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BEoL Stack Failure Mode Evaluation Utilizing Micromechanical Testing and FEM Modelling

by Jendrik Silomon, André Clausner, and Ehrenfried Zschech

2022 IEEE International Symposium on the Physical and Failure Analysis of Integrated Circuits (IPFA), Singapore, Singapore, 2022, pp. 1-8

This article is paywalled: https://ieeexplore.ieee.org/document/9915739

Hello researcher,

Thank you for reading this month's edition of Bruker's Nanomechanical Testing Journal Club.

This month I'd like to highlight a paper by André Clausner and co-authors that focuses on the **methodology of inducing stresses (and eventually failure) in microelectronic devices to understand failure modes, damage initiation, and damage propagation**.

This work summarizes and puts into perspective some of the authors' earlier, experimental work on both shearing and tensile loading of copper pillars that are bumped onto aluminum pads. The device stack also includes a polyimide underfill and multiple metallization layers and low-*k* material. I would encourage any readers interested in microelectronic device failure to look back at some of these earlier works.

In this article, finite element modeling (FEM) is employed to understand stresses within the stack. These FEM results are analyzed in the context of micro-mechanical loading results from Bruker's Hysitron TI 950 TriboIndenter equipped with a 3D OmniProbe high-bandwidth transducer.

For shear tests, a flat-sided probe is brought into contact with the side of a Cu bump. If the probe is lifted, a longer lever arm is created at the Cu-Al pad interface. This long lever arm results in crack initiation at this interface, as determined by FIB slices for both failed and sub-critical loading. If the lever arm is shortened – both the Cu-Al interface crack and low-*k* – metallization delamination occurs. This failure mode, described in this work as cratering, results in these two cracks growing to meet and causing failure well into the 4th and 5th metallization layers. Layers M1-M3 delaminate and are ejected from the damage region.

Since both long and short lever arm modes tend to cause damage initiation at the Cu-Al interface, the authors use the FEM to look at the possibility of changing the Al pad size. They do find that the Al pad should be larger than the Cu pillar to increase the load at failure, but further work is required to optimize the structure to prevent damage to the device.

I encourage you to spend some time with this paper, as this is a great example of **using experimental and modeling results to make engineering decisions on real projects.**

Douglas Stauffer, Ph.D.
Sr. Manager of NI Applications Development
Bruker Nano Surfaces and Metrology
Douglas.Stauffer@bruker.com

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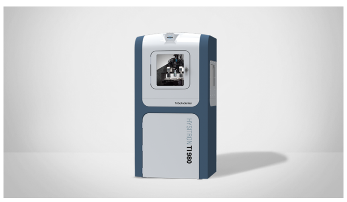

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Bruker Nano Surfaces and Metrology
Hysitron Nanomechanical Test Instrumentation
9625 West 76th Street
Minneapolis, MN 55344 USA
+1 952-835-6366
productinfo@bruker.com