Success Story
COMET

[MPPE
Materials-, Process- and Product-Engineering
Programme: COMET – Competence Centers for Excellent Technologies
Programme line: K2-Centres
COMET subproject, duration and type of project:
PCB Interface (A7.14), [02/2013 – 06/2015], multi-firm

Novel test for characterizing interface strengths in Printed Circuit Boards

Printed circuit boards (PCBs) are the backbone of all electronical devices. They have a layer wise build up consisting of insolating materials and layers with electrical conductive material. Delamination between these layers is one of the most important issues for reliability of PCB's and therefore a precise control of adhesion energy is crucial for further improvements of reliability. A test setup, that was originally only applicable to brittle materials was further developed and applied to PCB's. A plug-in for simulation software was programmed and transferred to industry enabling fast and reproducible characterization of interfaces.

Motivation and Introduction

Printed circuit boards (PCBs) are the backbone of all electronical devices; they act as interlay wiring and are responsible for the mechanical stability. Most PCB's consist of fibre reinforced polymers and Copper. The polymeric faction acts as di-electric and mechanical carrier whereas the Cu is responsible for the electrical connectivity. In order to overcome design limitations and to enhance the functionality, multi-layer PCBs are manufactured. In such boards up to 14 layers of Cu and polymer-composite are laminated together.

This stacking bears an intrinsic source of failure because the different types of materials have a high difference in their thermal expansion coefficients. This and the polymeric shrinkage during solidification can lead to failures such as cracks in the dielectric or delamination between Cu and polymeric parts. The latter one is the main cause of failure in PCB's subjected to thermo-cyclic loading. Such thermo-cycles occur during fabrication of the boards, in the soldering cycles during mounting of components on the boards and during service when, for example, a mobile phone is exposed to the sun. In the last decades a lot of effort has been made to overcome these issues, mainly by introduction of new composite materials, new processes and improved overall process control.

The recent development of new stacking systems and applications with on-going miniaturization reached the limit of available testing facilities, thus the knowledge-based design was hindered and new testing methods had to be developed.

Innovation and Testing Procedure

The project team took up the challenge to find methods for testing and detailed understanding of near to perfection engineered interfaces between Cu and Polymer-composite.

The new developed method consists of special designed sample build up, a so called 4 point bending test, coupled with a finite element (FE) simulation tool for secure evaluation of analytically gained results. The test is sketched in Fig. 1. As shown, the test specimen consists of eight Cu sheets, fixed together by 7 polymer composite dielectrics.

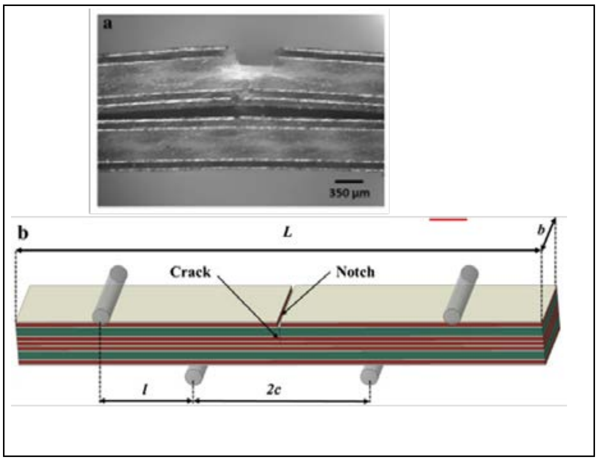

Fig. 1: Fractured interface from 4PB test (a) and lay out of samples in the 4PB test (b) (published)

When a bending experiment is performed, the force raises constantly till the fracture strength of the sample in the notched area is reached as shown in Fig. 2a. At this point a crack forms at the notch and is deflected at the weakest interface as shown in Fig. 1a, leading to a load plateau in the force displacement curves. The force-displacement curves are the basis for the further evaluation and interpretation of interface toughness in PCB materials. Only with simulation, as shown in Fig. 2, it is possible to account for the nonlinear material behaviour and the friction between the sample and testing device.

The resulting interface energy is calculated considering all mechanical properties of the test species, details are summarized in [1]. The FE code was summarized in an easy to use plug-in called “Bending Test” and transferred to company partners where it is used in house.

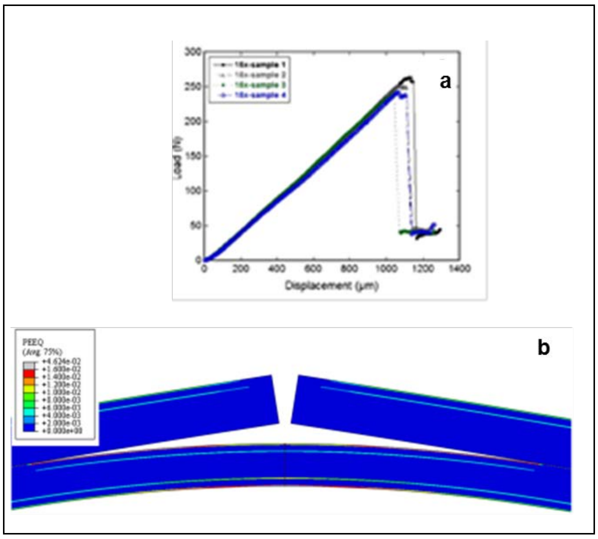

Fig. 2: Force displacement curves of 4 samples of the same type showing the typical behaviour (a) Simulation of the 4 point bending test (published).

Impact and effects

The project generated a deep insight into the main causes of delaminations in printed circuit boards via the design of a suitable test method for high quality PCB’s. The main impact of this project is the knowledge build up regarding interface strength and the new testing method. The first one could be directly used by fabrication partners for the optimization of the manufacturing processes; the second one is now part of the process-design and qualification routine at AT&S and Panasonic Austria. It should be one cornerstone in the development of next generation PCBs for highly loaded applications.

[1] R. Schöngrundner, et al., Adhesion energy of printed circuit board materials using four-point-bending validated with finite element simulations, Microelectronics Reliability (2015)

Contact and information

MPPE / A7.14 "PCB Interface"
Materials Center Leoben Forschung
Roseggerstrasse 12, 8700 Leoben
T +43 3842 45922 11
E mclburo@mcl.at, www.mcl.at

Project coordinator
Dr. Guenther Maier

Project partners

Organisation	Country
Austrian Academy of Science, Erich Schmid Institute	Austria
AT&S Austria Technologie & Systemtechnik Aktiengesellschaft	Austria
Panasonic Industrial Devices Europe GmbH.	Austria