Abstract—The aim of this research is to study and simulate the theoretical designing of a radial superlattice structure that is used in reducing RF loss under high frequency operation. Some critical design parameters, including the numbers of layers, thickness ratio of each material and the exact dimensions of CRS (cylindrical radial superlattice) conductor will be studied and testified during the simulation process. Finally, a possible fabricated structure is expected to be manufactured by the end of this project.

I. INTRODUCTION

With an increasing demand for high-speed systems, the operation frequency of the integrated circuits has boosted in the past decade, reaching an average at 3GHz. Meanwhile, the undesirable conduction loss at radio frequency (RF) also grew as the skin effect generated by nearby conductors has raised. To suppress the loss at this targeted frequency, a radial superlattice structure was purposed for its better performance in forcing the current to flow inside the volume of the conductor rather than the edges[1]. Ideally, a proper positioning of the multiple layers of ferromagnetic (Ni80Fe20 and FeCo)/non-ferromagnetic(Cu) metals used in the structure would reduce the permeability of the ferromagnetic material close to zero, thereby causing the eddy current canceling effect[2]. In this case, the skin depth and the effective area would both be enlarged; the alternating current flow would be more uniform. Thus the focus of this research will be the simulation on superlattice interconnects structures to evaluate and examine the most effective scheme.

II. BACKGROUND

In a high frequency operating environment, the ohmic loss of conductor is largely governed by the following equation, where the skin depth increases as the material’s conductivity($\sigma$) and permeability($\mu$) decreases[1].

$$\delta = \sqrt{\frac{2}{\sigma \mu \omega}}$$  

Thus, in order to maximize the skin depth, the permeability inside the conductor should be minimized to a value close to zero. This can be achieved by juxtaposing multi-layers of ferromagnetic and non-ferromagnetic materials. The current in each layer would run in opposing directions relative to its neighbor, which eventually causes the eddy current canceling effect inside the conductor, reducing the total permeability to its lowest possible value.

III. PROGRESS

All reference paper for [2] and additional tutorials on HFSS software was studied for the purpose of designing a schematic structure of superlattice. At this point, several basic structures like planar and cylindrical shaped materials were already modeled and got their electromagnetic analysis done. Meanwhile training for cleanroom access is also in progress, including attending the lectures for metrology, etching, lithography and deposition.
IV. Future Work

As described, the final superlattice structure should show up to 100% reduction of the conductor loss in the simulation and experiment. Particularly, when selected materials are used as respectively for low and high frequency operation, both of them should demonstrate lower resistances comparing to the value from the solid Cu core. In the HFSS modeling and simulation, a fabricated structure according to the calculated dimensions should exhibit a measurement that matches the computer simulation results.

References
