Application for MEMS Design Scholarships at 2004

I am a full-time, second year PhD student at University of Alberta. I am working for Professor Jed Harrison. I'd like to be considered for a fellowship in the Bio MEMS category.

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Proposal

The rapid expansion of proteomics demands far more rapid, sophisticated and automated analysis of proteins. Microfluidics is being evaluated as a potentially useful method. We have proved that we can integrate protein separation, fractionation, digestion and peptides concentration on the same microfluidic chip, due to the miniaturization of chips. The separated peptides are then detected by Mass Spectrometer allowing the protein to be identified.

The integrated chip that we are designing is divided into four parts — the separation channel, fraction collector, digestion beds packed with trypsin beads and SPE beds packed with C18 beads for peptides concentration. In Figure 1, the proteins are first separated in the main channel by isoelectric focusing (IEF) according to their own pI points. Then, the protein zones are mobilized from the main channel to the branch channels. (Please double click the icon below Figure 1 for the cartoon of flow.) Then, the proteins are driven through the digestion beds and the concentration beds. Figure 1 shows a conceptual illustration of the device requirements, not specific designs we are currently developing.

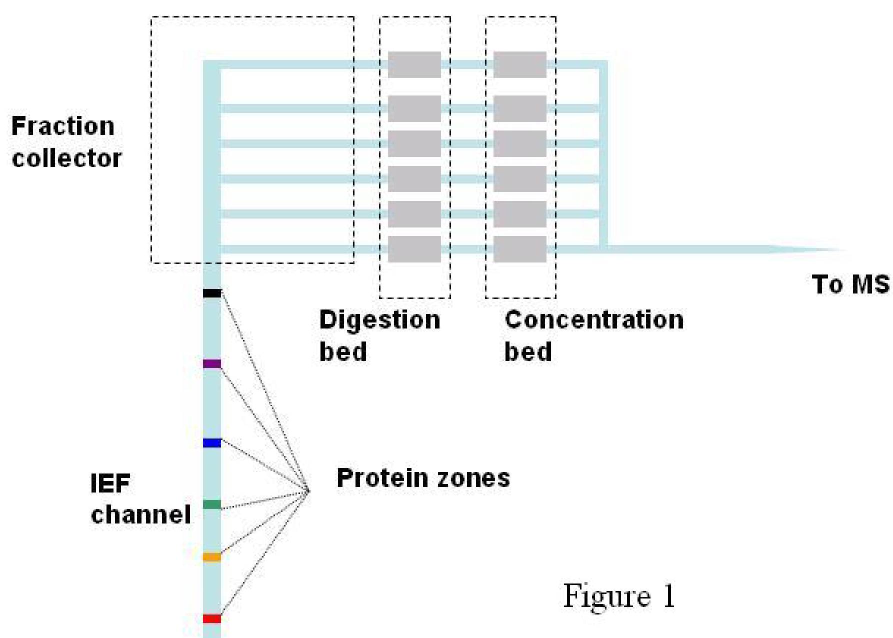

Figure 1

flow movie.avi

The biggest concerns regarding device design revolve around how to control the flow directions during all steps of the analysis. In order to let one protein zone go into one branch, we use electrokinetic force to direct the flow. Impedance modeling provides a first level of analysis, good to about 90 % accuracy. Even so, it is still hard to predict the flow direction, since there are so many crossing points, and secondary forces arising from pressure balancing terms become very important to the final outcome. Thus we need a tool to predict the flow direction as accurately as we can, because we can not afford to test different mask layouts again and again, using trial and error approaches. So far, we use Pspice software to simulate the current flow in microchannels by considering the channels as resistors. To a first approximation, current flow can then be correlated to fluid flow. But, there are two problems with this approach. First, if the dimension of the crossing point is not negligible compared with the channels, then, it is hard to evaluate the flow at the crossing point using a lumped element resistor model. Second, and most important, this simulation does not consider the flow resistance of channels, yet when the fluid is driven by electrokinetic force, both the electric and the flow resistance together decide the flow direction. CoventorWare 2004 is a well-known simulation software which is highly suitable for microfluidics. If we could use CoventorWare to give an accurate description of the flow in microchannels, then we could reduce the cost of masks, save experimental time, and establish the validity of modeling approaches to microfluidic chip design.

Your positive consideration of my application will be highly appreciated.