst on the platelets in a collective way. We tested the thermal evaporation of Platinum: the thin catalyst layer, of 1500Å thickness, is coated uniformly all over the micro channels walls, not necessitating specific semi-circular channels.

In the center of the stack we inserted a platelet containing metallic electrical resistances acting as heating source and thermal sensors, thus allowing the temperature control and monitoring of the whole microreactor. The result is an optimized control and thermal efficiency due to the proximity of the heating elements with the reaction chambers. An external housing is not necessary to provide a controlled thermal environment. The different resistances are made from Platinum deposit, the same material used for the catalyst.

The catalytic oxidation of volatile organic compounds (VOC) was investigated to demonstrate the potentialities of our silicon microreactor technology. The experimental results obtained for 200 x 200µm² microchannels have shown conversion rates around 95% for various species such Acetone and Methyl ethyl ketone at 300°C, and near 100% for Toluene at 250°C. It is interesting to note that in the case of Toluene conversion, the consumed power at 250°C is about 30W.