# Protecting the Habitat from Heating Effect of Integrated Circuits

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**ABSTRACT**
*Heating of integrated circuits (ICs) has become a big nuisance today in electronics world. Heat is an unavoidable by-product of operating electronics. Due to IC heat, reliability of integrated circuits decreases and parametric changes may occur in an electronic device and its components. Hazardous heat by ICs adversely affects the environment as it causes depletion of Ozone layer thus leading to global warming, skin cancer etc. Hence thermal management is essential. The cooling technique presented in this paper uses recently invented "digital microfluidic" platform.*

***Keywords***-Integrated circuits, electronics, reliability, global warming, thermal management and digital microfluidic.

## I INTRODUCTION

In technical world, electronic components consist of integrated circuits (ICs). Recently there has been a urge to monitor and control heat produced by ICs.Heat is anything but the unavoidable by-product in electronic equipments.Reliability of integrated circuits gets decreased due to heating of ICs as a result parametric changes may occur in the device[1].

Current flowing through active and passive components results in power dissipation and increased temperatures. The amount of power dissipated by a device is a function of [2]-

(a) Type of device
(b) Geometry
(c) The path from the device to the heat sink.

Power dissipation may occur in both active and passive devices. It is a function of the type of current that is received. This calls for effective thermal management of integrated circuits which will reduce the problems caused by IC heat to a considerable extent.

## II IC COOLING TECHNIQUES

Wide range of cooling techniques exist which helps in effectively cooling of integrated circuits as they have certain characteristics that are common to them.Basically,cooling techniques are categorized into following-

**(a) Passive Cooling Technique**- Passive cooling includes thermal conduction (e.g., pastes, metal lines, and vias), natural convection (e.g., finned heat sinks and ventilation slots), and radiation (e.g., coatings and paints). Heat pipes and thermosyphons also fall in the category of passive methods, but they offer higher performance [3].These devices have following advantages-

- Less cost.
- Simple in design.

**(b) Active Cooling Technique**- Active cooling requires input power, and includes methods that require external components such as in forced convection (e.g., fans and nozzles), pumped loops (e.g., heat exchangers and cold plates), and refrigerators (e.g., Peltier/thermoelectric and vapor-compression based) [3]

## III CURRENT METHODS FOR IC COOLING

Generally there are five cooling techniques used to tackle hazardous heating of integrated circuits (ICs).These are-

- Heat-sink-fan (HSF)-based cooling
- Macro fluidic-based cooing
- MEMS-based cooling
- Refrigeration cooling
- Microfluidic-based cooling

**(a) Heat-sink-fan (HSF)**-This type of cooling uses heat spreader and forced-convection methods. It is one of the mostcommonly used cooling techniquesthatisin use over the past years. Fan-based cooling technique is widely used in laptops. Due to its use in laptops, the amount of heat given off into the environment is reduced considerably. Thus it efficiently protects human being from hazardous diseases that are caused due to adverse dangers on environment like-depletion of Ozone layer, global warming, etc.

**(b) Macro fluidic-based cooling**- This involves methods pertaining to liquid cooling at macro scale. They are of two types-

(i) **Direct cooling-**It consist of a pool of inert dielectric liquid in which immersion of electronic chip occurs.
(ii) **Indirect cooling**-They are mainly concerned with two-phase flow.

**(c) MEMS-based cooling**- It has complex structures and made are by micro fabrication methods. Thus, this design promotes dissipation of heat and conduction.

**(d) Refrigeration-based cooling systems-** Integrated circuits (ICs) are cooled using refrigeration-based cooling systems, such as vapor compression, gas compression, or thermoelectric devices. They generate a sub-zero effective thermal resistance. This helps in avoiding global warming because of IC heat. To chip package, evaporator is connected whose contact temperature is lower than cooling temperature of air.

**(e) Microfluidics based cooling**-It operates on the premise of pushing small volumes of liquids (less than microliter volumes) across the surface of an IC in order to conduct and dissipate heat away downstream. Originally introduced in the 1980's, microfluidic handling technologies quickly faced limitations and was unable to be realized in a practical commercial system [3].Harmful UV rays are not able to penetrate the earth's environment thus the efficiency of this cooling method is good.

## IV ADAPTIVE COOLING OF INTEGRATED CIRCUITS USING DIGITAL MICROFLUIDICS

We attempt to address these architectural and implementation issues by proposing an alternative approach to microfluidic cooling. We begin by first outlining the requirements for a viable reconfigurable IC-level cooling device. Based on these requirements, we propose a novel cooling method using a microfluidic technology called "digital microfluidics", which helps to safeguard the environment from the heat generated by integrated circuits (ICs).

As feature sizes decrease and operating frequencies interconnect resistance, and package densities continue to increase, ICs are quickly reaching temperatures that will render current package-level cooling techniques inadequate [4].

