System and Package-Level EMI Shielding Effectiveness Analysis for AR/VR Devices

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***Abstract*—Conformal metal sputtering on package mold compound provides an alternative to meet package and system electromagnetic interference (EMI) and RF interference (RFI) requirements without sacrificing product form factors. However available coating thickness and material options on the industry semiconductor assembly and test (OSTA) market is limited and inadequate. An EM-circuit co-simulation method was developed for conformal shielding effectiveness (SE) analysis for augmented and virtual reality (AR/VR) applications. SE results of various coating thickness and materials are presented to show the custom needs for thicker Cu coating and high permeability coating materials such as Ni.**

I. INTRODUCTION

AR/VR devices demand hyper level of system integration and miniaturization to meet the ergonomic and socially acceptable appearance requirements. Unique signal integrity, power integrity, EMI and RFI challenges come with the territory. This paper focuses on a unique EMC challenge where conventional shield cans in larger consumer electronic devices are no longer applicable due to height, real estate and/or weight constraints. Furthermore, EMI and RFI intensify in such systems due to proximity between high-speed digital circuits, sensors and RF components. Conformal coating on mold compound offers new possibilities for package design to improve features such as heat sink capability, 3D-circuit patterning and EMI shielding [1]. Cu sputtering coating is one of the most readily available option by OSTA vendors. However, thin coating thickness requirement and Cu-only material option limit SE in the low frequency range. Magnetic interference from clock sources is one of the challenging problems AR/VR system designers are facing. This paper studies the thickness and material permeability impacts on SE in a representative AR/VR system.

II. METHODOLOGY

An application processor (AP) of an AR prototype device was used to study the near field and sputtering coating SE. Package substrate, mold compound, BGA, C4 bumps and sputtering coating were included in the modeling process. Scattering parameters of two clock nets: a 38.4MHz single ended clock and a 100MHz differential clock were extracted by 3D full-wave EM solver. Their corresponding transient waveforms and spectrum were simulated in a circuit simulator and pushed back to the 3D solver as field EMI excitations, the simulation flow is shown in Fig.1. A confined region with boundary conditions that are conformal to the package surfaces was picked to eliminate field leakage from the bottom and side of the package substrate. As a result, sole sputtering SE can be calculated from the near field distribution changes. Coating thickness, material permeability and frequency dependencies of SE were analyzed with this methodology, and they are summarized in the results section.

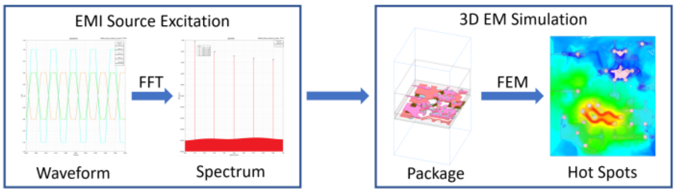

Fig. 1. Near field scan and push-excitation based SE simulation flow

III. RESULTS AND DISCUSSION

Magnetic field strengths of both the simulated clocks are significant and are comparable to the noise source spectrum of a LPDDR4 DRAM system [2], as shown in Fig.2. In addition, results in Fig.2 emphasizes the challenge of using thin Cu shielding to isolate magnetic field at low frequencies. Fig.2 and Fig. 3 confirm that thicker coating and Ni are both effective and necessary to isolate the magnetic field emission. It is desirable for the OSTAs to explore options such as thicker metal plating with adhesion promoter and adding ferromagnetic material alloy to their offerings for the next wave of AR/VR devices. Measurements are planned and will be underway in the next few months.

	0um	6um	10um	15um	20um
H (mA/m)	190	10	6.3	2.1	0.6
H (dBA/m)	-14.4	-40	-44	-53	-64.4
SE (dB)	0	25.5	29.6	38.6	50

Fig. 2. 38.4MHz clock induced magnetic field strength and SE

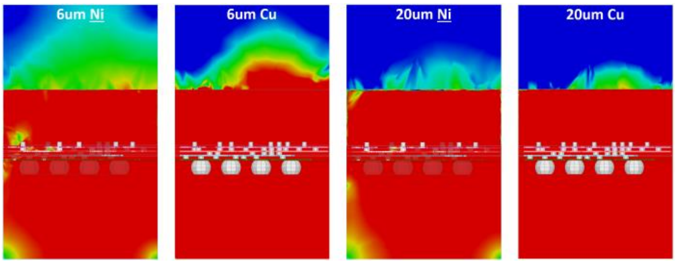

Fig. 3. Shielding thickness and material impacts on near field and SE

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