Electromagnetic-Thermal Modeling of System-in-Package using One Parallel Computing Infrastructure

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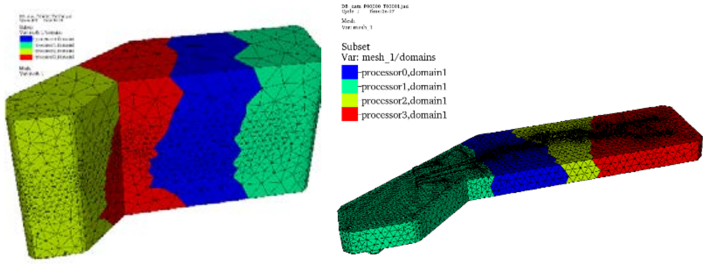
Multifunctional integration and miniaturization are the developing directions of modern electronic like System-in-Package(SiP). With the lower voltage of active devices and high-density passives devices, SiPs are extremely susceptible to multiphysics effects induced by electromagnetic pulse. However, traditional modeling based on circuit simulation cannot adequately handle the effects like parasitic, cross-talk and temperature rise, where full-wave simulations become emerging techniques. Numerical full-wave methods and their parallel algorithms are investigated to conduct electromagnetic simulations of SiPs, such as finite element method(FEM) and finite difference time domain(FDTD) method. Besides, downscaling of mesh size and high simulation frequency always leads to large-scale complex discrete systems. Parallel simulations of multiphysics effects of RF devices have been investigated using frequency-domain methods[1].

In this work, we proposed an electromagnetic-thermal coupling simulation method and highlights of this method can be concluded: 1)Multiphysics effects are simulated using time-domain method and different grids are used for different physics. 2) An efficient parallel interpolation algorithm between different physics associated with different grids are investigated. Our code are implemented based on an in-house parallel infrastructure JAUMIN. Figure 1 shows the grid for electromagnetic and thermal parallel simulations. Figure 2 shows the temperature rise of SiP at the site of current injection. The time step of electromagnetic simulation deviates severely from that of thermal simulation. Thus, joule heat accumulated in $\Delta t_t = 1.0e-6$ are calculated as thermal source. 4 CPU cores are launched both for the simulation of electromagnetic field and thermal field.

	Number of grids	Number of Cores	Central frequency	Time step (second)	Total time （second）	Peak current input
electromagnetic	180,000	4 CPU core	100.0 MHz	2.0e-10	1.0e-5	370A
Thermal	340,000	4 CPU core	-	2.0e-7	1.0e-5	



(a) (b)

Figure 1 Grid for (a) electromagnetic simulation and (b) thermal simulation, patches with different colors are assigned to different processes

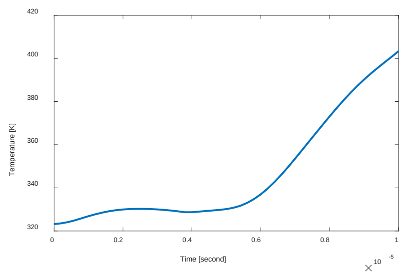


Figure 2 Temperature rise of SiP at the site of current injection

1. H. X. Zhang, Q. E. Zhan, L. Huang, et al., “A Scalable HPC-based Domain Decomposition Method for Multiphysics Modeling of RF Devices,” *IEEE Transactions on Components, Packaging and Manufacturing Technology*, **11**, 12, pp. 2158-2170, 2021, doi: 10.1109/TCPMT.2021.3121540.