Mapping of Copper Metallization

Copper Metallization Non-Contact Sheet Resistance and Film Thickness Mapping

Using a standard value of 1.68 micro ohm cm for pure copper, the sheet resistance for the following three thickness values is:

Pure Copper

- 2000 A = 84 milli ohms per square
- 15,000 A = 11.2 milli ohms per square
- 20,000 A = 8.4 milli ohms per square
- where R_S = Sheet Resistance, ohms per square
- Rho = Resistivity, ohm cm
- t = film thickness, cm
- and R_S = Rho/t

This shows that we should have no difficulty with thin copper layers of 2000 A or less. The other two values of 15,000 A and 20,000 A are somewhat below our specified sheet resistance range but we do have some limited experience with samples having sheet resistance this low. For samples above 35 milli ohms per square we have a conservative specification of 0.55% for one standard deviation for the precision in our XL range. The accuracy of the measurement will depend on the accuracy of an independent determination of the resistivity of the copper that is actually used. If we can get some samples for the two thicker ranges we can get some additional experience for the precision. For the accuracy we will need to have calibration to an independently determined thickness that can be used to calculate the apparent value of resistivity. This value of resistivity can be used to calculate a thickness based on a sheet resistance from our system. The thickness accuracy will depend on the accuracy of the independently determined thickness. It will also depend on good agreement between the resistivity of the material used for thickness calibration and the resistivity of the material where the thickness is to be measured on our system.

This may sound somewhat involved, but in practice it could be quite routine. The foregoing approach would not work for product wafers where the sheet resistance of the added layer is not 10 times less

that the stack that it is under it such as for example in multi-layer metal structures. In these situations monitor wafer strategies can be used where an appropriate product structure is chosen to represent the capability of the fab operation.

Four point probes have increasing difficulties in handling thicker copper metal layers. Blanket copper deposits can be 20,000 A or more. In this case the copper sheet resistance can be so low that it can approach the contact resistance of 4 point probes of perhaps 5 milli ohms per square.