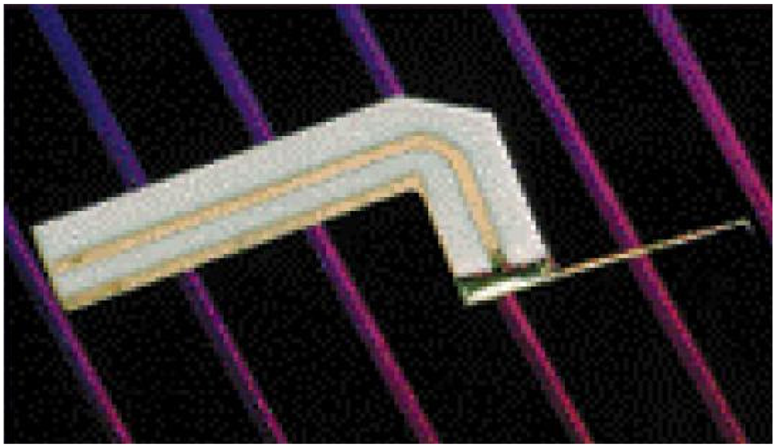
Introduction:

The importance of wafer probing as a tool to lower the cost of test in the manufacturing process has grown dramatically in recent years due to the emergence of advanced device technologies and the increased need for higher productivity and process automation. Nowadays the design of probe cards with Ceramic blade has increased to a greater level because of their performance while using in Giga Hertz applications. Though these blades use Ceramic as dielectric material which has high Er than other normally used materials, they deliver better performance while working in Giga Hertz range because of their reduced dielectric loss. In the document below we are going to analyze a ceramic blade with the given dimensions, measure both insertion and return losses and optimize it using Zeland IE3D, a full-wave Electromagnetic simulator to deliver expected results.

Ceramic Blade:

The Ceramic Blade to be analyzed is assumed to operate for frequencies of up to 3 GHz. Below are the parameters of the Blade:

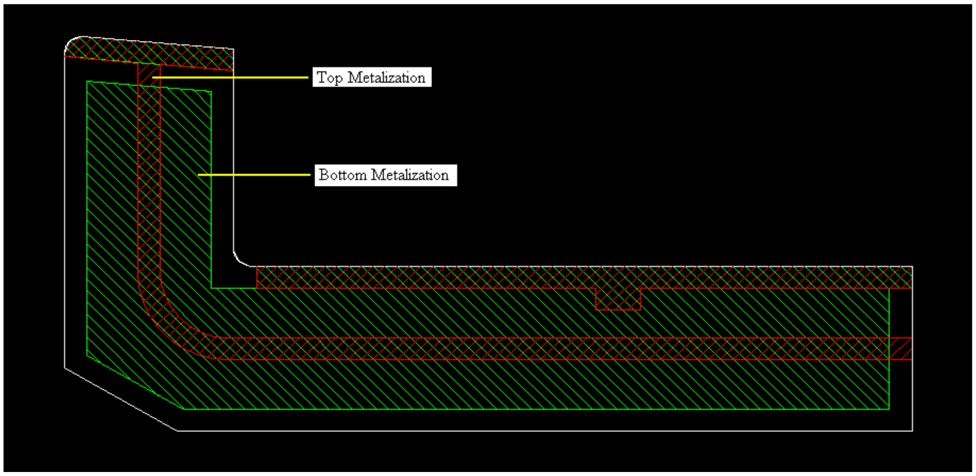
Conducting Material	–	Moly-Manganese
Dielectric Material	–	Aluminium oxide (Al_2O_3)
Plating Material	–	Nickel & Gold
Metallization Thickness including Plating	–	0.5 Mils
Dielectric Thickness	–	14 Mils
Dielectric Constant (Er)	–	9.2
Dielectric Loss Tangent	–	0.0003
Conducting Path Width	–	20 Mils



