Static interface strength measurement in thin films: Mode I fracture delamination using double cantilever beam

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Introduction

Continuing demands in semiconductor industry demand increase in density of integrated circuits (ICs) and complex material combinations. Mismatch in material properties like coefficient of thermal expansion and Young's modulus lead to stress concentrations that might result in fracture initiation and propagation. Quantitative assessment of such thin film interface fracture toughness would certainely add a significant contribution to the ongoing reaserach and developments in this field.

Experimental Methodology

We performed Double Cantilever Beam (DCB) experiments on two different Silicon wafers as shown in Figures 1 (Dimensions in mm) and 2. The material properties of both tested material and the adhesive used for DCB sample preparation are listed in Tables 1 and 2.

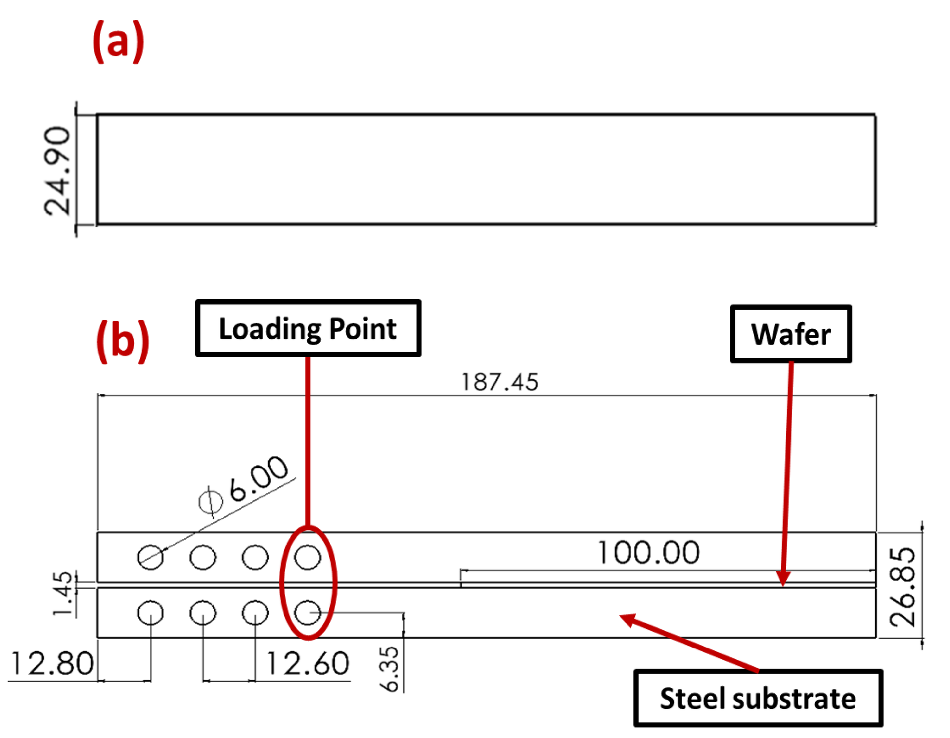

Figure 1. DCB joint geometry. (a) Top view and (b) Lateral view.

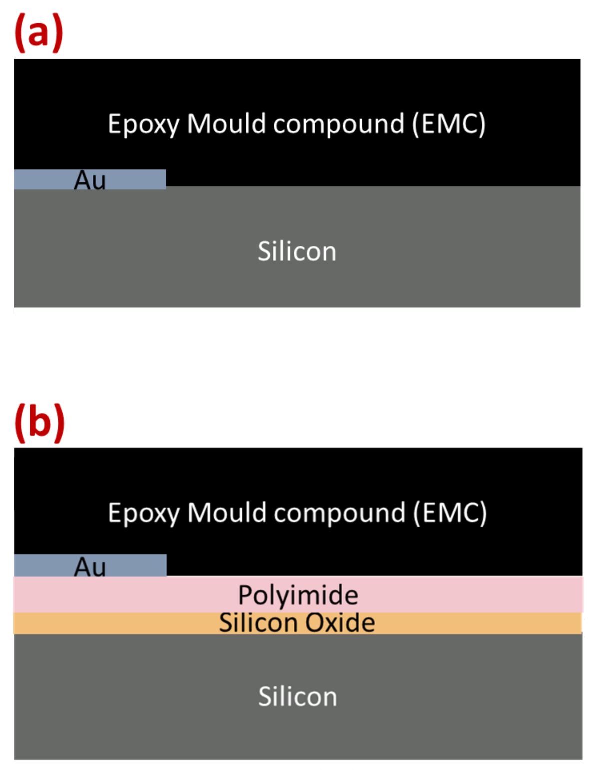

Figure 2. Scheme of (a) type 1 interface and (b) type 2 interface.

