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Presentation

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"Dye-Pull"- An Inexpensive Fast Failure Analysis Technique for Solder Joints

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ABSTRACT

With continuous miniaturization of components and increase in complex circuit card assemblies the check on integrity of hundreds of hidden joints of ball grid array and other bottom terminated components creates a challenge. The assessment of Ball Grid Array (BGA) SMT joints through X-ray and visual inspection is frequently desired in Printed Circuit Board Assembly (PCBA) industry as part of prototype build assembly qualification. Additional product assurance review and failure analysis investigations are also desirable to minimize field risks.

The "Dye and Pull" process utilizes dye penetration in order to visually detect fractured and separated solder joints after component prying from assembly surface. This has shown to be a proven, viable, and inexpensive quick turnaround characterization method. This presentation will discuss Dye-Pull technique encompassing scope and limitations.

INTRODUCTION

In the Circuit Card Assembly (CCA) industry, failure analysis (FA) is the process of identifying, most often, an electrical failure in order to understand which component or location on a printed circuit board assembly (PCBA) is not functioning properly.

- Non-destructive FA techniques are the first step to gather relevant details without damaging the assembly or components.
  - Visual/Optical Inspection
  - X-Ray Inspection
  - Electrical Characterization
- Destructive FA techniques are usually employed as a last approach in CCA failure investigation and root cause analysis.
  - Cross-Section
  - Dye-Pull (also known as Dye-Pry)

    A fast and inexpensive method for evaluation of hidden solder joint integrity.

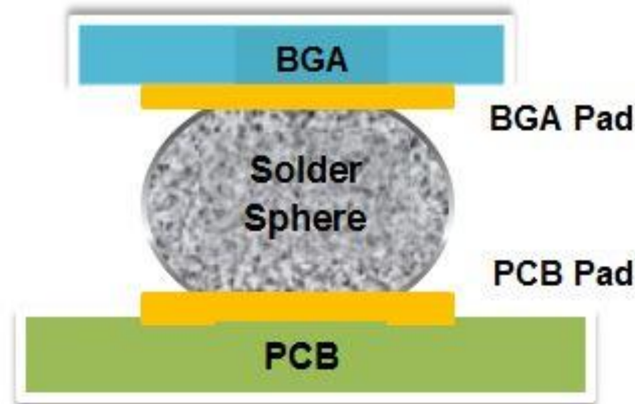
TEST METHODOLOGY

The Dye-Pull technique is based on penetration of a dye into a crack or fracture that results in either partial or full separation of the solder joints.

- Pre-clean the site to be analyzed to remove any flux residues or potential contamination from the region of interest.
  - The successful penetration of dye fluid into very fine fractures or cracks is greatly limited by presence of flux residue and poor cleanliness.
- The mounted Ball Grid Array (BGA or LGA) region on circuit card is treated with dye to facilitate adequate fluid penetration into the existing solder joint anomalies.
- The technique require careful processing of sample so not to introduce additional joint defect during the procedure.
- A detailed step by step description of Dye-Pull procedure is provided in the recently approved[1] IPC-TM-650 specification (08/2017).

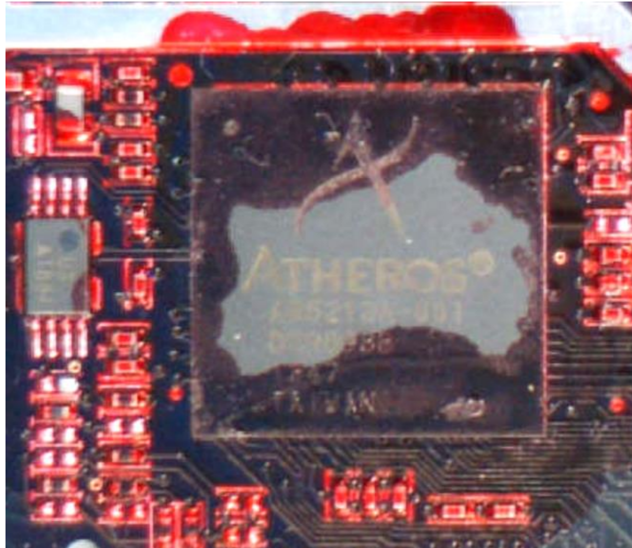
JOINT ASSESMENT

- Typical bonding interfaces of a joint which could have dye stained appearance are located on both board and component sides as represented in solder stack-up diagram below.



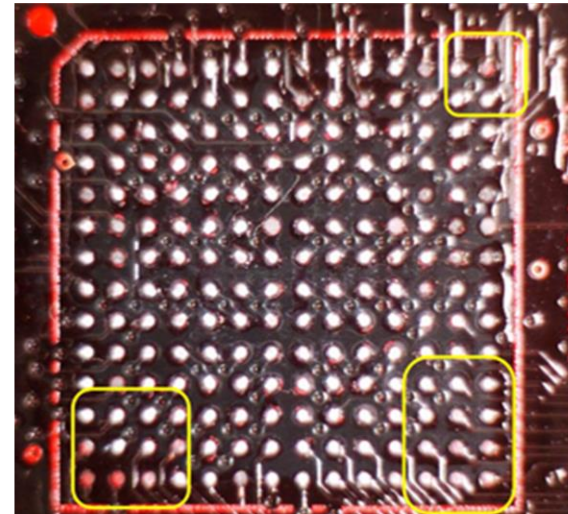
- The forceful prying of the component in the Dye-Pull method facilitates the breaking of a bond at the weakest interface.
- The absence of dye on both component and board surfaces is an indication of good formed joints.
- The assessment is solely based on visual detection of dye tint in suspected regions. Therefore the examination of tint presence must be performed under high magnification with good lightening.