Snapshot of a Sample Ceramic Blade

Design of the Blade Structure in 2-D Environment:

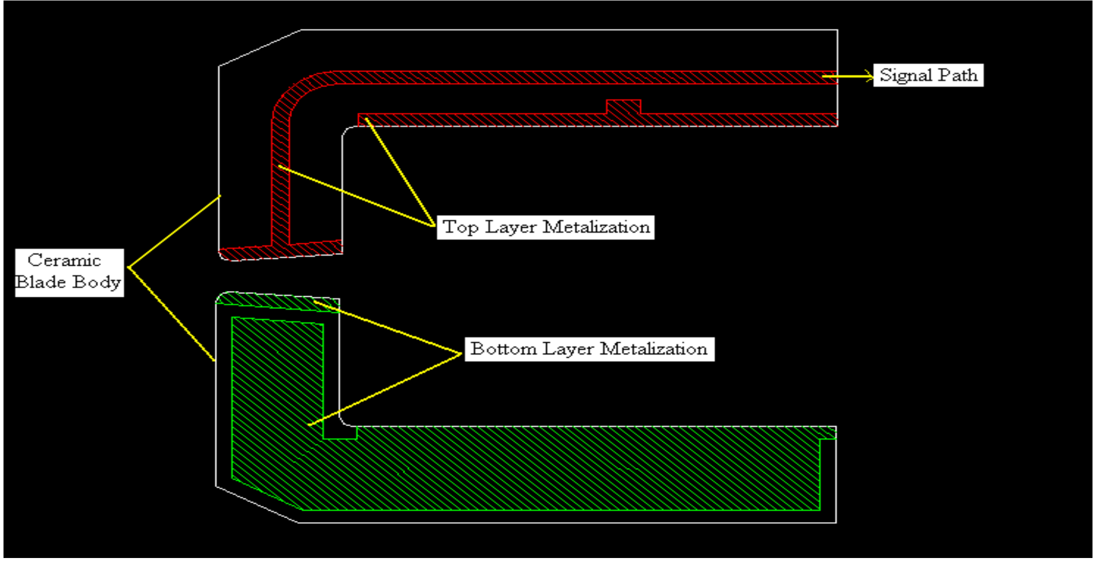
The blade to be analyzed has been designed and constructed in 2-D design software for the ease of importing it into IE3D. The blade designed in 2-D environment is shown below:



Snapshot of the structure in 2-D design environment

The above figure shows the exact structure of the ceramic blade and the metal pouring is indicated as Top and Bottom Metalization. Since the design is in 2-D environment it's not possible to view the dielectric part (ceramic) and the actual projections in the design.

The below figure shows the Ceramic blade 2-D structure with its top and bottom layers split for ease of viewing:



