Modeling of Randomly Rough Surface Effects on Absorptions by Conductors at Microwave Frequencies

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Methods for modeling the impact of randomly rough conductor surface on the power absorption by conductors of high-speed interconnects are presented. The roughness of the interface, especially in microelectronic packaging based on organic materials, is often used to facilitate the adherence of the copper structures to the dielectric layers. Since the speed of interconnects is rapidly increasing to the multi-GHz region, the propagation and radiation at the shorter wavelength can cause the roughness of the surface to have significant effects on signal integrity. Existing commercial software tools do not allow users to model the surface roughness of the substrates accurately. There only exist simple empirical models with limited or unknown validity.

We model the effects of a random rough surface on the absorption by a metallic surface at microwave frequencies using 2-D and 3-D small perturbation methods. The results depend on the characteristics of rough surfaces: the RMS height, correlation length and correlation function. We further show the similarity with and differences from Morgan's classical result. The power absorption by a metallic surface is quantified through the development of the solution of electromagnetic fields on the rough dielectric-metal interface. The analysis leads to the extraction of frequency-dependent power attenuation for each given metal roughness profile.

We demonstrate the method for random Gaussian and exponential rough surfaces. We also extract the rough surface profiles from real measured surface data on PCBs and packages. Results are illustrated for the frequencies of interest that extend up to 50 GHz. Statistical results are further obtained from Monte-Carlo simulations. The roughness profiles are up to 4 microns in RMS height with correlation lengths 0.3 to 3 times the RMS heights.