CFD Simulation on IC Thermal Cooling through Water Involved TiO_2, AlN and CuO Nanofluids

N. K. Kund

Abstract*: *In persevering courteousness, CFD codes got developed and run with water based TiO_2, AlN and CuO nanofluids to envision the thermal alarms of ICs. The convective governing equalities of mass, force and drive are computed for envisaging the thermal issues of ICs. The time pace selected throughout the intact computation is 0.0001 s. The soundings affect CFD forecasts of temperature curve, temperature arena plus fluid-solid boundary temperature of IC. Corresponding fluid-solid boundaries temperatures of IC are viewed as 351, 312 and 338 K for water based TiO_2, AlN and CuO nanofluids, respectively. The temperature of water-AlN nanofluid stands peak contiguous to the IC locality as it stands far less than the chancy temperature limit of 356 K. Further, the temperature of water-AlN nanofluid gently drops with improvement in aloofness from IC. Afterwards, this becomes surrounding temperature in the distant arena precinct. The analogous tinted temperature curve stands accessible. In addition, the congruent plot of temperature verses distance from IC stays publicized. The apprehension of CFD lenient stand adjacent to the facilities of expressions.

Index Terms*: *CFD Codes, Thermal Control, TiO_2, AlN and CuO Nanofluids.

I. INTRODUCTION

A report of tall heat tolerances in various devices from interconnects to server remain hardened in figure 1. Electronics thermal control caught numerous routines for illustration.The standard thermal control arrayed heretofore for instance, atmospheric convection is inappropriate for extreme thermal flux treatments. In the preceding years the strange way of thermal control has compelled the researchers for the exasperating of nanofluid heat control.

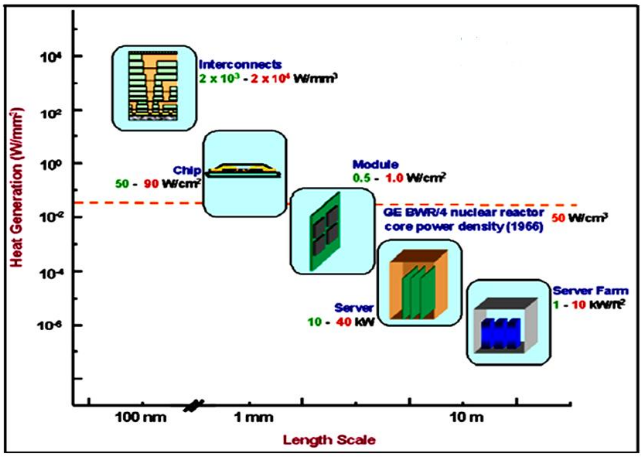

Figure 1. Progressive evolution of electronic devices

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N. K. Kund, Department of Production Engineering, Veer Surendra Sai University of Technology, Burla (Sambalpur), Odisha, India.

The nanofluid heat control is undeniably strong as ambient thermal control is poor to deliver the drive as well. Numerical and experimental reviews on heat spreading over rectangular domain are existent in texts [1-7]. Computational and experimental work with solidification remain noticeable as well [8-20].

Nevertheless of the proofs that the nanofluid cooling equivocates the issues about the extreme heat battle as to ambient thermal control and hence, the treatment of nanofluid remains the significant drive of the extant exploration. Here, the thermal control of electronics through water based TiO_2, AlN and CuO nanofluids remain snitched numerically.

II. DEPICTION OF PHYSICAL CHALLENGE

Figure 2 demonstrates the physical issue vis-à-vis the heat evolution from integrated circuit (IC) indicating the foot edge. Rest three edges are signposted through ambient situations. Here, the thermal controls of electronics is done through water based TiO_2, AlN and CuO nanofluids. Besides, the thermophysical and model data of nanoparticles reflected in the existent analysis plus the ambient situation involved in the current path simulations, are amalgamated in Table 1.

