SILICON SYSTEMS GROUP

# An Introduction to 3D Packaging

Historically, wire bonding has been the preferred approach used to connect a semiconductor device to the packaging substrate. By their nature, these connections are limited to the outer perimeter of the device, thereby limiting input/output (I/O) density. Furthermore, the presence of the wire bonds extending beyond the semiconductor device increases the real estate necessary for the final device package. For high-speed devices, the use of wire bonds will also limit performance due to signal delays.

A growing number of advanced semiconductor devices are fabricated today using under bump metallization (UBM). This metallization is deposited on the top metal level of the device after conventional “fab” wafer processing is complete (Figure 1). Solder metal is then used to directly connect the device to the packaging substrate. UBM metallization can be deposited in the conventional wafer fab or in facilities dedicated to semiconductor assembly and test services.

In UBM, the connection points between the device and the packaging substrate are distributed over the entire top surface of the chip. This increases the I/O density by using a higher percentage of the device surface area for connection to the packaging substrate. In addition, this direct connection between the device and the packaging substrate makes possible a reduced form factor and higher speed performance relative to wire bonding.

Redistribution layers (RDL) refer to the conductive metal lines formed to re-route wire bond connections from the edge to the center of a semiconductor device. After the redistribution layer is formed, the device packaging process flow can continue using UBM metallization instead of conventional wire bonding. RDL layers can also be used to maintain existing package designs while accommodating the smaller die produced by semiconductor manufacturers transitioning to advanced technology nodes. Finally, deposition of redistribution layers before the bonding process will be required as part of the 3D integration process flow.

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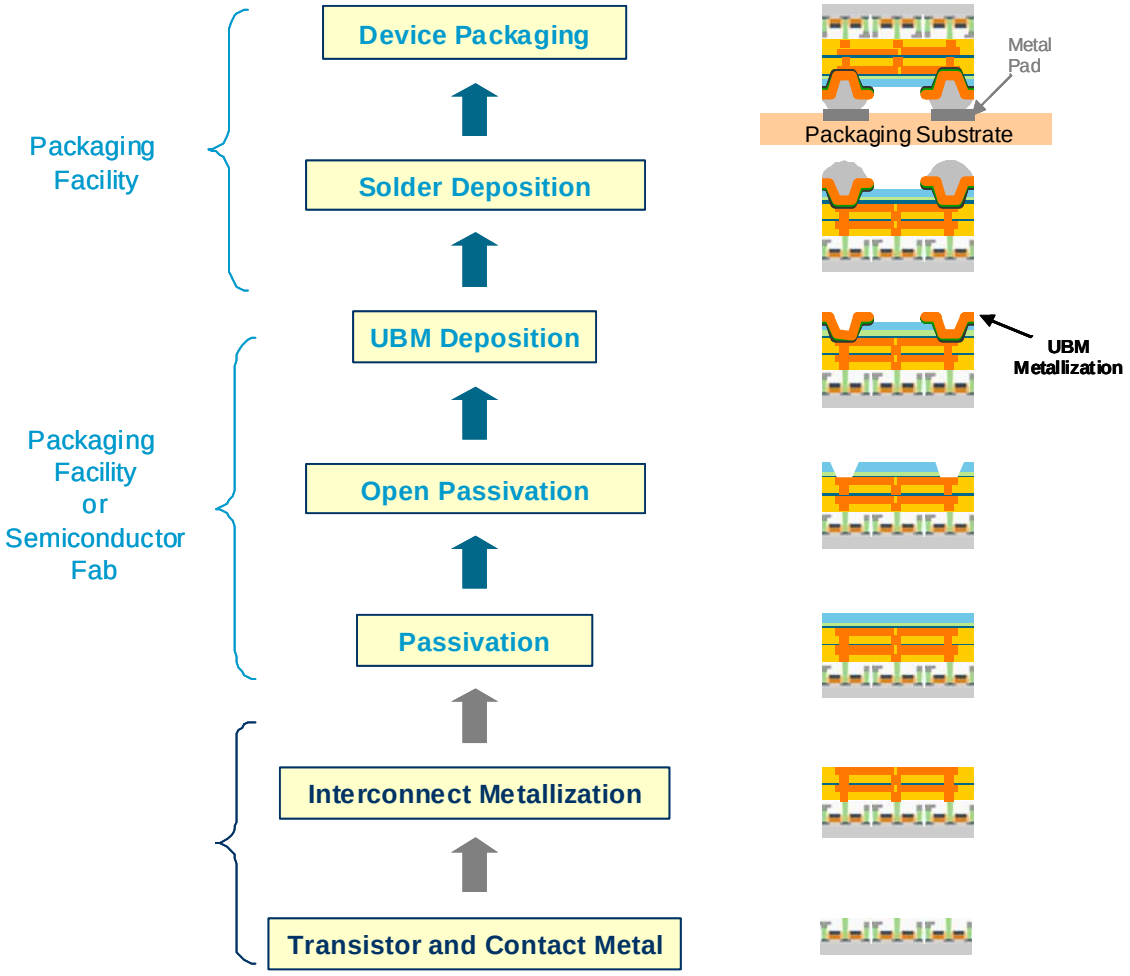


Figure 1. Packaging metallization process flow.

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Physical Vapor Deposition (PVD) is the preferred approach for depositing UBM and RDL layers, based on the maturity, flexibility, and low cost of the PVD process.

An appropriate selection of metals combined with optimized wafer treatment and deposition processes directly affects the reliability of the device package. UBM and RDL metallization requires:

1. Physical removal of high-resistance oxides and contamination using an ion bombardment wafer treatment.
2. Deposition of a low-resistance barrier layer to prevent intermixing of the solder with the exposed metal of the device. The barrier must provide a low-stress mechanical and ohmic connection with good adhesion to all surrounding metals and dielectrics.
3. Deposition of a wetting layer to promote good bonding of the solder to the UBM/RDL metal stack.

Wafers requiring either UBM or RDL deposition are commonly processed in facilities dedicated to device packaging, assembly, and test. Traditional semiconductor manufacturing equipment has been adapted for use in these packaging facilities. However, they are poorly suited to the films deposited in the UBM or RDL flows. Chamber incompatibility with organic films commonly used causes defect excursions and corresponding yield loss that necessitate frequent servicing of these systems. The result is a significant reduction in system productivity and higher manufacturing costs.

The Applied Charger UBM PVD system blends production-proven Endura2 PVD technology with innovations that address the unique requirements of the packaging industry. By nearly doubling the wafer output of current systems, the Applied Charger UBM PVD system delivers the highest available productivity. Proprietary Isani™ wafer treatment technology is key to this superior productivity, enabling the Charger UBM system to process 10 times more wafers between servicing to deliver best-of-breed uptime and the lowest available per-wafer cost.