Controlling Under Bump Metallization Etch with Veeco WaferEtch® Platform

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Copper pillar bumping has become an essential approach for flip chip bonding in advanced packaging technology. As pitch size decreases, the need for controlling under bump metallization (UBM) undercut has become an increasingly important issue to tackle. While choosing chemistry that is selective to the films and materials on the wafers is necessary, process control is crucial for minimizing undercut. The WaferEtch platform is equipped with several features such as programmable hyperbolic arm scan motion and enhanced end point detection that enable an undercut less than 200

Enhanced End Point Detection (EEPD)

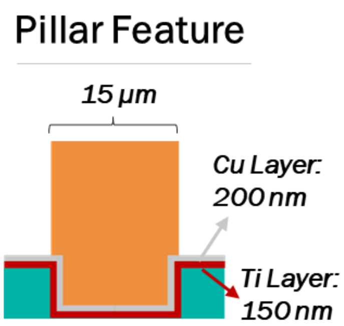

Figure 1: Schematic and CD's of Cu pillar processed on WaferEtch®.

Utilizing a color CCD camera and proprietary color space algorithms, Veeco's proprietary WaferChek® software can determine the completion of a process by detecting in-situ changes to RGB and HSV values during the etching process. Several regions can be monitored along the wafer surface to ensure a uniform and complete etch. This technology enables accurate identification of etch endpoint to minimize undercut, improve throughput, and lower chemistry consumption.

The capabilities of Enhanced End Point Detection (EEPD) on WaferEtch® platform were highlighted by performing Cu and Ti under bump metallization (UBM) etch on 300 mm substrates containing 30 um copper pillar arrays. Critical dimensions (CD's) of the pillar features can be found in Figure 1.

Eight EEPD regions were inspected starting from the center to the edge. Appreciable drops in the red channel were monitored by the software to determine the endpoint for both etching processes (shown in Figure 2). A complete etch was determined once endpoint was detected in all regions, including a user-specified over etch (OE) percentage.

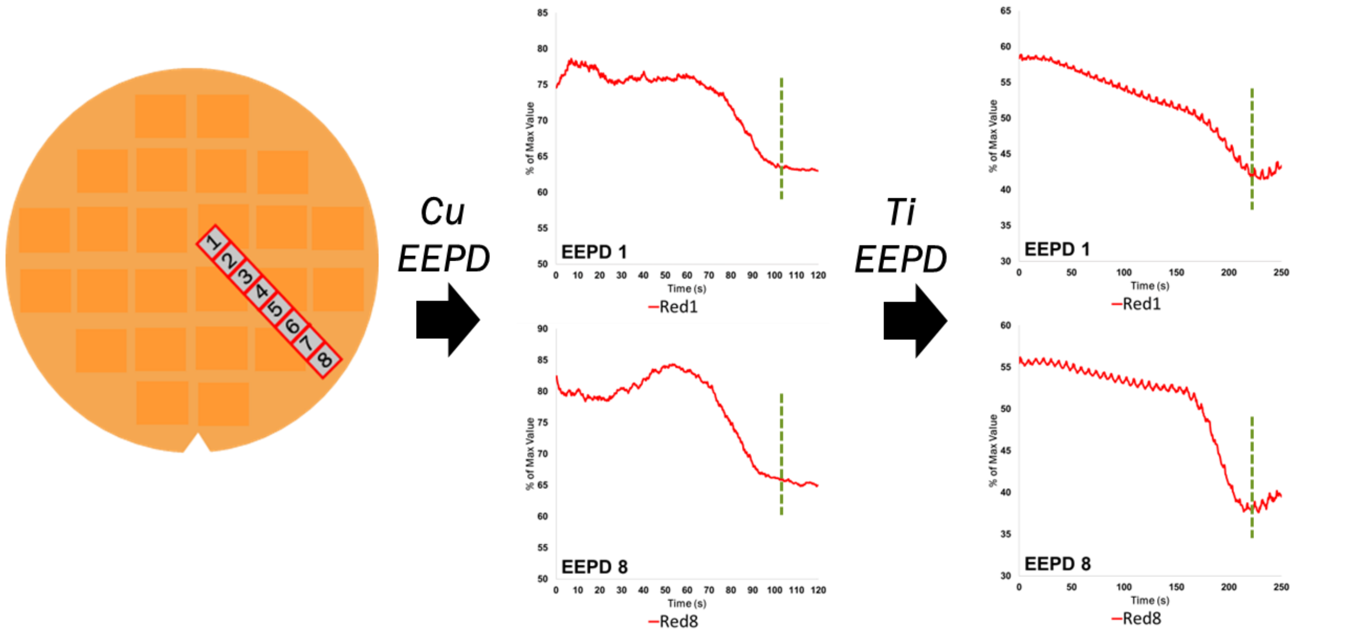

Figure 2: (Left) Schematic showing EEPD locations along wafer surface for Cu and Ti etch processes. End points are highlighted for locations 1 and 8 for Cu etch (middle) and Ti etch (right). Dotted green line indicates endpoint detection for the respective layers.

UBM Etch Performance

EEPD was complemented with hyperbolic motion, which can modulate the dispense arm scan velocity across the wafer to ensure a uniform and consistent etch. A 10% OE for both processes produced complete etching of the Cu seed and subsequent Ti barrier layer. Microscopy images in Figure 3 highlight the center EEPD Pos 1 (center) and EEPD Pos 8 (edge) of the wafer.