Table 1. AV138 adhesive properties [1,2] .

Young´s Modulus (GPa)	4.59 ± 0.81
Ultimate Tensile Strength (MPa)	41.01 ± 7.28
Poisson´s Ratio	0.35

Table 2. List of material properties [3,4].

Materials	Ultimate Tensile Strength (MPa)	Poisson´s Ratio	Young´s Modulus (GPa)
Silicon	165	0.28	112
EMC	90	0.38	2.36
PM300	1020	0.33	205
Polyimide	300	0.4	3.73
Silicon Oxide	45	0.17	73

Experimental Results

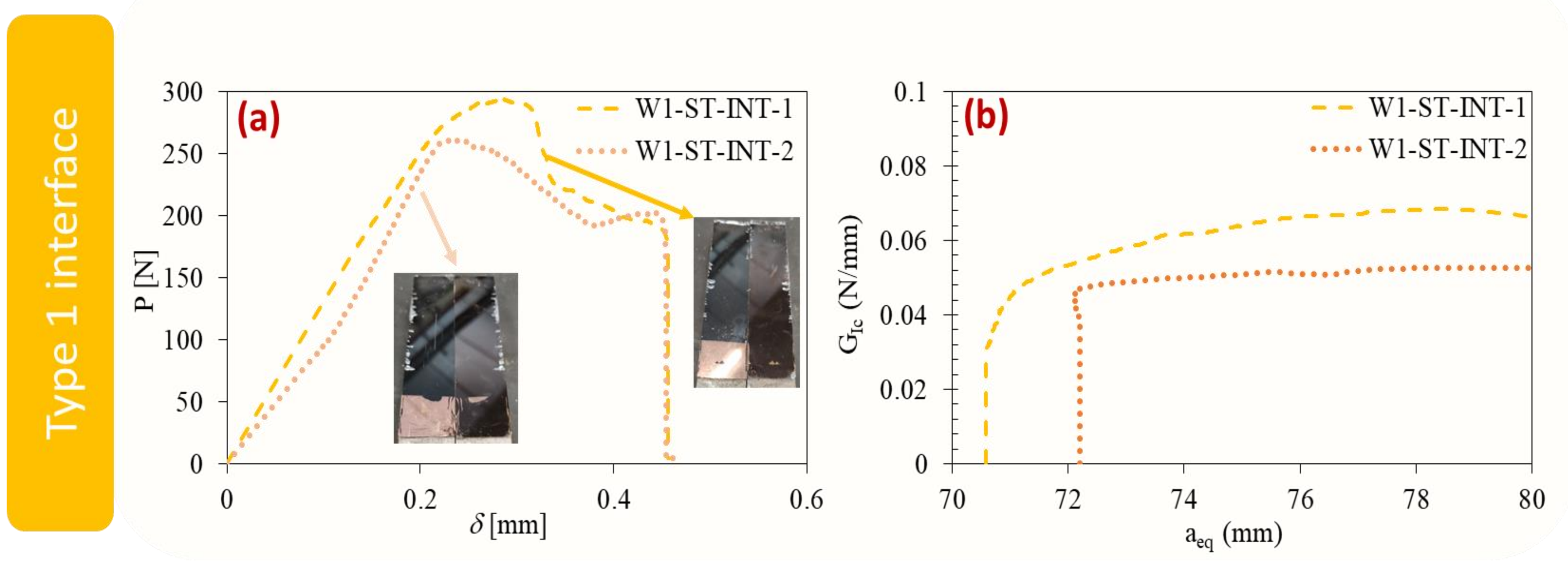

Figure 3. Type 1 interface quasi-static results. (a) Load-displacement curve. (b) R-curve.