**(a) Requirements for Adaptive cooling**- In an attempt to provide safety to environment from hazardous integrated circuits (ICs) heat adaptive cooling is done at architectural as well as implementation level.

- **Requirements at architectural level -** The requirements are-
  (i) System should have a mechanism to transfer and remove heat efficiently.
  (ii) System should be a closed loop.
  (iii) Some cooling devices require a replenishable source.
- **Requirements at implementation level-** The requirements are following-
  (i) System should have an easily integral control mechanism.
  (ii) System should be self-regulating.
  (iii) System should easily interface with the IC.
  (iv) In the event that the primary cooling method fails, the system should revert to a backup cooling mechanism.

**(b) Digital Microfluidics**- We refer to this approach as "digital microfluidics," as it is analogous to the design techniques in digital microelectronics. Digital microfluidic platform is amenable to both hot-spot cooling and IC-level integration. A micro-pump utilizes the phenomenon of electrowetting. The surface energy in electrowetting is directly modified by application of an electric field.Due to decrease in electric field, contact angle decreases. This causes droplet to spread or effectively wet the surface.

Large number of discrete droplets can be independently programmed and reprogrammed to address the changing thermal profiles in an IC.The division of liquids into independently controlled packets of liquid for manipulation is done.

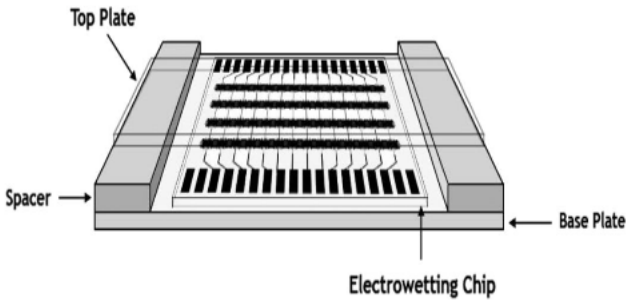


**Fig.1 Schematic of an assembled digital microfluidic electrowetting chip[3].**

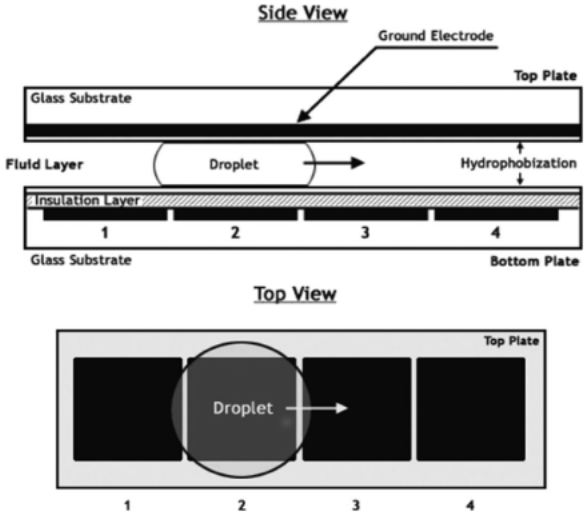


**Fig.2 Schematic side and top views of the electro wetting chip.**

**(c) Advantages Over Existing Techniques**

- Microfluidic operations can be reduced to a set of basic discrete operations.
- Absence of permanently etched structures allows for a completely reconfigurable system.
- Given a 2-D array of actuating electrodes, liquid droplets can be manipulated laterally in any arbitrary path without the need for external pumps and valves.
- Liquid flow has been shown to inherently increase with increasing temperature.

## V CONCLUSION

We have presented a promising IC cooling technique based on a recently invented "digital microfluidic" platform which utilizes electrowetting phenomenon. Thus the cooling technique presented here reduces the IC heat which helps to safeguard environment.

## REFERENCES

[1] Philip Y. Paik, Vamsee K. Pamula, and KrishnenduChakrabarty,"*Adaptive Cooling of Integrated Circuits Using Digital Microfluidics", IEEE Transactions on very large scale integration (VLSI) systems, Vol. 16, No. 4, April 2008.*

[2] M. G. Pollack, R. B. Fair, and A. D. Shenderov, "*Electrowetting-based actuation of liquid droplets for microfluidic applications," Appl. Phys. Lett., vol. 77, pp. 1725–1726, 2000.*

[3] M. G. Pollack, A. D. Shenderov, and R. B. Fair, "*Electrowetting-based actuation of liquid droplets for microfluidic applications," Lab on a Chip, vol. 2, pp. 96–101, 2002.*

[4] E. G. Colgan, B. Furman, M. Gaynes, W. Graham, N. LaBianca, J. H.Magerlein, R. J. Polastre, and M. B. Rothwell, *"A practical implementation of silicon microchannel coolers for high power chips," in Proc.21stIEEE Semi-thermSymp,pp. 1–7, 2005.*