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# Simulation of Electronics Cooling Deploying Water-Zinc Oxide Nanofluid

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***Abstract*: Research work involves mass, momentum as well as energy balances for computing electronics cooling level. 2D computational model of integrated circuit segment is established for examining thermal issues by means of water-zinc oxide (ZnO) nanofluid coolant. Computational modeling encompasses other significant terms such as inertia, viscidness, gravity in addition to thermal buoyancy influences in spite of common concerns vis-à-vis present somatic problem. However, this model oversees both compressibility as well as viscous dissipation paraphernalia. Computational model is excellently established for the same with integrated circuit segment heat transfer/area of 70 W/cm$^2$ other than thermophysical properties of nanoparticle in addition to model data as vivacious considerations. Finally, the model outcomes are also alongside the expected lines. For comparison a pilot scale experimental preparation is underway due to nonexistence of related model in the texts. This is perceived that water-zinc oxide (ZnO) nanofluid gives proper cooling without any thermal disaster by keeping integrated circuit segment temperature pretty below safety bound.***

***Index Terms*: Integrated circuit, Computational, Cooling, Water-zinc oxide (ZnO), Nanofluid.**

## I. INTRODUCTION

Miniaturization of electronic gadgets causes increase in heat flux involvement. That is why, nanofluid coolant is very much necessary as air cooling is not enough to serve the purpose. Several methodologies aimed at thermal management of electronics are very pleasantly described in literature [1]. Computational modeling in the company of simulation rehearses are pronounced decoratively in texts [2-11]. Acute reviews for diverse electronics cooling performances are superbly pronounced [12].

Over the last few decades, electronics cooling have played key role to keep apparatuses temperature at desired level for fulfilling role as well as reliability of devices. Because of rise in device operation, the dimension of devices upturn from interconnects to server farm creating higher heat production rate as illustrated in the fig. 1. The intensified heat flux at all spots from chip to farm postures key cooling tasks.

Since the quoted investigations, to the researcher's understanding, this is pragmatic that no such computational modeling are carried out about influences of water-zinc oxide (ZnO) nanofluid on thermal issues of integrated circuit segments. Using this stance, the current article establishes computational examinations of the same. In addition, the computational modeling comprises other important terms such as inertia, viscidness, gravity as well as thermal buoyancy influences despite common concerns relating to current somatic problem. But, this model overlooks both compressibility as well as viscous dissipation paraphernalia. Computational model is superbly developed for the same using integrated circuit segment heat flux other than thermophysical properties of nanoparticle as well as model data as vital considerations. Eventually, the model predictions are also alongside the expected lines.

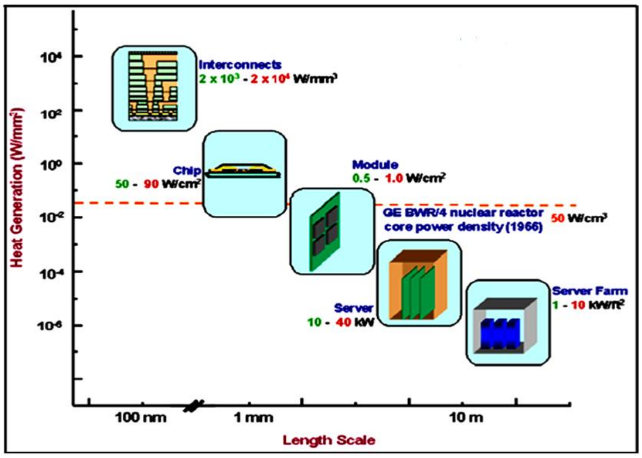


**Fig. 1. Sequential development of electronics mechanisms**

## II. SOMATIC PROBLEM DEFINITION

Spick-and-span illustration of a usual integrated circuit segment representing the bottom edge of square formed cavity is presented in fig. 2. This one depicts the whole heat transmission from integrated circuit segment retained flat at bottom of square formed cavity. Water-zinc oxide (ZnO) is introduced as coolant in present examinations. X-Y plane model is used for saving work out period through snubbing side paraphernalia in crosswise path. Computations take account of thermal resilience, viscidness accompanied by gravity influence on top. Fluid movement is taken as laminar as well as incompressible. Atmospheric alongside no slip edge circumstance is quantified at faces. Thermal management of the integrated circuit segment pertains to convective edge situation through heat transfer rate/area at bottom edge.

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Simulation involves whole temperature distinction within square cavity caused by heat transmission. Thermo-physical characteristics of related nanoparticle alongside supplementary system information, are mentioned in table 1 as well.

