

Microelectromechanical Systems for Thermal Characterization and Manipulation of Biomolecules

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Thermal effects are ubiquitous to biological processes. Microelectromechanical systems (MEMS) technology allows the integration of sensitive thermal detection and efficient thermal control with microfluidic manipulation, thereby enabling the interrogation of biomolecules in controlled microscale environments unattainable with conventional technologies. This presentation will highlight our efforts in applying MEMS technology to thermally based biomolecular characterization and manipulation.

We will discuss the application of MEMS technology to thermodynamic characterization of biomolecules, focusing on a miniaturized differential scanning calorimeter. The device consists of a pair of freestanding microfluidic chambers integrated with thermal sensing and control elements. Minute differential heat between the sample and buffer contained in the chambers is measured to assess the biochemical reaction, potentially with orders-of-magnitude smaller sample volumes when compared with conventional instruments. We will also present an investigation of microfluidic platforms for manipulating biomolecules using synthetic and bio-polymers that undergo strong temperature-induced, reversible conformational changes. For example, aptamers, or oligonucleotides with sequence-dependent shape to bind specifically to other molecules, can potentially enable efficient miniature extraction systems. This is demonstrated by capture of small-molecule analytes by aptamer-functionalized microbeads in a microfluidic chamber, analyte release and device regeneration by thermally induced, reversible breakage of analyte-aptamer binding, and detection of the released analyte by mass spectroscopy.