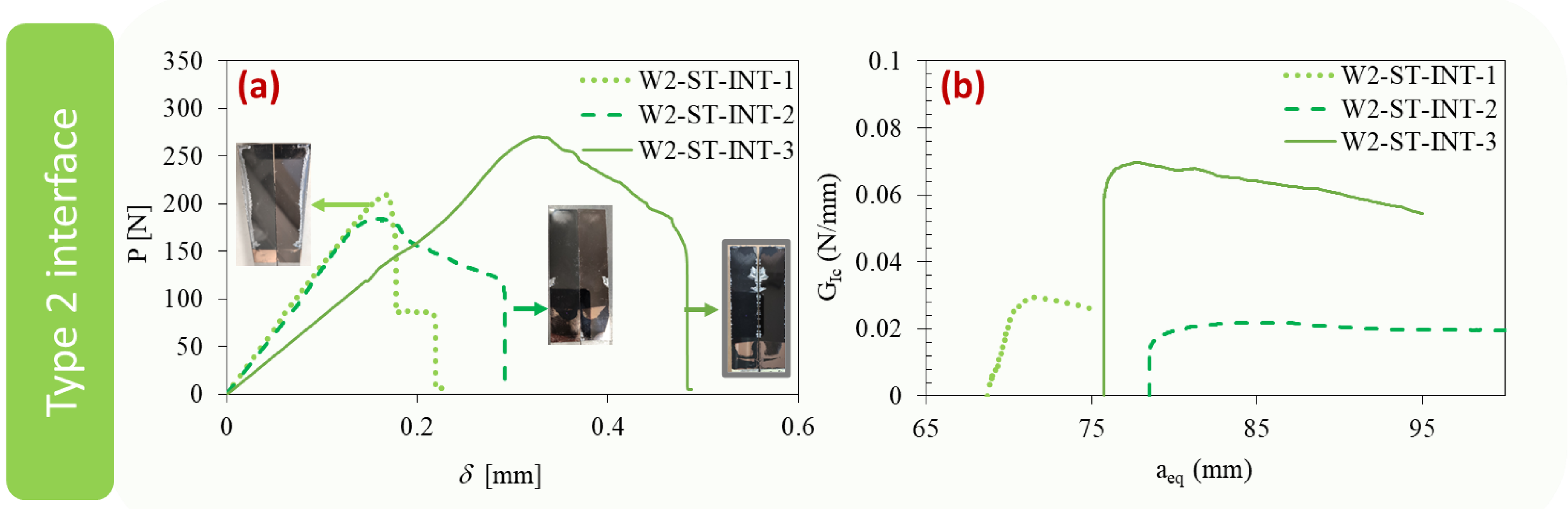

Figure 4. Type 2 interface quasi-static results. (a) Load-displacement curve. (b) R-curve.

