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Design and Evaluation for Mechanical Strength of an Anodically Bonded Pressurized Cavity Array for Wafer-Level MEMS Packaging

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We present a strength evaluation method and design guidelines for a pressurized cavity array fabricated by the anodic bonding of silicon substrates to glass cavity plates. The mechanical strength of the bonding of a pressurized cavity array has been evaluated in terms of the interfacial fracture toughness measured for a silicon-glass specimen with pre-inserted blades. From a set of the glass-silicon bonding specimens, we have obtained an average value of the critical interfacial fracture toughness of 6.12 J/m^2. Using a theoretical analysis, a simple fracture mechanics model of the pressurized cavity array has been developed. The interfacial fracture toughness for a bonded cavity of infinitely wide plates has been derived analytically in terms of cavity dimensions, material properties and cavity pressure. For a bonded cavity of plates of finite width, we performed a finite element analysis and evaluated interfacial fracture toughness by varying intercavity bonding length. In the case of a cavity array with an intercavity bonding length longer than half the cavity length, the bonding strength approaches that of an infinite plate. For a cavity array having shorter intercavity bonding length, however, the bonding strength of the cavity array decreases as the ratio of the bonding length to the cavity size decreases. The measured interfacial fracture toughness and the derived equations result in a cavity design chart, which enables us to determine the ratio of bonding length to cavity size required for the failure-free wafer-level MEMS packaging of a pressurized cavity array.

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