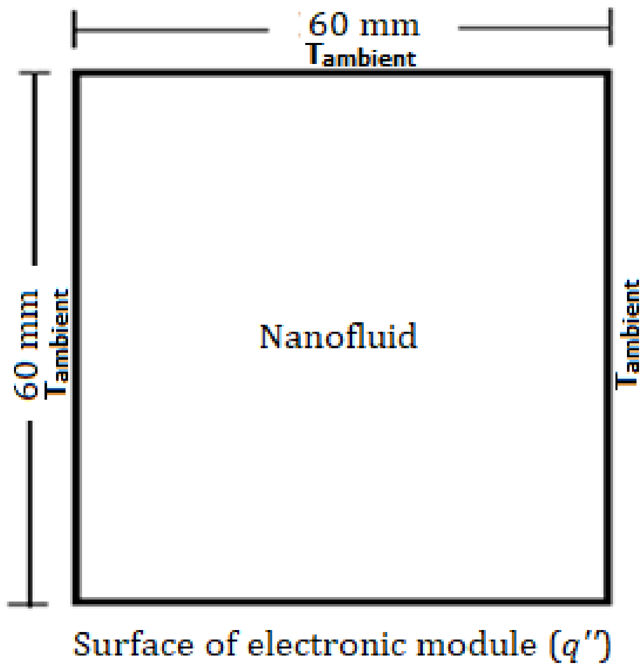

Figure 2. Illustrative sketch of IC computational zone

Table 1. Thermophysical properties and model data.

Nanoparticle Properties	TiO_2	AlN	CuO
Density, ρ (Kg/m^3)	4176	3261	6316
Specific heat, C_P (J/kg.K)	693	741	533
Heat conductivity, k (W/m.K)	9	286	34
Model Data	**Values**		
Cavity size	60 mm		
IC size	60 mm		
Ambient temperature	300 K		
IC heat transfer rate/area	70 W/cm^2		

III. COMPUTATIONAL PRACTICE

As putative overhead, the figure 2 issues the CFD workbench aimed at computing the physical topic course. To facilitate the CFD forecasts the binding stages such as constructing geometry and purview, meshing and initialization are followed to run the simulation. Here, the prevailing equalities (as termed below through equalities 1-4) of mass, force and drive beside the edge states are chosen. Linearized equalities are computed through the CFD codes. After the development of computations, CFD codes form the shapes and curls through that numerous graphs stand strained to amalgam the CFD forecasts through the prognoses. With the later dispensation the forecasts are scrupulously explored intended for accepting overgenerous permeations.

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

X-momentum:

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

Y-momentum:

$$\rho\left(\frac{\partial v}{\partial t}+u\frac{\partial v}{\partial x}+v\frac{\partial v}{\partial y}\right)=-\frac{\partial P}{\partial y}+\mu\left(\frac{\partial^2 v}{\partial x^2}+\frac{\partial^2 v}{\partial y^2}\right)+\rho g\beta\Delta T \qquad (3)$$

Energy:

$$\left(\frac{\partial T}{\partial t}+u\frac{\partial T}{\partial x}+v\frac{\partial T}{\partial y}\right)=\alpha\left(\frac{\partial^2 T}{\partial x^2}+\frac{\partial^2 T}{\partial y^2}\right) \qquad (4)$$

In the synchronous analysis, CFD codes remain developed and executed with water based TiO_2, AlN and CuO nanofluids to visualize the thermal concerns of ICs. The convective governing equalities of mass, force and drive are computed for envisaging the thermal issues of ICs. The time step chosen all over the whole computation is 0.0001 s.

IV. RESULTS AND DISCUSSION

CFD codes are developed and accomplished with water based TiO_2, AlN and CuO nanofluids. It envisages the impacts on thermal control of ICs. The soundings affect CFD forecasts of temperature fields, temperature contours and fluid-solid boundaries temperatures of ICs.

Effect of Water-TiO_2 Nanofluid on IC Thermal Cooling

Figure 3 bares the CFD ridge of temperature field besides the tinted measuring scale screening the temperature values over K. It stands viewed at the documented archetype statuses bearing in mind the water-TiO_2 nanofluid for IC thermal control. The fluid-solid boundary temperature of IC is viewed as 351 K. This stands far less than the chancy limit of 356 K temperature wished for the objective of outwitting thermal cataclysm of IC. The temperature of water-TiO_2 nanofluid looks maximum close to the IC vicinity.

