A Monolithic Microfabricated ElectroSpray Ionization Chip and Robotic Interface

Abstract:
To date, the main thrust of our project has been the development of a monolithic microfabricated microfluidic device which, when coupled to a mass spectrometer, enables rapid and precise automated infusion analyses for compounds of interest. We have successfully commercialized this device and its supporting robotic platform. This spring we have launched the next evolutionary step from our old NanoMate HD™ integrated robotic platform—the “Triversa NanoMate™”.

The major focus of chip research over the past year has been the continuing development of the ElectroSpray Ionization (ESI) chip fabrication process in a range dimensions to produce devices of ultra-low to high flow regimes for specific applications.

Summary:
The ESI-HD chip™ nozzle pictured in Figure 1 was fabricated from single crystal silicon using standard microfabrication techniques. Deep Reactive Ion Etching was used to create the nozzle feature and a channel through the wafer to a liquid reservoir etched into the backside of the wafer. The nozzles are etched in arrays on a 1.125 mm pitch. The ESI-HD chip™ provides a robust means of producing a nanoelectrospray that is controllable and provides highly reproducible results. Samples of interest can be directly infused via the Triversa NanoMate™ through the backside inlet and nanoelectrosprayed for immediate analysis. Sample cross contamination is eliminated by using a new pipette tip and nozzle for each sample. The Triversa NanoMate™ also brings the new capability of allowing the user to couple to a LC or nanoLC column and spray directly or to collect fractions of the LC effluent either online or offline whilst performing LC/MS.

New nozzle architectures and geometries have been developed in the past year to create devices specifically tailored to application. At one extreme are ultra-low flow devices which produce an electrospray that consumes on the order of 20 nanoliters of sample per minute; alternatively, we have also fabricated high flow “cannon” devices which can spray at up to 3.5 microliters of sample per minute. As well as nine other device iterations at intermediate flow rates between these two extremes.

The Triversa NanoMate™ and ESI-HD chip™ are interfaced with atmospheric pressure ionization mass spectrometers to provide molecular mass, structural information, and quantitative data for molecules of interest.

Applications for the ESI-chip™ include large scale pharmaceutical industry testing programs, proteomics, single nucleotide polymorphisms (SNPs), lipidomics, glycosylation studies and various small molecule qualitative and quantitative determinations.
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Figure 1: A packaged ESI-HD Chip™; 400 nozzles ready for use.

Figure 2: The Advion BioSystems, Inc. Triversa NanoMate™ integrated robotic platform.

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Figure 3: SEM of an ultra-low flow nozzle.

Figure 4: SEM of a high flow “cannon” nozzle.