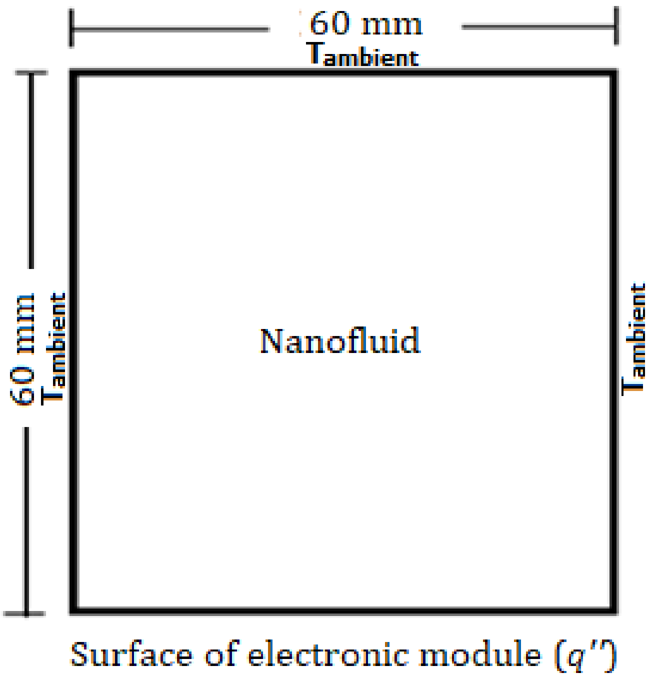


**Fig. 2. Graphical representation of integrated circuit computational field**

**Table 1.** Thermophysical properties of nanoparticle and model data

| **Nanoparticle Properties** | **ZnO** |
|---|---|
| Density, $\rho$ (Kg/m$^3$) | 5605 |
| Specific heat, $C_P$ (J/kg.K) | 668 |
| Thermal conductivity, $k$ (W/m.K) | 12.8 |
| **Model Data** | **Values** |
| Cavity size | 60 mm |
| Integrated circuit size | 60 mm |
| Atmospheric temperature | 300 K |
| Integrated circuit heat transfer rate/area | 70 W/cm$^2$ |

## III. NUMERICAL FORMULATION

Prevailing topic is thrashed with current numerical methods vis-à-vis modeling as well as simulation. Concerned mass, momentum as well as energy equivalences in x-y plane are noticeable in parities from (1) to (3), in that order. Compressibility plus viscous dissipation impacts are overlooked at existing stage. Instead, the thermal buoyancy factor (represented by $\rho g\beta\Delta T$) is incorporated in y-momentum balance (2b).

Continuity: $\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} = 0$ (1)

X-momentum:

$$\rho\left(\frac{\partial u}{\partial t} + u\frac{\partial u}{\partial x} + v\frac{\partial v}{\partial y}\right) = -\frac{\partial P}{\partial x} + \mu\left(\frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2}\right) \quad (2a)$$

Y-momentum:

$$\rho\left(\frac{\partial v}{\partial t} + u\frac{\partial v}{\partial x} + v\frac{\partial v}{\partial y}\right) = -\frac{\partial P}{\partial y} + \mu\left(\frac{\partial^2 v}{\partial x^2} + \frac{\partial^2 v}{\partial y^2}\right) + \rho g\beta\Delta T \quad (2b)$$

Energy:

$$\left(\frac{\partial T}{\partial t} + u\frac{\partial T}{\partial x} + v\frac{\partial T}{\partial y}\right) = \alpha\left(\frac{\partial^2 T}{\partial x^2} + \frac{\partial^2 T}{\partial y^2}\right) \quad (3)$$

## IV. NUMERICAL TECHNIQUES

### A. Computational Scheme as well as Algorithm

Aforementioned prevalent equalities are changed to ample formulation given below.

$$\frac{\partial}{\partial t}(\rho\varphi) + \nabla.(\rho\mathbf{u}\varphi) = \nabla.(\Gamma\nabla u) + S \quad (4)$$

Changed prevalent equalities are discretized by dint of upwind technique using pressure involved FVM using SIMPLER procedure, while, symbols got normal connotations.

### B. Grid, Interval as well as Convergence Trials

Outcome of GI test discloses 60 × 60 similar grids for eventual computation. Correspondingly, gap intended for computation is $10^{-4}$ s. Besides, more refined grid assembly certainly unaltered results profoundly. In addition, more refined grid implicates more computation time. Convergence is complete as soon as $\left|\frac{\varphi - \varphi_{old}}{\varphi_{max}}\right| \leq 10^{-4}$ is held good for every variable, while, symbols got normal connotations.

