Tanaka Promotes Low-Temperature Bonding Thru Sub-Micron Au Particles

More recently, metal-to-metal wafer bonding has been popularly evaluated in the field of microelectromechanical system (MEMS) packaging. This technique could decrease the sealing line area, which would result in the reduction of chip size and the realization of hermetic sealing, and it also enables electrical interconnections between two bonded wafers. A low-temperature wafer bonding has also become important for various purposes, such as reducing post-bond residual stress at the mechanical structure in MEMS devices, and preventing bowing or cracks when bonding two materials with dissimilar coefficients of thermal expansion (CTE).

In order to lower the bonding temperature for MEMS packaging, Tanaka Kikinzoku Kogyo K.K has newly developed sub-micron spherical particles having 99.95 mass% gold (Au) and also improved the bonding technique for practical applications in cooperation with SUSS MicroTec KK

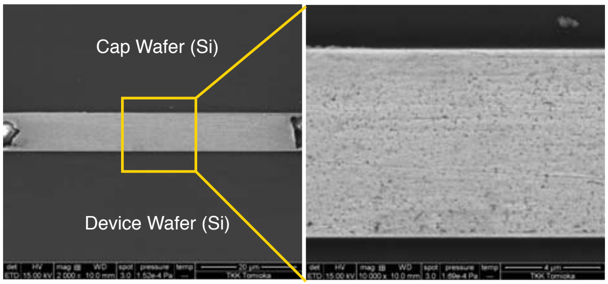

Figure 3: Cross-section of densified Au particles by thermocompression bonding at 200°C, 100MPa for 10min. The black areas correspond to the top and the bottom wafers and the bright part shows a densified Au particle sealing line. Au/Pt/Ti metallization layer was deposited on each surface of Si wafer.

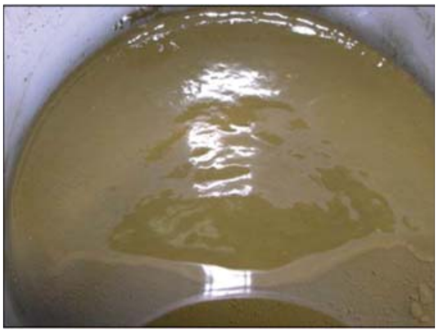

Figure 1: The slurry having sub-micron-sized Au particles being termed "AuRoFUSE".

Bonding Process

Figure 1 shows the gold slurry, the AuRoFUSE, used for the actual process, and was prepared by mixing the sub-micron Au particles with an organic solvent and surface active agents.

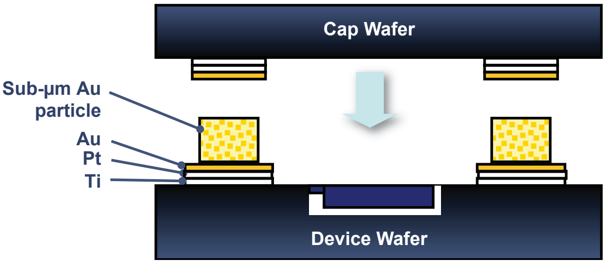

Figure 4: Hermetic sealing using Au particles, which were bonded in vacuum on the SUSS SB8e wafer bonder at 200°C under the pressure of 100MPa.

Figure 2 presents the temperature dependence behavior of sub-micron Au particles with average particle size of 0.3μm diameter heated at 150 and 200°C. The particles can be connected even at 150°C, and they made rapid progress on surface diffusion at 200ºC. The possible bonding temperature is significantly influenced by the particle size.

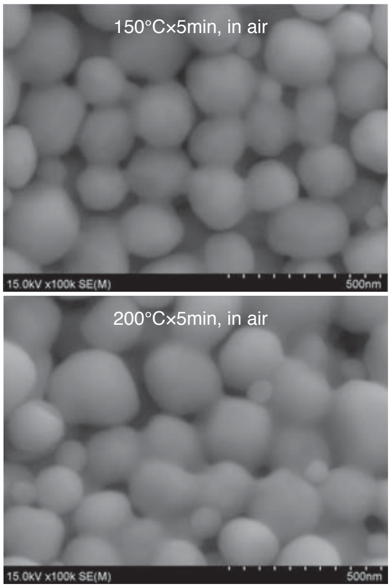

Figure 2: Reaction of Au particles by heating without pressure force.

Figure 3 shows a cross-section scanning electron microscope (SEM) image of a sealing line of Au particles bonded at 200°C with a pressure of 100MPa. The bonding surfaces of both Si wafers were metalized through the sputtering method of a 50nm-thick Ti, a 50nm-thick Pt, and a 200nm-thick Au layers. The photo demonstrates that sub-micron Au particles were compressed into bulk Au, which is suited to hermetic sealing, while eliminating voids. Besides, the tensile strength between chips was measured using the stud-pull method on a universal mechanical-strength tester. The average bond strength of the sealing line of bulk Au was 45.8MPa.

As shown in Figure 4, the sealing performance of the sub-micron Au particle bonding was checked by the bonded wafer pairs immersed into a low-viscosity hydrofluoroether liquid, Novec by Sumitomo 3M Ltd., in a vacuum container evacuated down to 10kPa. Gross leak can be easily checked by seeing whether the liquid flows into sealed areas or not. As the results of a good sealing property against the liquid, the preliminary hermeticity capability of Au particles was confirmed.

Furthermore, additional features of the Au particle bonding are as follows: a) a low electrical resistivity of $5 \times 10^{-6}\Omega$•cm; b) a high thermal conductivity of 150W/m•K; (c) a good coverage of surface roughness and/or topography at the bonding surface. Tanaka Kikinzoku anticipates future applications of this technology in the area of MEMS, high-power devices, and 3D-IC.

The company will continue to develop new materials in the precious metals field with a positive outlook. ❑

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Tanaka Kikinzoku International K.K

Head Office (Tokyo Marunouchi)	TEL : +81-3-5222-1380
Seoul Branch	TEL : +82-2-588-1854
Hong Kong Branch	TEL : +852-2736-0011
Singapore Branch	TEL : +65-6778-4411
Taipei Branch	TEL : +886-2-2536-2053
Kaohsiung Sales Office	TEL : +886-7-223-5215
Manila Representative Office	TEL : +63-2-631-2726

Tanaka Kikinzoku International (Shanghai) Co.,Ltd.

Head Office (Shanghai)	TEL : +86-21-6448-5988
Shenzhen Branch	TEL : +86-755-2588-2500

Tanaka Kikinzoku International (America), Inc.

Head Office (Chicago)	TEL : +1-224-653-8309
San Jose Branch	TEL : +1-408-779-0461

Tanaka Kikinzoku International (Europe) GmbH

Head Office (Frankfurt)	TEL : +49-69-2193870

Tanaka Kikinzoku International (Thailand) Co.,Ltd.

Head Office (Bangkok)	TEL : +66-2-652-5180

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