# Printed-Wiring-Board Microfluidics for Thermal Management of Electronic Systems


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This work presents the use of organic multilayer lamination of epoxy-glass printed wiring board material to produce microfluidic structures, and the exploitation of these structures along with integrated drivers to produce a synthetic-jet-based integrated cooling solution for electronic systems. Thermal management of electronic systems becomes more complex as the density and compactness of the system increases. Traditional methods of cooling, such as fan/heat sink combinations, either become inadequate to remove the generated heat fluxes or are incompatible with compact, low-profile design. Recently, synthetic jets [1] have been suggested as alternatives to fans for cooling of electronic systems.

Synthetic jets are formed when a rigid-walled cavity is bounded on one side by a flexible membrane and on the other side by an orifice. Vibration of the membrane results in the alternating entrainment and expulsion of air into and out of the cavity through the orifice hole, resulting in a directional jet emitted from the orifice. Due to the small-scale vortical structures of the jet, enhanced heat transfer over that available from fans is possible. In addition to the higher heat transfer coefficients available from synthetic jets, they have the capability to be fabricated in a low-profile format.

This process has been combined with the synthetic jet to produce an active cooling substrate (Figure 2), in which the jet driver, ducting, and outlet ports for chip cooling are integrated into the thickness of the printed wiring board substrate (Figure 2). The electromagnetic actuator, which consists of a permanent magnet and a voice coil, is used to vibrate a laminated corrugated diaphragm. The driver is in fluidic communication with a duct and orifice outlet formed in the printed wiring board during lamination by the process described above. To form a thermal testbed, a microfabricated silicon heater/sensor chip [2] is integrated on the printed wiring board using standard packaging techniques.

A photomicrograph of the device integrated with the test silicon heater chip is shown in Figure 3 and the cooling performance is shown in Figure 4. The power consumed by jet is 0.06W, temperature reduction of the chip is about 30°C. The total heat flux removed by the embedded synthetic jet is 3.6W/cm$^2$. The cooling performance is three times better than that of a traditional fan. There is a trade-off between deflection and frequency of the corrugated diaphragms in order to obtain the best cooling performance of the synthetic jets.

References:


[1] Smith, B. L. and Glezer, A., "The Formation and Revolution of Synthetic Jets,", Phys. Fluids, vol. 10, p2281 (1998).

[2] Yoon, Y.K. and Allen, M.G., "An Integrated Pt Heater/Sensor Array for Microfluidic Assessment," Proc. ASME Winter Annual Meeting, New York, NY (2001)


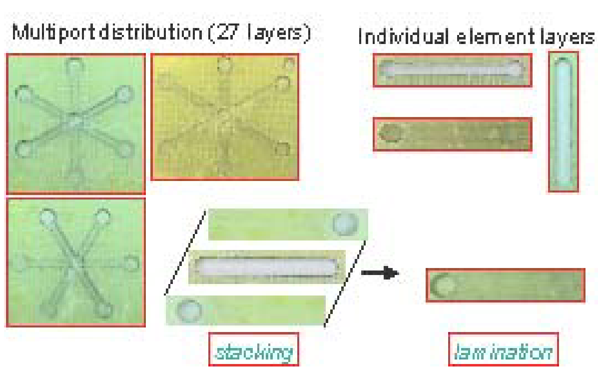


**Fig 1: Multilayer lamination process**

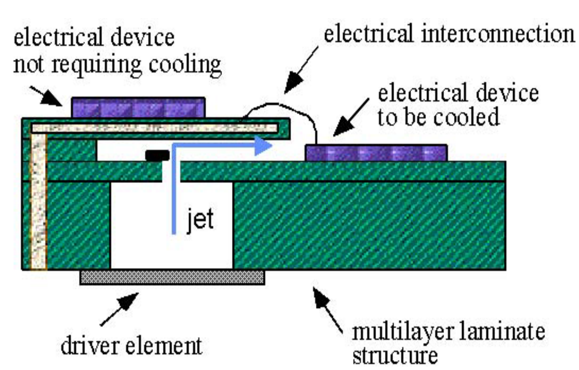


**Fig 2: Active cooling substrate**

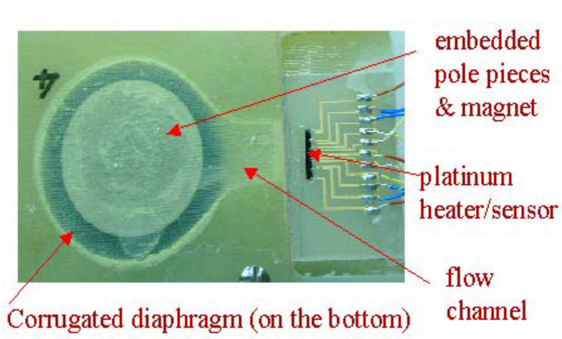


**Fig 3: Real device with silicon heater**

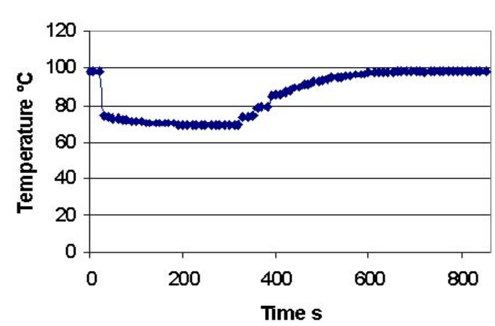


**Fig 4: Cooling performanc**