

## **Automated Skiplot Sampling for Photoresist Thickness Measurement**

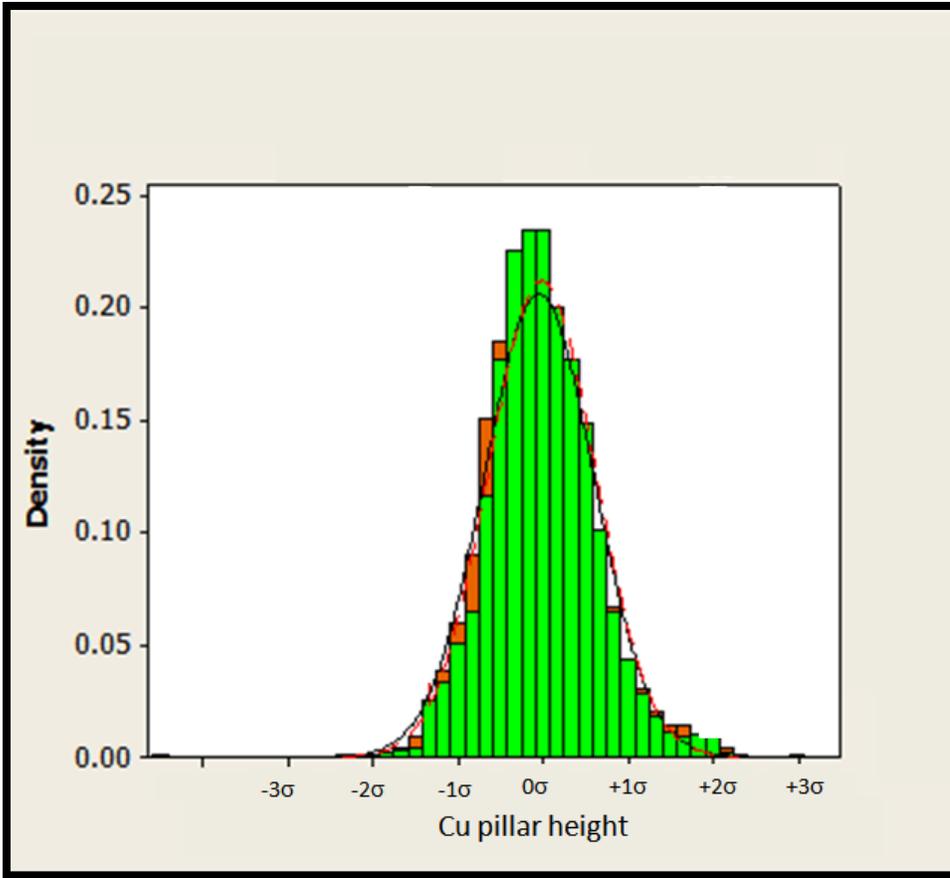
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This paper describes how statistical methods were used to justify a substantial metrology reduction in Cu flip chip processing. Prior to the project, photoresist (PR) thickness measurement was required for every wafer in every lot. On average, the combined processing and queue time for each lot was approximately 3.5h. To justify the metrology reduction, the sources of variation for photoresist thickness were characterized. This effort included a gauge R&R study of the thickness gauge and also an analysis of the sources of variation from the process and the incoming material (e.g. within lot, lot to lot, PR batch to PR batch, etc..). In summary, the analysis of variation confirmed that each PR batch must be qualified, but once an average PR thickness of the batch is determined – that average may be used for all wafers coated with that batch. In other words, not all lots need to be measured. This sampling scheme is sometimes referred to as ‘skiplot’.

A unique challenge for this metrology step is that it not only ensures that the lithography module is in control, but in addition, the PR measurement is fed forward for downstream process control as well. Prior to implementation, to ensure that no significant shift would result from skiplot sampling, 90 days of historical downstream data was recalculated replacing the actual PR measurement with the batch averaged PR measurement; no significant shift was observed. (see figure) To ensure that no lots escape the lithography module coated with a PR batch that is not qualified, an automated system was put in place that queries both lot history and tool PR batch history. When a lot reaches the metrology step coated with an unqualified photoresist batch, the automated system will flag the lot for required thickness check.

The skiplot sampling plan and automated PR batch qualification system was piloted on a single product for 5 weeks before rolling it out to other products. We have achieved 90% reduction in metrology, saving several thousands of hours of cycletime and freeing up half of the time of an operator per shift. No unintended consequences have been encountered.



Histogram of downstream process control parameter (Cu pillar height). Green = distribution from no sampling at PR thickness. Red = distribution using skiplot sampling for PR thickness.