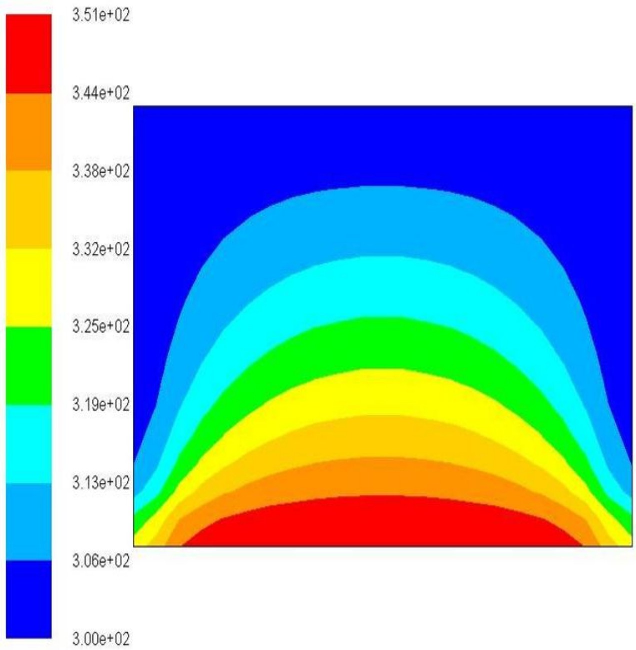

Figure 3. Temperature field with water-TiO_2 nanofluid

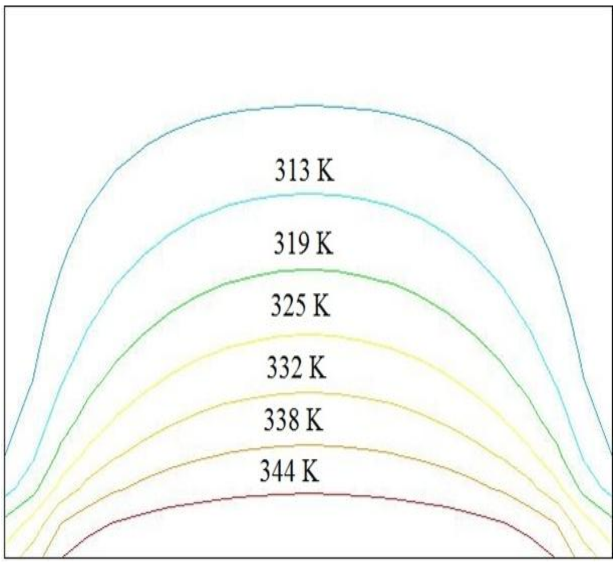

Figure 4. Temperature contour with water-TiO_2 nanofluid

Also, the temperature of water-TiO_2 nanofluid smoothly drops with improvement in aloofness from IC. Afterwards, this becomes surrounding temperature in the aloof arena precinct. The equivalent tinted temperature contour remains available in figure 4 as well.

Effect of Water-AlN Nanofluid on IC Thermal Cooling

Figure 5 bares the CFD ridge of temperature field besides the tinted measuring scale screening the temperature values over K. It stands viewed at the documented archetype statuses bearing in mind the water-AlN nanofluid for IC thermal control. The fluid-solid boundary temperature of IC is viewed as 312 K. This stands far less than the chancy limit of 356 K temperature wished for the objective of outsmarting heat commotion of IC.