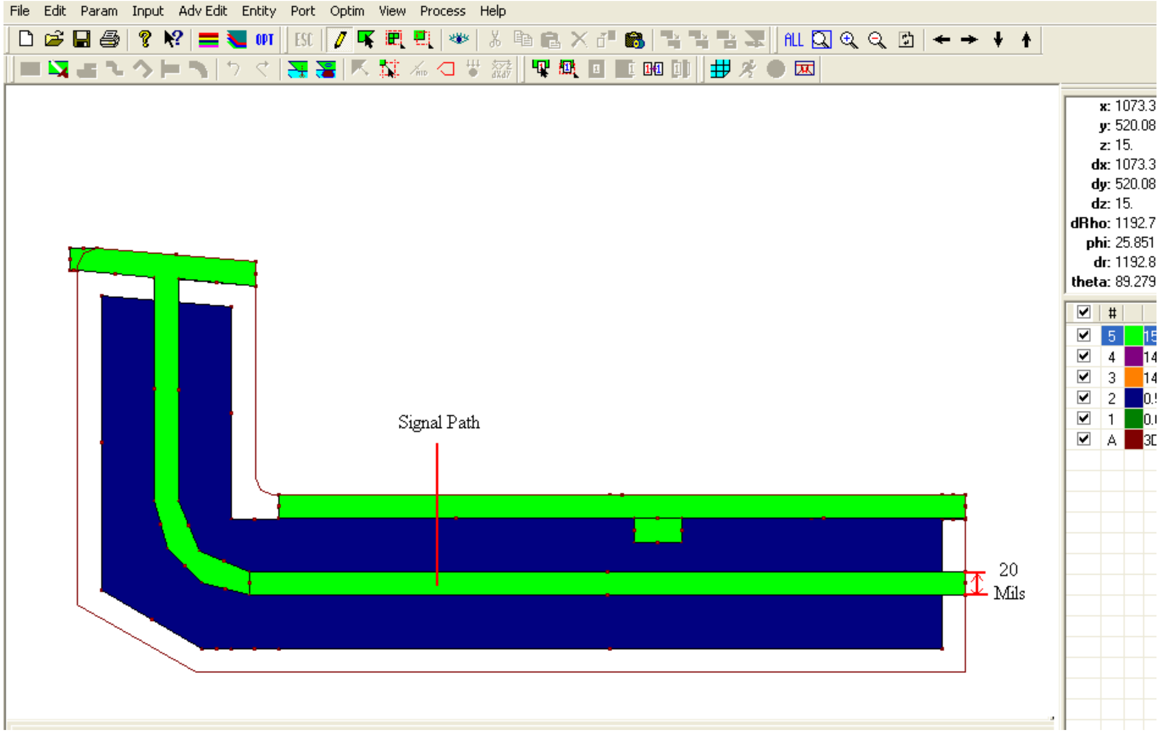
Snapshot of Split view of the Blade Structure

Simulation of Ceramic Blade using IE3D:

The main aim behind this analysis & simulation is to construct an optimized structure from the given blade structure, meaning the expected insertion and return loss are achieved for better performance at the GHz ranges. The loss introduced by ceramic blade to the system obeys the interconnect loss budget, when it meets the basic requirement of insertion loss (S21) is greater than -0.3 dB and return loss (S11) less than -18 dB. Measurement of loss parameters of 3-D structures can be carried out using efficient & user-friendly software, IE3D. IE3D is a full-wave, method-of-moments (MoM) based electromagnetic simulator for analyzing and optimizing planar and 3-D structures. IE3D is accurate and efficient because of its approach towards S parameter generation using different port schemes for different applications and moreover capable of producing reliable results, a basic parameter to cut the time & cost.

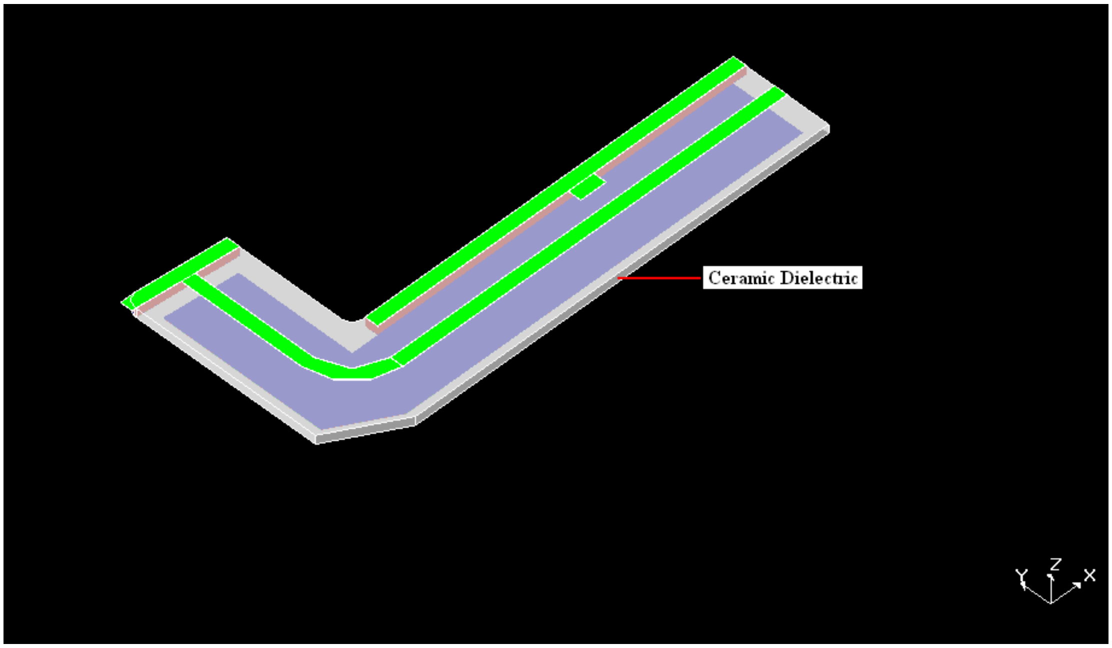
IE3D allows import and export of 2-D structures and other geometry files in an easier manner. The above structure is imported in the IE3D software (MGrid) for performing 3-D simulation. The basic parameters like dielectric height, dielectric constant and metal strip types were defined appropriately to replicate the actual ceramic blade in 3-dimension.