## V. RESULT AND DISCUSSIONS

Mathematical computations are carried out to examine the influences of water-zinc oxide (ZnO) nanofluid on thermal management of electronics gadgets. The investigations pertain to computational predictions of temperature contour as well as temperature field within the stated water-zinc oxide (ZnO) nanofluid flow domain in addition to fluid-solid interface temperature of integrated circuit segment. At the outset, the square compartment-like computational domain of dimension 60 mm is considered. In addition, the heat transfer/area of 70 W/cm$^2$ concomitant with the present integrated circuit segment is considered.

**Influence of Water-Zinc Oxide (ZnO) Nanofluid Coolant**

With the intention of investigating the influence of water-zinc oxide (ZnO) nanofluid on integrated circuit cooling, the present physical model is simulated computationally through making an allowance for thermophysical properties as well as model data pertaining to the existing circumstances.

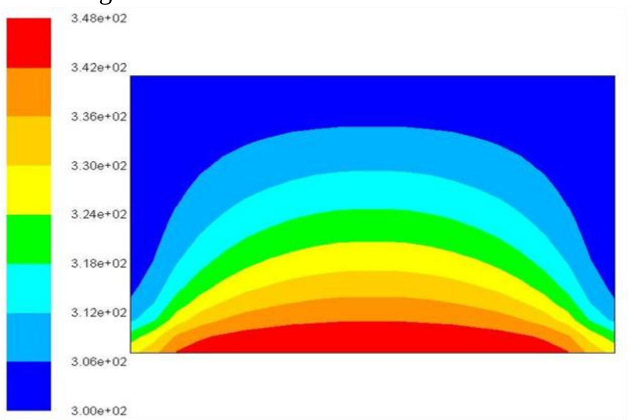


**Fig. 3. Temperature field with water-zinc oxode (ZnO) nanofluid**

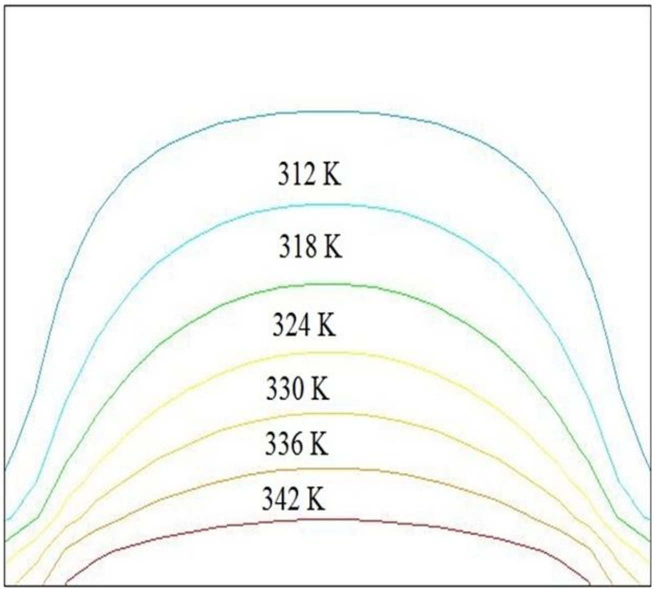


**Fig. 4. Temperature contour with water-zinc oxode (ZnO) nanofluid**

Fig. 3 demonstrates the computational prediction of temperature field in the company of colored gauge bar showing the temperature standards through K, witnessed at the itemized model circumstances taking into account the water-zinc oxide (ZnO) nanofluid for thermal management. The fluid-solid interface temperature of integrated circuit segment is observed as 348 K that is pretty below the dangerous boundary of 356 K temperature preferred with the intention of circumventing thermal catastrophe of electronics gadget. True to form, the temperature of water-zinc oxide (ZnO) nanofluid is highest adjoining to the neighborhood of integrated circuit segment. In addition, the temperature of water-zinc oxide (ZnO) nanofluid progressively shrinkages with upsurge in remoteness from integrated circuit segment and thereafter this turn out to be ambient temperature in the extreme field regime. The related colored temperature contour is presented in fig. 4 as well. Here too, the nature of computational observations are alongside the lines of anticipations.

## VI. CONCLUSION

Two dimensional computational model of integrated circuit segment is developed for investigating thermal issues using water-zinc oxide (ZnO) nanofluid coolant. Computational modeling comprises other important terms such as inertia, viscidness, gravity as well as thermal buoyancy influences despite common concerns relating to current somatic problem. But, this model overlooks both compressibility as well as viscous dissipation paraphernalia. Computational model is superbly developed for the same using integrated circuit segment heat transfer/area of 70 $W/cm^2$ other than thermophysical properties of nanoparticle as well as model data as vital considerations. Eventually, the model predictions are also alongside the expected lines. For assessment a pilot scale experimental arrangement is underway owing to nonexistence of similar model in the texts. This is witnessed that water-zinc oxide (ZnO) nanofluid provides suitable cooling without any thermal catastrophe by retaining integrated circuit segment temperature far behind safety limit.

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