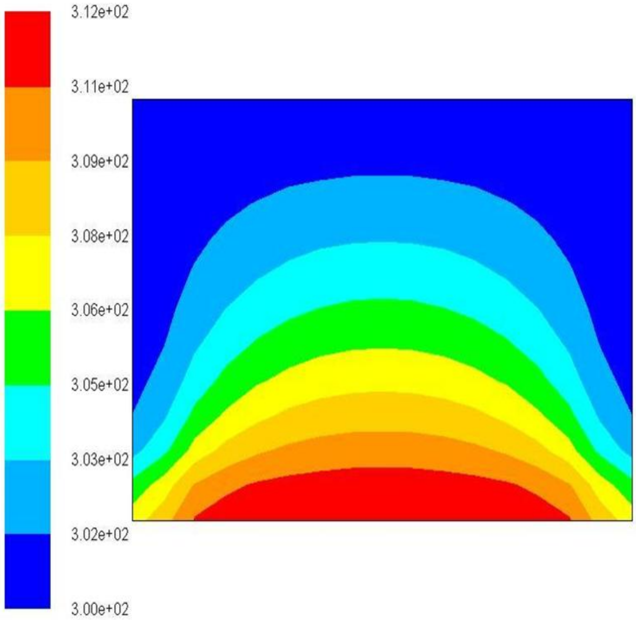

Figure 5. Temperature field with water-AlN nanofluid

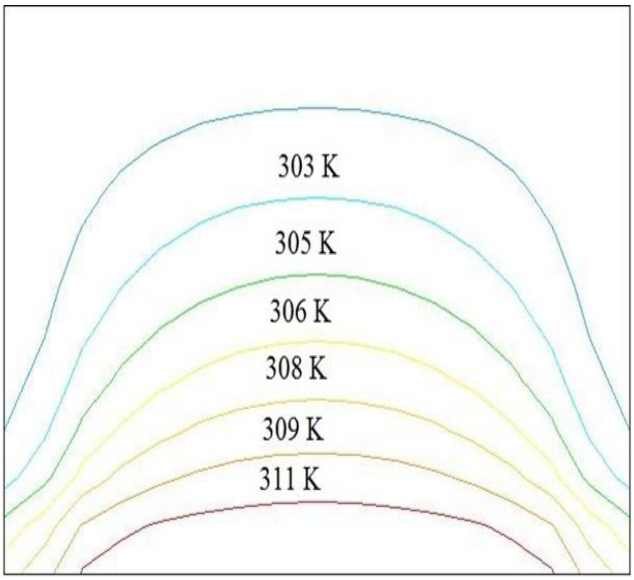

Figure 6. Temperature contour with water-AlN nanofluid

The temperature of water-AlN nanofluid becomes extreme neighboring to the IC vicinity. Further, the temperature of water-AlN nanofluid gently drops with improvement in aloofness from IC. Afterwards, this becomes surrounding temperature in the aloof arena precinct. The equivalent tinted temperature contour remains available in figure 6 as well.

Effect of Water-CuO Nanofluid on IC Thermal Cooling

Figure 7 bares the CFD prediction of temperature field besides the tinted measuring scale screening the temperature values over K.

