

Use of Hertzian Ring Crack Initiation to Measure Surface Flaw Densities and Probe Interfacial Adhesion Behavior

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Blunt (Hertzian) indentation has tremendous potential to elicit valuable information about the surfaces and interfaces of brittle materials. Hertzian ring crack initiation loads on glass, using spherical WC and glass (G) indenters, are measured and analyzed. Our measurements demonstrate that humidity plays a key role in determining load to fracture; experiments conducted without controlling this variable cannot be used to obtain material properties. The role of friction is explicitly considered for dissimilar (WC-G) elastic contacts. For this material pair, the stresses at fracture are well described by a boundary lubrication value of friction coefficient. The fracture loads are used in a fracture-mechanics formulation to calculate crack sizes on glass surfaces. The “searched-area” concept for dissimilar contacts is described, and used to estimate crack density values for these surfaces. In the second part of the talk, the use of this technique to probe the adhesion properties of glass and alumina to an engineering epoxy, and to differentiate substrate processing methods is described. This loading generates high shear and compressive stress at the interface below the indentation impression, while the compressive stresses decay to ~zero near the edges of the impression. Hence delamination can initiate near the indentation edge due to shear stresses alone. The load at which delamination occurs and the size of the delamination allow for the determination of interfacial shear strength and fracture toughness respectively. In the systems of interest, extremely high loads (>800N) were required to initiate delamination of coatings, and large variability in delamination loads was observed at ambient temperature. When the test temperature was reduced to -55°C, more predictable delamination behavior was observed. The colder temperature increases residual stress in the coating due to thermal expansion mismatch and effectively reduces the load to initiate delamination. Results on multiple samples with different surface treatments are discussed, and important processing steps that can improve adhesion in this system are identified.

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