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Combined x-ray nano-tomography and Small Angle Neutron Scattering characterisation applied to reliability and process development

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Synchrotron radiation and neutron techniques have proved to be powerful tools in the understanding of failure mechanisms and in the characterisation of physical and morphological properties of complex structures for microelectronics. The ability to get high quality local as well as statistical information on defects has become paramount for failure analysis and reliability assessment of new process technologies. In this work we show the application of synchrotron x-ray nano-tomography to the study of voids and intermetallic precipitates in copper pillars used as vertical interconnections in 3D integration technologies. A Cu pillar is basically a Cu cylinder topped by a Sn hemisphere. Thermal reflows are then applied to stabilise the structure. Several defects appear at the interface between Cu and Sn features, jeopardising the mechanical and electrical reliability of the structure. These structures cannot be fully characterised by conventional electrical microscopy techniques as they are real 3D objects. Synchrotron X-ray nano-tomography with real resolution down to 30nm appears as an alternative to the standard lab characterisation tools. The local investigation is then complemented by the use of Small Angle Neutron Scattering (SANS) technique, an advanced method to provide statistical information the average size and number of these defects as a function of the number of reflows. Thousands of copper pillars are characterised at the same time providing insights on the yield and mechanisms of defect formation, coalescence and propagation. Understanding the influence of process parameters in the reliability of 3D interconnects is paramount for the semiconductors industry.

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