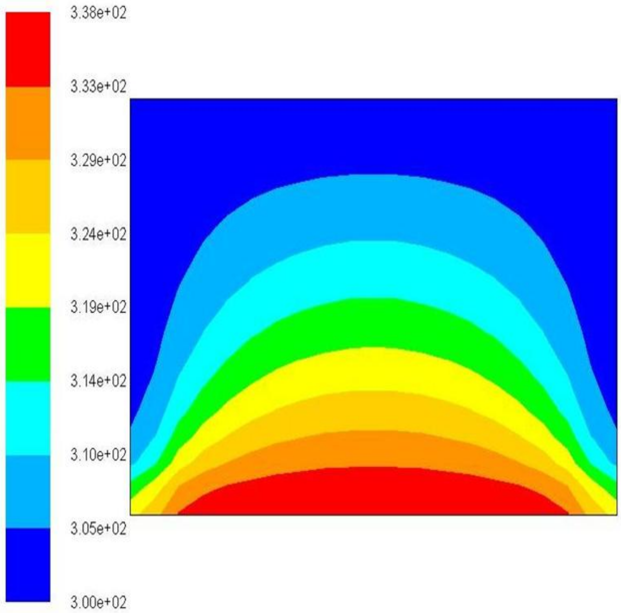

Figure 7. Temperature field with water-CuO nanofluid

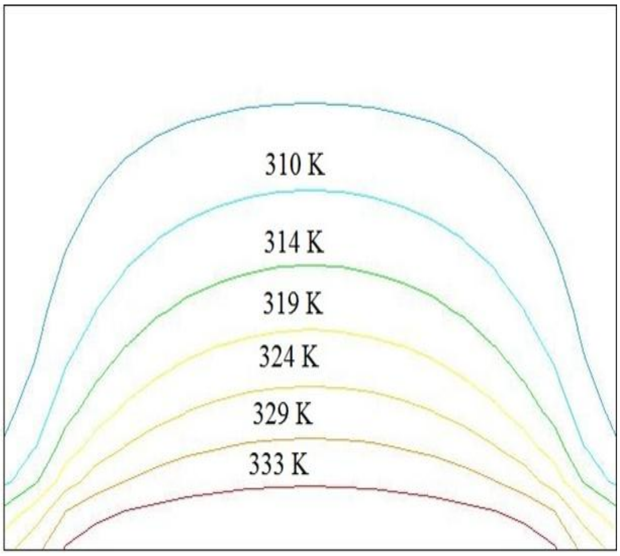

Figure 8. Temperature contour with water-CuO nanofluid

It retains realistic at the anticipatable core prominences bearing in mind the water-CuO nanofluid for IC thermal control. The fluid-solid boundary temperature of IC is viewed as 338 K.

This stands far less than the chancy limit of 356 K temperature wished for the objective of outwitting thermal cataclysm of IC. Tritely, the temperature of water-CuO nanofluid stands peak contiguous to the IC locality. Further, the temperature of water-CuO nanofluid gently drops with improvement in aloofness from IC. Afterwards, this becomes surrounding temperature in the distant arena precinct. The consistent tinted temperature plot stays accessible in figure 8.

Table 2 summarizes the fluid-solid boundaries temperatures of ICs witnessed with water based TiO_2, AlN and CuO nanofluids. Though the trends of fields/contours results are similar, however, the discrepancies are owing to the variations in the thermophysical properties of the related nanoparticles as agglomerated in table 1. Figure 9 displays the equivalent plot of IC temperature verses nanofluid.

Table 2. Summary of IC temperatures along with nanofluids.

Nanofluid	IC Temperature (K)
Water-TiO_2	351
Water-AlN	312
Water-CuO	338

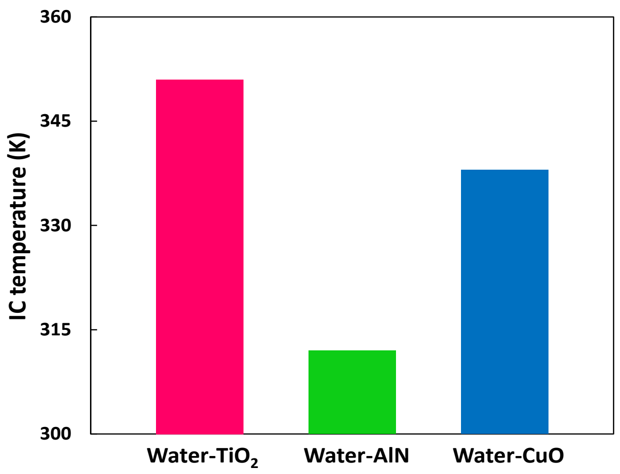

Figure 9. IC temperature vs. nanofluid

V. CONCLUSION

In steadfast empathies, CFD codes are developed and deployed with water based TiO_2, AlN and CuO nanofluids to envision the thermal alarms of ICs. The convective governing equalities of mass, force and drive are computed for envisaging the thermal issues of ICs. The time pace selected throughout the intact computation is 0.0001 s. The soundings affect CFD forecasts of temperature field, temperature contour and fluid-solid boundary temperature of IC. Corresponding fluid-solid boundaries temperatures of IC are viewed as 351, 312 and 338 K for water based TiO_2, AlN and CuO nanofluids, respectively. The temperature of water-AlN nanofluid remains top neighboring to the IC neighborhood, nonetheless, it stands pretty below the dangerous temperature limit of 356 K. Additionally, the temperature of water-AlN nanofluid gently drops with improvement in aloofness from IC. Afterwards, this becomes surrounding temperature in the distant arena precinct. The analogous tinted temperature curve stands accessible. Besides, the harmonizing graph of temperature against distance from IC stays exposed. The development of CFD analysis stand in common with the perceptions of performances.

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AUTHORS PROFILE

Dr. N. K. Kund has obtained both M.Tech. & Ph.D. in Mechanical Engineering from Indian Institute of Science Bangalore. He has also obtained B.Tech.(Hons) in Mechanical Engineering from IGIT Sarang, Utkal University Bhubaneswar. He has published several research papers in international journals and also guided many research scholars, besides, wide teaching and research experience. He is presently working as Associate Professor in the Department of Production Engineering, VSSUT Burla (A Government Technical University).