Low-Temperature Hybrid Bonding for Heterogeneous Integration

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Abstract:

Low-temperature hybrid bonding, as a key technology enabling high-density interconnections without the need for bumps, offers a transformative approach to 3D packaging and high-performance chip integration. This technology shows great potential in meeting the demands for chip miniaturization, high integration density, and low power consumption. However, achieving efficient integration between wafers or between wafers and chiplets, while ensuring the reliability and long-term stability of the bonding interface under varying operating conditions, remains a critical challenge. This lecture will systematically explore the design and optimization of hybrid bonding interfaces, covering surface treatments, interface connections, and process controls to comprehensively analyze the key factors for improving bonding quality. Additionally, it will examine the structural characteristics of metal-dielectric hybrid interfaces and their applicability in high-density interconnections. Drawing on practical cases, the lecture will further discuss strategies for optimizing interface performance, revealing the mechanisms of interface reactions, and providing innovative approaches for achieving more efficient and reliable low-temperature hybrid bonding.

Outline:

1. Introduction
    - 1.1 Development Trends in 3D Packaging and High-Density Interconnection Technologies
    - 1.2 Advantages and Technical Challenges of Low-Temperature Hybrid Bonding
2. Low-Temperature Hybrid Bonding Based on Surface Synergistic Activation
    - 2.1 Synergistic Activation via Surface Co-Hydroxylation for Hybrid Bonding
    - 2.2 Residue-Free Hybrid Bonding via Surface Co-Hydrophilization
    - 2.3 Transition from Homogeneous to Heterogeneous Cu/SiO_2 Hybrid Bonding
    - 2.4 Hybrid Bonding for Ultra-Narrow Pitch 3D Integration

2.5 Surface Activation Techniques and Optoelectronic Chip Integration

3. Next-Generation Innovations in Ultra-Fine Pitch Hybrid Bonding

3.1 Future Directions and Perspectives for Hybrid Bonding Technologies

3.2 Open Discussion and Q&A Session

Who Should Attend:

Targeting academic researchers, engineers, university students and faculty, equipment manufacturers, and business decision-makers, it covers technical principles, process workflows, equipment optimization, and application prospects, focusing on theory and practice to drive innovation and growth.

Speaker's Biography:

Dr. Chenxi Wang a full professor in School of Materials Science and Engineering at Harbin Institute of Technology. He received the Ph.D. at The University of Tokyo in 2009. His research interests focus on wafer bonding, heterogeneous and dissimilar bonding, 3D integration and packaging, and the joining of advanced medical materials. Prof. Wang was awarded the prestigious JSPS Fellowship for Foreign Researchers and participated in the JST-CREST major project. After returning to China, he led three National Natural Science Foundation projects and undertook over 20 provincial and corporate research projects. He has published more than 130 SCI/EI-indexed papers, received seven international conference awards for best paper and presentations, and holds 16 granted patents. Additionally, he has served as a technical committee member of ICEPT. He is a Senior Member of IEEE, and a Senior Member of the Chinese Mechanical Engineering Society. He has been recognized with honors such as the National Award for Outstanding Self-Financed Students Abroad, the Dean’ s Award from The University of Tokyo, and the Heilongjiang Provincial Natural Science First Prize. In education, Dr. Wang has won many first prizes in provincial and university-level teaching competitions, led four teaching research projects and co-authored two textbooks.