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Innovative bonding technology for 3D integration

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<Abstract>

Effectiveness of the surface activation for room temperature bonding was demonstrated in the middle of '80, for example, for Al-Al and Al-Si3N4 in 1992, for Cu-Cu micro-bonding in 1993, and for the direct wafer boding of Si-Si in 1996. The method is called as the surface activated bonding (SAB) and has been developed for heterogeneous bonding between different materials at room temperature, attracting increasing interest due to its simple process flow, no need for additional intermediate materials for bonding, and compatibility with CMOS technology. The standard SAB method is based on surface bombardment by Ar beam in ultra-high vacuum to clean the surfaces so that they can be bonded very strongly at room temperature without heat treatment. Modifications of the surface activation have been investigated to extend the standard SAB method for various materials and applications. The standard SAB method uses Ar beam bombardment to remove surface adsorption and oxidation layer to realize bonding between semiconductors when two surfaces are brought into contact. It has been studied for bonding of Si-Si, Ge-Ge, and compound semiconductors such as GaAs-Si. The standard SAB, however, failed to bond some dielectric materials, such as glass and silicon oxide. A modified SAB was developed to solve this problem, by using an intermediate layer of Si, metals, or even metal oxide deposited on the activated surfaces. The modified SAB is now applied to bond not only SiO2 glasses but also polymer films such as PEN and Polyimide, as well as WBG semiconductor wafers to diamond substrate with a wide perspective of the applicability on heterointegration for 3D, flexible and power electronics.

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Tadatomo SUGA joined the Max-Planck Institut fur Metallforschung in 1979, and received the Ph.D. degree in materials science from University of Stuttgart in 1983. Since 1984 he has been a faculty member of the University of Tokyo, and since 1993, he has been a professor at the Department of Precision Engineering of the School of Engineering. He was also the director of Research Group of Interconnect Ecodesign at National Institute of Materials Science (NIMS), and a Member of Japan Council of Science, as well as the chair of IEEE CPMT Society Japan Chapter. His researches focus on micro-systems integration and packaging, and development of interconnect technology, especially the room temperature bonding technique for 3D integration. He has endeavored to establish collaboration between industries and academia for the packaging technology, directing R&D project of the Institute of Micro-System Integration (IMSI), and advocating also importance of the environmental aspects of packaging technology as the key organizer of Japanese roadmap of lead-free soldering and International Eco-design Conference as well as the general chair of IEEE Workshop on Low Temperature Bonding for 3D integration. In March, 2019, he retired from the University of Tokyo, and joined Meisei University as a professor of the Collaborative Research Center on April 1. 2019. He became also an Emeritus Professor of the University of Tokyo on June 18. 2019.