

## Refinements to the miniature mixed mode bending device for interface delamination characterization

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# Refinements to the miniature mixed mode bending device for interface delamination characterization

M. Kolluri<sup>\*,†</sup>, J.P.M. Hoefnagels<sup>†</sup>, J.A.W. van Dommelen<sup>†</sup>, M.G.D. Geers<sup>†</sup>

<sup>\*</sup>Materials innovation institute (M2i)  
Mekelweg 2, P.O. Box 5008, 2600 GA Delft, The Netherlands  
m.kolluri@tue.nl

<sup>†</sup>Eindhoven University of Technology  
Department of Mechanical Engineering, P.O. Box 513, 5600 MB Eindhoven, The Netherlands  
j.p.m.hoefnagels@tue.nl

## ABSTRACT

High levels of integration, lower costs and a growing need for complete system solutions in electronic has led to the emergence of Systems In Package (SIP), which have multiple thin and stacked layers of various materials. Intrinsic and thermal mismatch stresses are inevitably present, making interface delamination a primary failure mechanism. Lacking adequate interface characterization tools, the industry is still heavily depending on trial-and-error methods for product/process development. Therefore, there is a strong demand for a generic experimental methodology that yields interface properties (e.g. fracture toughness) over the full range of mode mixity.

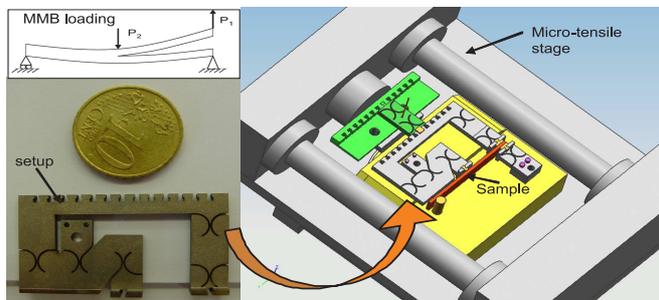


Figure 1: Miniature mixed mode bending setup (left bottom) together with a sample in a micro tensile stage (right).



Figure 2: Micro-tensile stage in scanning electron microscope chamber.

A miniaturized mixed mode bending (MMMB) setup (Fig. 1) capable of in-situ delamination testing in a scanning electron microscope (SEM) (Fig. 2) was previously developed [1, 2]. The functionality of the setup was demonstrated successfully by in-situ delamination testing on custom made samples. Figures 3 and 4 show the typical load displacement curve recorded during a test and the critical energy release rate (CERR) measured as a function of mode angle, respectively. High magnification microscopic visualization of the delamination test, which is possible with this setup, allows capturing of fine details in the delamination mechanism in addition to precise crack tip identification (Fig. 5).

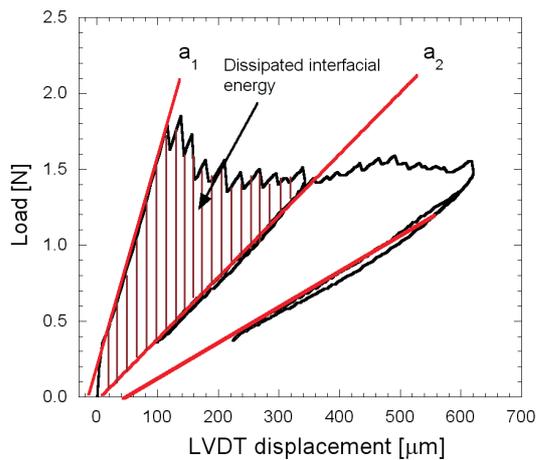


Figure 3: load displacement response of a mode I test. Shown also are stiffness lines at crack lengths  $a_1$  and  $a_2$ .

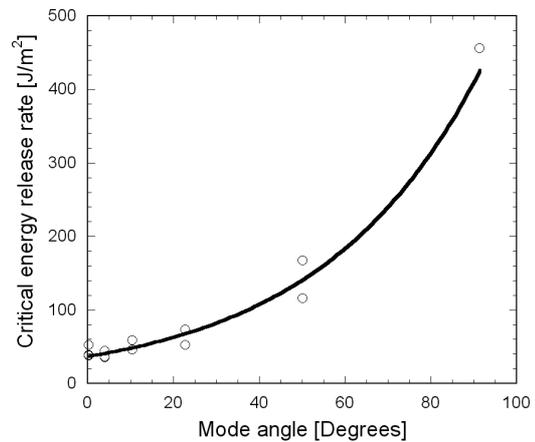


Figure 4: CERR (dissipated energy per unit increase in crack length) plotted as a function of mode angle.

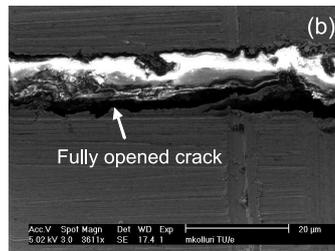
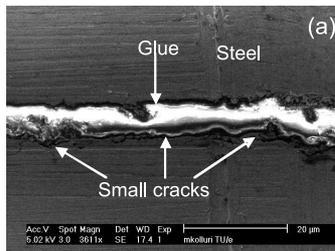


Figure 5: SEM micrographs showing the mechanism of delamination: (a) formation of small cracks ahead of the crack tip before (b) full opening of the crack.

The existing MMMB setup, which is first of its kind, can successfully be applied for delamination characterization. However, its range of applicability is limited by the following aspects: i) The maximum amount of load is limited to 20N; ii) The maximum amount of stroke is limited to  $300\mu\text{m}$  for mode II dominant tests; iii) The elastic hinges used in the design are fragile, mounting and un-mounting of the sample demands high operator skill.

This paper focuses on various fundamental improvements to the current MMMB design in order to stretch its maximum applicable load and stroke limits and to make the setup more robust. Specific improvements include, i) optimization of the position and design of the elastic hinges; ii) incorporation of additional hinges and iii) design changes to ease the sample mounting-unmounting procedure. Clean interface samples for validation have been manufactured. Proof of principle measurements on these validation samples will demonstrate the advantage of the improved setup compared to the previous MMMB design.

## References

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- [2] M. Kolluri, M.H.L. Thissen, J.P.M. Hoefnagels, J.A.W. van Dommelen, and M.G.D. Geers, *Int. Jl. Fracture*, (submitted).