Reliability of Electronic Packaging: Past, Present and Future

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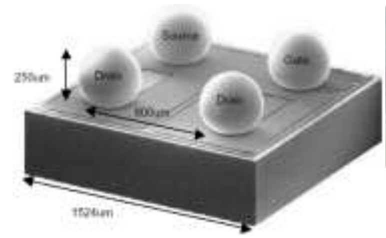
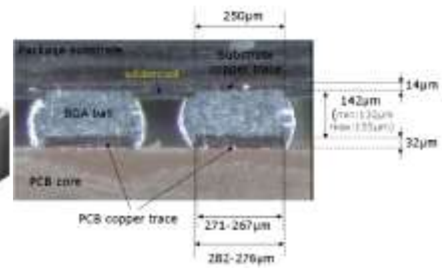
Electronic packaging historically been defined by the type of joints used to connect the layers in a package. Wire bonding, Ball Grid Array (BGA) and flip chip packaging has been used extensively. Due to insatiable demand for miniaturization of devices, for higher I/O count and for more real estate on a package wire bonds and solder balls are made smaller and smaller. However, when solder joints reached their capacity 3-D packaging with Thru- Silicon-Via (TSV) copper connectors become appropriate to package stacked devices. Traditionally the failure in a well-designed and well-manufactured electronic packaging is in the weakest link which is usually a solder joint or a wire bond or a copper via. In the past low cycle thermal fatigue was the main failure mechanism. Transition of solder alloys from Tin/Lead solder joints to led free-came with its own challenges.

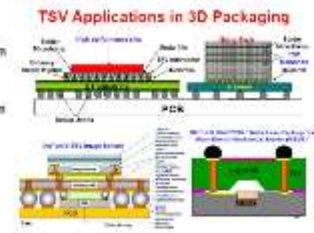
As the market demand for smaller and faster electronics with more functionality increased, failure modes in electronic packaging progressed from simple thermal fatigue to electromigration and thermomigration under high direct current density. Electro-Thermo-Mechanical-Chemical driving force induced mass transport is a major reliability concern for the present high density packaging. The trend in flip-chip packaging to increase I/O count drives the interconnecting solder joints to be smaller in size and, thus, carry higher current density. The current density increases further as chip voltage decrease and absolute current levels increase. The research on electromigration and thermomigration in solder joints is still in its early stages, hence the literature is very poor in publicly available data. The failure modes under high electric current stressing in lead-free solder alloys are still not well understood.

Traditional metals and semi-conductors cannot meet the frequency spectrum, high current density and high temperature requirements of the next generation electronics packaging. All metals are susceptible to electromigration and thermomigration at high current density levels. Moreover traditional metals' and semiconductors' high temperature operational capacity is very limited. As result, for next generation packaging there is a strong effort to replace traditional metals and semiconductors with covalent bonded nano materials, like Single Walled Carbon Nano Tube (SWCNT) and Graphene Nano Ribbon. These covalent bond materials have much superior properties to traditional packaging materials. The fact that Graphene and Carbon Nano Tube can be metallic and semi-conductor, would also solve many problems faced with CTE mismatch in any package.

In this presentation, computational simulations and experimental studies conducted on reliability of past, present and future electronic packaging will be discussed.

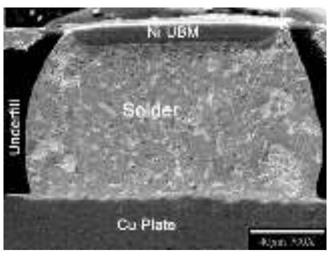




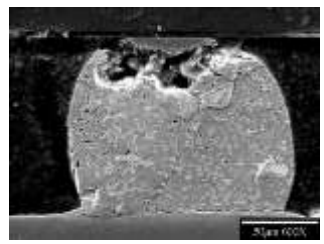


FlipFET™ MOSFET package BGA Package 3-D Package

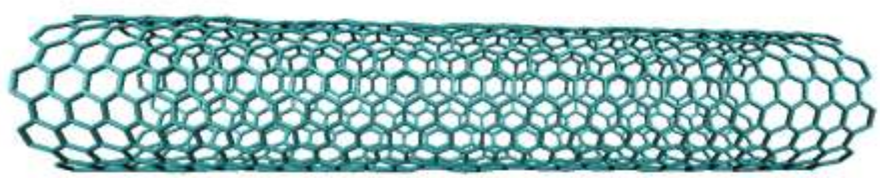
http://info.ec.hc360.com/2009/11/271059158222-4.shtml



Solder Joint before



After Electro-Thermo-mechanical loading



Single Walled Carbon Nano Tube

Armchair Graphene Nano Ribbon

Zigzag Graphene Nano Ribbon