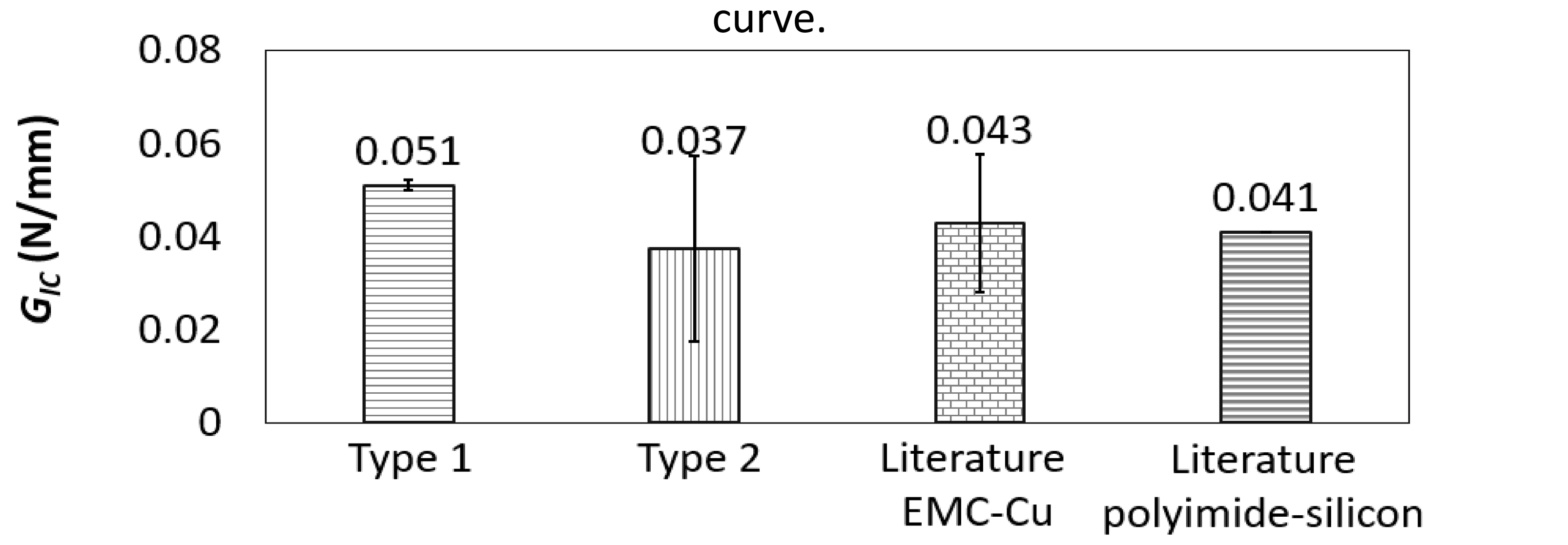

Figure 5. G_{IC} comparison with literature EMC-Cu [5-8] and polyimide-silicon [9] interfaces.

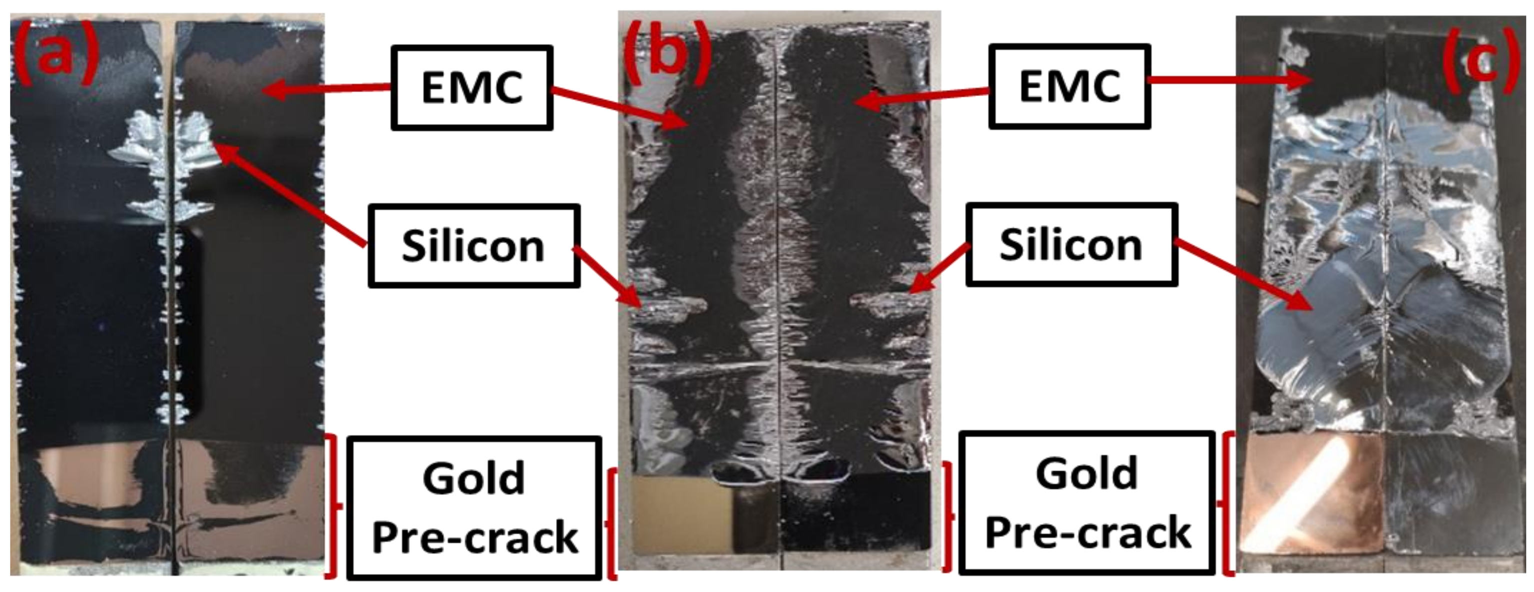

Figure 6. Typical fracture surfaces. (a) Interfacial failure. (b) Mixed failure. (c) Silicon failure.

Conclusions

1. The average G_{IC} for type 1 and type 2 interfaces are determined as 0.051N/mm and 0.037N/mm respectively. Literature comparison of G_{IC} values as shown in Figure 5, confirms that our measurement data and G_{IC} values are in the correct range.

2. Preliminary testing of these wafer material stacks showed different fracture modes such as interfacial, mixed and bulk silicon cracking as shown in Figure 6.

3. Defect free silicon substrates from wafer separation, sample sidewall grinding and polishing, selection of adhesive types were found to be highly critical for DCB experiments on such thin films.

References

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