Below figure shows the MGrid Layout Editor window with the blade structure imported from 2-D tool:



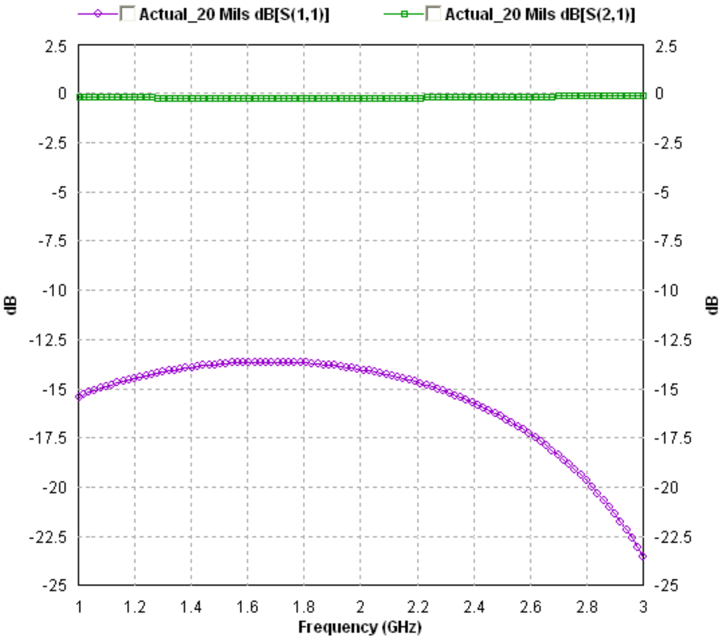
x: 1073.3
y: 520.08
z: 15.
dx: 1073.3
dy: 520.08
dz: 15.
dRho: 1192.7
phi: 25.851
dr: 1192.8
theta: 89.279