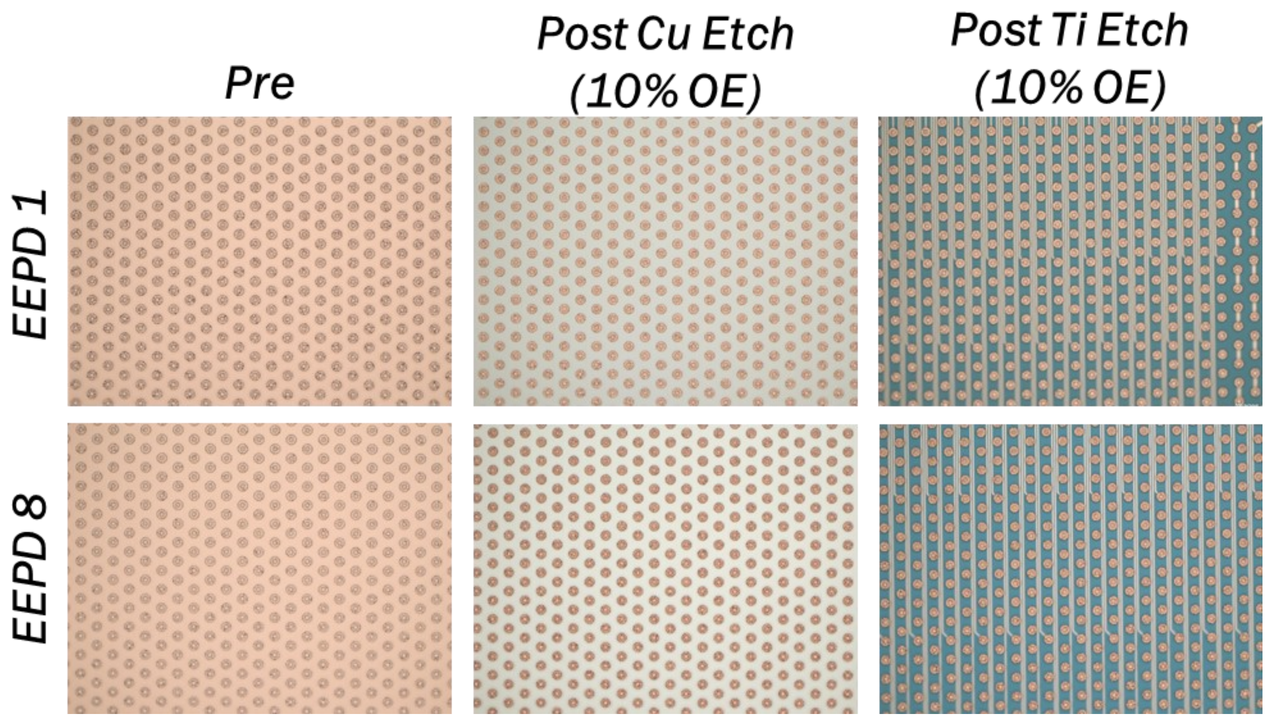

Figure 3: Microscopy images (10x magnification) displaying EEPD regions 1 and 8 in the as-received state (left), post Cu seed layer etch (middle), and post Ti barrier layer etch (right).

Cu Pillar Undercut

With optimized UBM etch parameters, cross-sectional SEM reveals that undercut was minimized to ~140 nm (Figure 4). Results obtained from WaferEtch Platform showcase the ability to process current and future advanced packaging applications.

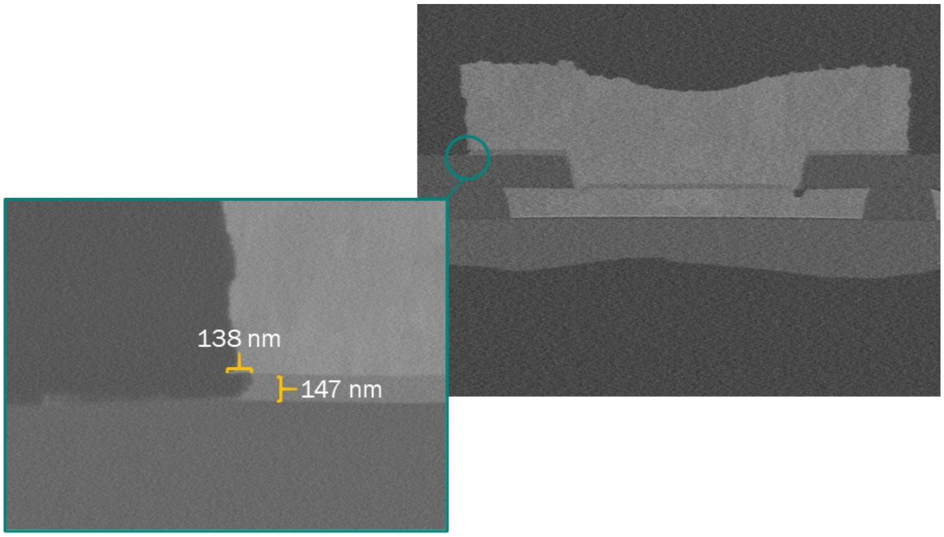

Figure 4: Ion-milled cross-sectional SEM images of copper pillar post Ti etch, revealing undercut less than 140 nm.