Using LIGA in fabrication of Microfluidic Device for Diagnostic Analysis of Human Body Fluid

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Currently a lot of research is being conducted in the area of non-invasive diagnostics [1]. Therefore, body fluids like saliva and sweat, the easily accessible non-controversial mediums have recently been the focal point of research on markers for health and disease monitoring in human beings [2]. The research conducted in this study focuses on LIGA (German acronym lithography, electroplating and molding)/ micro-electro-mechanical systems (MEMS) based solution for multiple ion measurement (marker for health/disease monitoring) from bodily fluids by providing a user friendly diagnostic chip and an instrument/reader for the convenient display of results. This work continues our research presented recently where we designed and fabricated a microfluidic polymeric chip (sweatstick) to collect 600 µl of human sweat that was analyzed to measure the Ca^{2+} ion content to diagnose bone mass loss [3]. However, this required processing by skilled personnel using conventional centrifuge separation and other analytical equipment in a laboratory setting. In order to overcome this limitation we developed a user-friendly BioMEMS analytical device capable of performing point-of-care, multiple diagnostic analysis of human body fluid collected using the sweatstick. This device uses the electronics and a microcontroller to run the analysis automatically and independent of skilled personnel.

The present devices' function is to perform a diagnostic analysis of Ca^{2+} and Cl^{-} ions content using the colorimetric assays for bone mineral density loss and cystic fibrosis, respectively [4-5]. The micro-controller and the electronics were built around a microfluidic chip with two analytical chambers measuring 2 x 2 x 60 mm that could test body fluid samples for any two analysis/ions simultaneously. The detection method being absorbance based, therefore a super-bright LED provided the light and a photodiode read the absorbance. The LED/photodiode pair is placed at the ends of the chambers. After sample collection and extraction, a measured amount of reagent and sample were mixed and transported to the analytical chambers by using off-chip solenoid type micropumps. The results for Ca^{2+} analysis obtained were linear and sensitive enough to make it a viable diagnostic device. However, in order to further reduce the error margins mainly caused by uncontrolled air bubble formation affecting the absorbance signal, a better pump concept (micropump/vacuum micropump combination) is designed. The dimensions of the analytical chamber causes the flow to be laminar thereby making it extremely difficult for on-chip mixing. Therefore, off-chip mixing was performed. The mixing channels (250 x 450 µm and 250 x 150 µm) are designed to facilitate on-chip mixing and further miniaturization of the device. The new disposable chip design also includes fixed housing for the photodiode/LED setup to make the device more robust with respect to consistent sensing of the colorimetric assay. The entire process will be controlled by a microcontroller along with performing the calculations and providing the results to the user.

References

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