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Influence of Bonded Area Ratio on the Strength of FAB Seals between Silicon Microstructures and Glass

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The influence of the bonded area ratio (r_b) on the strength of field-assisted bond (FAB) seals in a thermally well-matched combination (Si and Pyrex 7740) was investigated by tensile testing. A general, micromachined test structure consisting of a Si(100) disc with a large number of etched-out microstuds sealed to a plane Pyrex plate was used. Low strength values in the range 0–2 MPa were obtained for small stud sizes, indicating that internal stress caused by thermal mismatch is the limiting factor when r_b is small enough. For ratios above a certain critical value r_{bc}, the strength results were higher (25–50 MPa), and essentially independent of r_b. The r_{bc} value found was remarkably low, just 1%. In the interval $r_b > r_{bc}$ the limiting factor is externally induced stress concentrations at stud corners, and the results obtained are roughly equal to the experimental FAB seal strengths reported by others. In a separate test series for $r_b < r_{bc}$, a studded Si disc was bonded to a plane Si disc with a 50 μm thick Pyrex interlayer. In this case the fracture limits were raised to 11–44 MPa, indicating a substantial reduction of the internal stresses. Spontaneous fracture due to slow crack growth in the glass was observed in some cases. In an Appendix, the thermal stress distribution in a studded Si-glass seal is analytically solved for a one-dimensional analogy.