저온 및 고전류밀도 조건에서 전기도금된 구리 박막 간의 열-압착 직접 접합

Thermal Compression of Copper-to-Copper Direct Bonding by Copper films Electrodeposited at Low Temperature and High Current Density

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초 록: Electronic industry had required the finer size and the higher performance of the device. Therefore, 3-D die stacking technology such as TSV (through silicon via) and micro-bump had been used. Moreover, by the development of the 3-D die stacking technology, 3-D structure such as chip to chip (c2c) and chip to wafer (c2w) had become practicable. These technologies led to the appearance of HBM (high bandwidth memory). HBM was type of the memory, which is composed of several stacked layers of the memory chips. Each memory chips were connected by TSV and micro-bump. Thus, HBM had lower RC delay and higher performance of data processing than the conventional memory. Moreover, due to the development of the IT industry such as, AI (artificial intelligence), IOT (internet of things), and VR (virtual reality), the lower pitch size and the higher density were required to micro-electronics.

Particularly, to obtain the fine pitch, some of the method such as copper pillar, nickel diffusion barrier, and tin-silver or tin-silver-copper based bump had been utillized. TCB (thermal compression bonding) and reflow process (thermal aging) were conventional method to bond between tin-silver or tin-silver-copper caps in the temperature range of 200 to 300 degrees. However, because of tin overflow which caused by higher operating temperature than melting point of Tin (232 ℃), there would be the danger of bump bridge failure in fine-pitch bonding. Furthermore, regulating the phase of IMC (intermetallic compound) which was located between nickel diffusion barrier and bump, had a lot of problems. For example, an excess of kirkendall void which provides site of brittle fracture occurs at IMC layer after reflow process. The essential solution to reduce the difficulty of bump bonding process is copper to copper direct bonding below 300 ℃.

In this study, in order to improve the problem of bump bonding process, copper to copper direct bonding was performed below 300 ℃. The driving force of bonding was the self-annealing properties of electrodeposited Cu with high defect density. The self-annealing property originated in high defect density and non-equilibrium grain boundaries at the triple junction. The electrodeposited Cu at high current density and low bath temperature was fabricated by electroplating on copper deposited silicon wafer. The copper-copper bonding experiments was conducted using thermal pressing machine. The condition of investigation such as thermal parameter and pressure parameter were varied to acquire proper bonded specimens. The bonded interface was characterized by SEM (scanning electron microscope) and OM (optical microscope). The density of grain boundary and defects were examined by TEM (transmission electron microscopy).