Copper Electrodeposition of High-Aspect-Ratio Vias for Three Dimensional Packaging
-Time shortening of Electrodeposition

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Three-dimensional Packaging will realize high-density packaging and high speed performance. Higher aspect ratios through chip electrodes offer shortest interconnection and reduce signal delay(Fig.1).

For the ASET three dimensional packaging, the interconnection pitch is 20µm. The minimum polished silicon thickness is 50µm and 20µm is necessary for nargin. Hence the via size of though chip electrode is 10µm in square and 70µm in depth. We will report on how to fill this high aspect ratio via of 70 µm in depth and 10 µm in square side within one hour.

This one hour is very critical time, since processing time of RIE, barrier and seed formation and also high speed CMP are order of several ten minutes. The copper via filling electrodepositing is the rate determining step. The cost estimation by ASET says that the three dimensional packaging process is commercialized if time shortening of one hour by copper via filling electrodepositing can be achieved.

1. Experiment

The bath consist of CuSO₄·5H₂O and H₂SO₄ for basic bath and Suppressor(SPR), Leverer(LEV), SPS (Bis(3-allopropyl) disulfide) and HCl as additives.

A chip with 70 µm in depth and 10µm in square via was mounted on rotating disk electrode(R.D.E.). Rotating speed of the R.D.E. was 1000rpm. Pulse reverse current was applied. Their cross sections were observed by FESEM. A CVS (cycling voltammetric stripping) method was used to evaluate the inhibition effect of LEV.

2. Results

1. SUP and LEV concentrations were optimized initially by increasing the current density of 4 and 5mA/cm². 5mg/L of SUP and 0.2mg/L of LEV were the optimized concentrations and perfect via filling with 90min by 5mA/cm². The difference in Ar/Ar-value by CVS also showed maximum difference at SPR concentration of 5mg/L.

2. SPS, HCl and H₂SO₄ concentrations were optimized by increasing the current density of 6mA/cm². 2mg/L of SPS, 70mg/L of HCl and 25g/L of H₂SO₄ were the

3. Next, the oxygen gas was bubbled into the abovementioned optimized bath by increasing the current density of 6mA/cm². We succeeded in perfect via filling with 75min by 6 mA/cm². The oxygen gas oxide the inhibitor of Cu⁺ to Cu²⁺. Therefore, the accelerato complex of Cu(I)thiolate accumulates at inside of the vi: and accelerates via inside preferentially(Fig.3).

4. Two steps current densities of initially lower current of 6mA/cm² at 50min and higher current of 15 mA/cm² a 10min were applied. With this two steps current densities method, we finally succeeded in perfect vi: filling of 60min(Fig.2). Time shortening was successful We further observed the marked bottom up V-shapes with applying initial current of 6mA/cm² for 50min.

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![High Aspect Cu Electrodeposition](Image)

![Fig.1 Three Dimensional Packaging](Image)

![Fig.2. Time shorting of 6 minute with 2 steps method](Image)

O₂ → 2Cu²⁺ + O₂ + 2e⁻ → Cu²⁺ + H₂O

Formation of Cu(I)thiolate

Accumulation of Cu(I)thiolate

2Cu²⁺ + MPS → Cu²⁺ + Cu(I)thiolate + 3H⁺