Efficient Heat Management Technique for Electronic Display Device

Prof. Dr. Deepak Gupta[1] and Utkarsh Shukla[*2]
[1,2]Dept. of Materials and Metallurgical Engineering, IIT Kanpur

Introduction

One of the major challenges faced by the semiconductor industry is that electronic circuits produce a lot of heat energy during their operation. And with the current scenario where the gates are packed so much close together, then the problem of heat generation has become extremely significant. So we are working towards the efficient heat management and dissipation solution for the heat generated in electronic devices. We were working on Organic Display Devices. (Fig. 1) shows the top view of the display which consists of vertical aluminum and horizontal chromium stripes in different layers. The light emitting organic material is placed in the middle layer at the cross points of the lines thus acting as a pixel. The heat is generated primarily in the organic material. Also some amount of heat is generated in the metal stripes due to the movement of electrons or current through them but that is quite negligible. The whole setup had to be enclosed within a glass cavity, to prevent the oxidation of the organic material, which created more problems for use of air as cooling media. The proposed solution to the problem is adding oil in the cavity, which will help in convection transfer of the oil from the heat generating area due to fluid thermal interaction, hence helps in dissipating heat. Also metallic fins of high thermal conductivity were embedded in the glass which have a large surface area outside the cavity, and they help in the exchange of the heat from the fluid to the external surface.

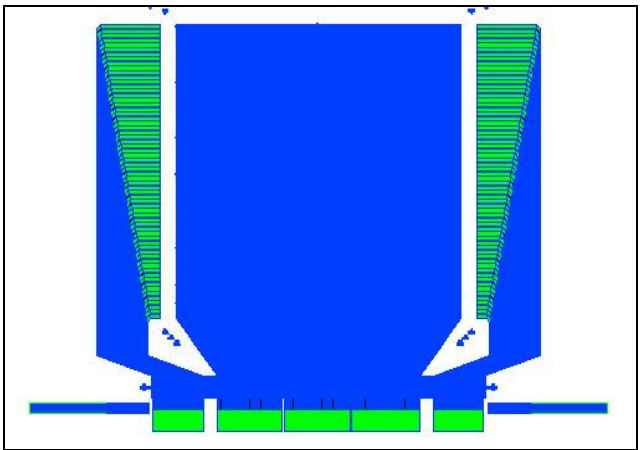

Figure 1: A schematic of the display electronics circuit The blue portion has fine vertical aluminum lines and yellow and green lines are horizontal chromium lines

Use of COMSOL Multiphysics

COMSOL was used to simulate the process. The original problem had a much bigger domain and the mesh generated was too large in size and since the main goal of the simulation was to compare different heat management techniques so a representative problem was constructed with less no of pixel where a pixel (consisting of a organic display segment, horizontal aluminum strip below and vertical Chromium below). COMSOL Thermal Fluid Interaction module was used. It was a three dimensional simulation with transient heat transfer from the organic material to the Aluminum material, Chromium material and to the oil and then solving the Navier Stokes Equation for the fluid where the driving force is the density difference due to the temperature difference, and then the interaction of the oil with the metallic fins present at a distance (they cannot be in contact with the heat source) and then the heat is conducted to the atmosphere where the heat is radiated.

Expected Results

The result currently obtained shows that the heat is not well conducted to the oil medium. The heat flux through the aluminum is more than that of chromium and some amount of heat is conducted from the metal to the oil. So some forced convection needs to be set up for the convective heat transfer through oil, for which we are trying to use Nano particles or some other technology for setting up forced convection and also increasing thermal conductivity.

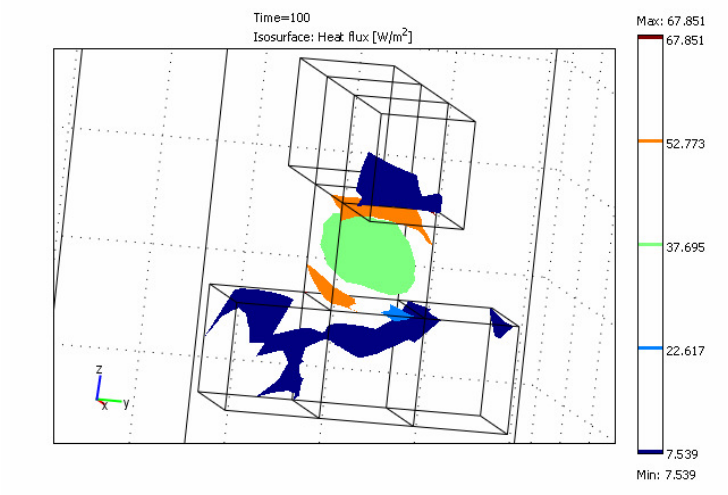

Figure 2. Result: A very basic figure where the lower three cubes are of aluminum and the top three were of Chromium. The central part is composed of the organic material which gives the light and is the heat source. This set corresponds to one pixel displayed on the screen.

Conclusion

Currently we did the simulation with thermal fluid interaction of oil with the heat generating material, conduction and convection of the oil inside the cavity due to temperature difference, the interaction of the fluid with the fins and then the radiation and convection the fins in the external atmosphere. The current results show that the amount of heat generated by the heated medium is not effectively conducted and convected by the oil, so we are planning to add Nano-particles in oil as they will increases the surface area and hence increase the conductivity of the liquid media and also we are testing different fluids as an alternative to oil. We are also trying to use some technology to create turbulence in the fluid which will help by increasing the convective heat transfer from the heat source. This could be by using ionic Nano Particles and an ionic plates or some other technology. We are currently testing upon those technologies, and will finish simulating such ideas soon.