# Thermal Analysis of Sub-Nanoliter Liquid Samples for Bio-Sensing Applications

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The demand to develop microscale analytical tools for small-volume liquid samples is recently in rapid growth as the micro total analysis systems in the bioengineering applications require integration of multiple functionalities in a single device with a capability to analyze biochemical samples as small as picoliters in volume. Among various analytical tools, thermal analysis techniques are particularly promising since they are easy to miniaturize and acquire the output of the diagnostics results quantitatively. This work presents a thermal-analysis technique and a microfabricated device to characterize sub-nanoliter scale liquid samples using the 3-omega technique. The method enables simultaneous detection of the thermal conductivity and heat capacity of a liquid sample less than 1 nl in volume. The sensing device is composed of a PDMS microchannel and an Au thin film heater fabricated on a glass substrate. A data processing scheme is developed to compute the heat transfer in the device and determine the thermal properties of the sample from the acquired 3ω signal. Experiments using several standard liquids demonstrate that the thermal conductivity and heat capacity of a sub-nanoliter sample can be measured with a reasonable accuracy. It is evident that the proposed technique has a variety of potential applications in the bioengineering field, including biochemical sensors and the thermal cell cytometry, as well as in fundamental studies to measure the properties of a single cell.