Snapshot of Blade structure in MGrid Layout Editor



Snapshot of Ceramic Structure in 3-D View

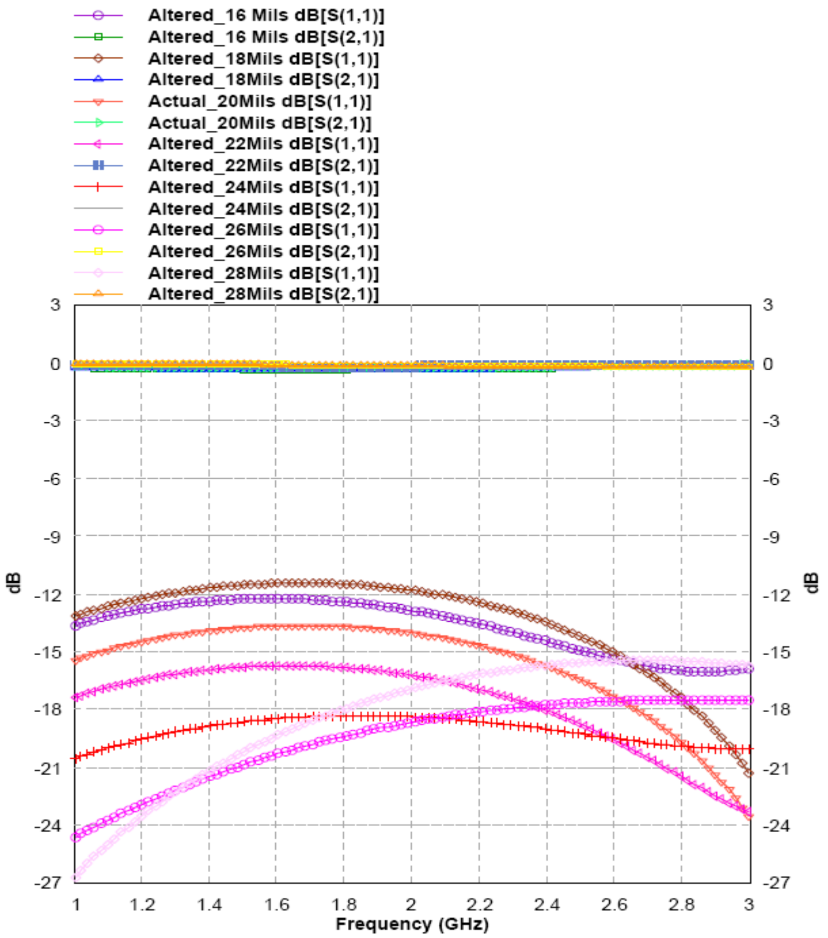
The imported structure has a signal path width of 20 mils. The ports (both signal & ground) for S parameter generation were set at the exact locations. The structure is simulated using IE3D Engine's Adaptive Symmetric Matrix solver, with a Meshing frequency of 15 GHz & frequency range from 1 to 3 GHz. Below is the snapshot of the simulated result for the path width of 20 Mils.



The above graph infers that, the Insertion loss measured is well below -0.3 dB and hence satisfies the loss budget requirement. But the return loss measured does not satisfy the requirement of less than -18 dB. Hence the structure has to be altered to get an optimum result to satisfy the requirement. There are various parameters like dielectric constant, loss tangent, signal path width that can be varied to reduce the return loss. The parameter chosen for optimization here is the path width.

The path width in the structure is varied for values below and above the actual 20 mils width. The path width is altered starting from 16 Mils to 28 Mils in MGrid Layout Editor and each structure
with altered path widths are simulated individually with a meshing frequency of 15 GHz for the frequency range of 1 GHz to 3 GHz.

The simulated results of the altered path width structures are represented graphically below:



The above graphical result infers that as the path width is reduced below the actual width of 20 Mils the insertion loss stays around – 0.3 dB and -0.4 dB at some frequency points and the return loss increases to -12 dB which is far beyond the requirement. As the width is increased above the actual width of 20 Mils, the insertion loss stays around -0.1 dB to -0.3 dB and the return loss reduces to a maximum of -27 db which satisfies the loss budget requirement and as the frequency increases the return loss increases near to -15 dB and this is not the expected. But the response (return loss) of 24 Mils width structure starts and also ends near -20 dB and its response is less than -18 dB for the full frequency range of 1 to 3 GHz. Hence the optimum width of signal path to obtain the desired response and to achieve the loss budget requirement is 24 Mils.

Conclusion:

The Ceramic blade structure is analyzed and optimized using IE3D for a frequency range of 1 to 3 GHz and the optimum signal path width for obtaining desired loss parameters were found to be 24 Mils.