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Forming a vertical interconnect structure using dry film processing for Fan Out Wafer Level Packaging

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The electrical interconnect technique of the advanced packaging process has been evolving. Generally, in order to provide increased functionality and performance in the same volume, the advanced packaging processes used multiple chips to integrate the systems into a single package. The development of these advanced packaging trends is being driven primarily by the rapid growth in mobile handheld devices such as smartphones. A lot of development and production are reached, inclusive of wafer level packaging, Cu pillar on through silicon via interposer, fan out wafer level packaged, and many more. The fine pitch copper pillar process is subjected to be replaced by the controlled collapse chip connection bump in the new system package designs. The wafer level packaging fabrication used the spun process of photo resist to plating the copper pillar. However, when the thicknesses of photo resist had been increased to 100μm, there are many process and manufacturing challenges; the thickness of photo resist coating and the uniformity of photo resist, throughput and costs of materials. And emerging as an attractive alternative is the use of dry film resist materials. Dry film photoresist materials were used not only on fabricating the PCB but also on WLP fabrication process in recent years.

For WLP fabrication process, dry film resist materials were used to make photo-patterning, combined with printing the solder paste, electroplating solder joint and fabricating the RDL. After printing or plating process, dry film resist materials were able to strip out using wet bench process. Several years, many benefits of dry film photo resist material were bulletined and involved in wafer level packaged fabrication process engineering comparing with liquid type photo resist material. Moreover, the famous properties were the laminated multilayer on single substrate due to its planarization effect, some exclusive advantages such like low exposure energy, wide band UV light make the fabrication process easy and fast have been pointed out.

Besides dry film photoresist materials were applied as temporary patterning masks, they are highly expected to be functionally better so as to be able to remain within packaging after wafer level process.

Here we study process of the lithography of copper pillars, with focus on heights in excess of 200μm and diameters of 150μm, in anticipation of future fan out wafer level packaging process requirements. The features of the dry film photo-resist are studied including the process development procedures. Some major concerns during process are pointed out. Sets of experiments are done to find solutions of those concerns mentioned above. Optimized process parameters are proposed.

Experiment and results are shown below:

a) This research selected a dry film photo-resist material apply to the thicker Cu pillar fabrication process. The standard procedures for this application are listed as follow: Preprocess → laminating → exposure → developing → plating → stripping.
b) The dry film photo-resist materials are produced in rolls of sheets whereby the resist had been coated in-between two protective layers.
c) The dry film photo-resist material is directly rolled to the Si wafer by laminator. After lamination, this will result in a uniform thick coat which does not require any ancillary solvent processing or lengthy wafer bakes processes.
d) Hence the temperature, pressure and rolling speeds will control the throughput and coating quality. This discussion which is related to a dry film photo-resist is suited to the electroplating application being developed.
e) The process flow which is being discussed is identical through electroplate, dry film photo-resist strip and field metal etching after the lithography process has been completed.

The development of vertical interconnects structure for Fan-Out Wafer Level Packaging with dry film process has made a few significant achievements. Some of the important results are summarized below:

1 Good performance of the developing process and cleaning after developing has been successfully achieved. The residues at bottom of via were removed using the descum process.
2 The good CD uniformity and vertical resist profile after developing have been provided.
3 The dry film resists stripping process has been successfully developed. Shorter stripping time and no dry film Residue near the Cu pillar were observed after stripping process.
4 We can fabricate copper pillars 200μm in height which have the flat top surface of copper pillars and are free of voids and defects.