DYE PENETRATION EXAMINATION



← PHOTO 1
ATHEROS BGA treated with red dye on Printed Circuit board.

PHOTO 2 →
Joint anomalies in marked areas. The dye tint indicates joint defect site.



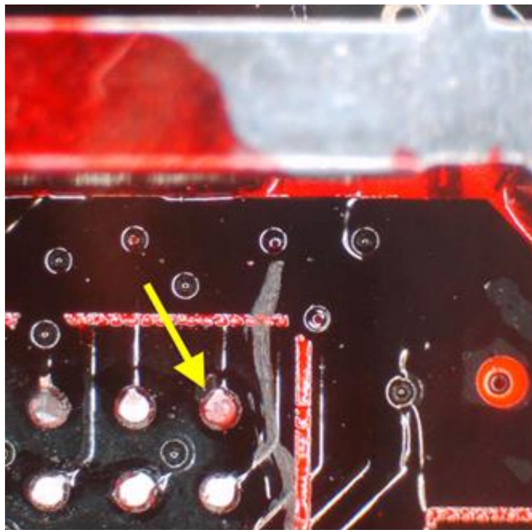


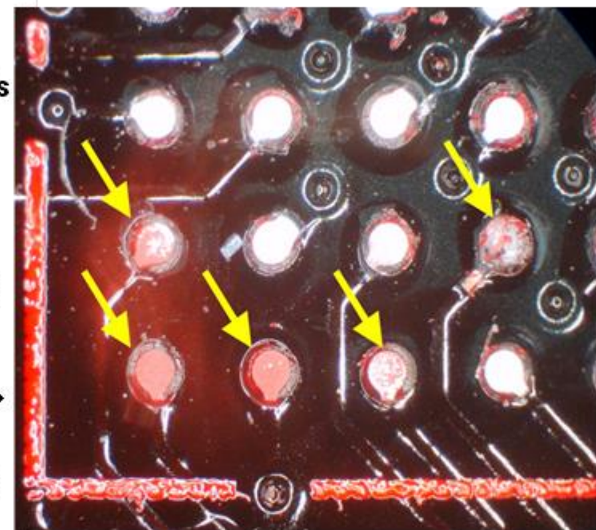
PHOTO 3

BGA Joint Defects

(Yellow arrows)

←Full Separation
(upper right corner)

Partial and Full →
Joint fracture
(lower left corner)



BGA JOINT ASSESMENT

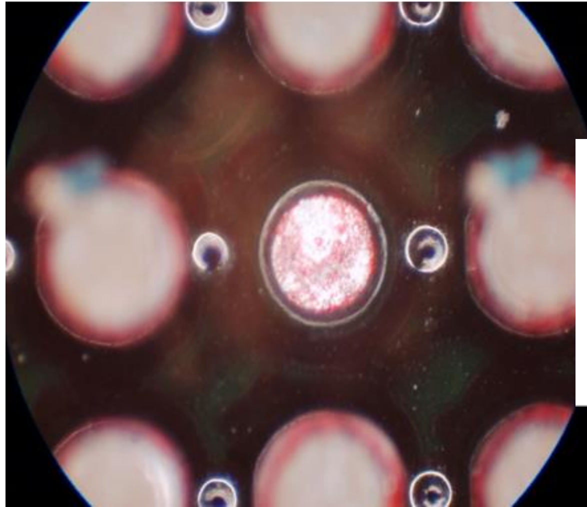
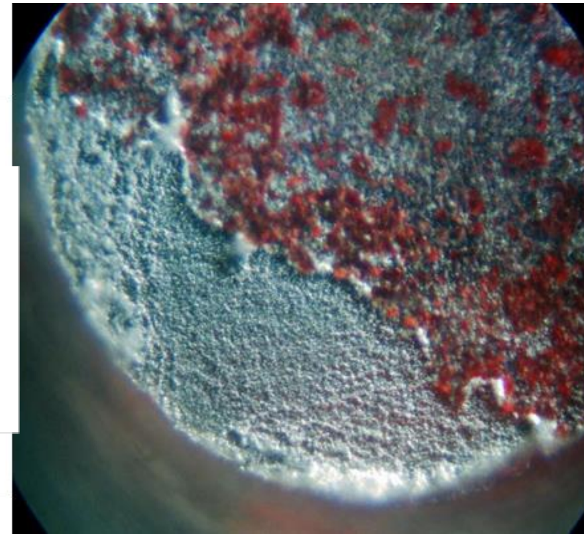
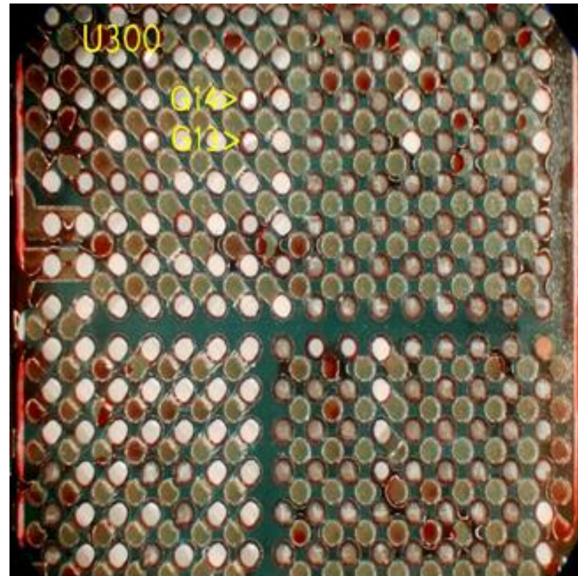


PHOTO 4

Dye Stains

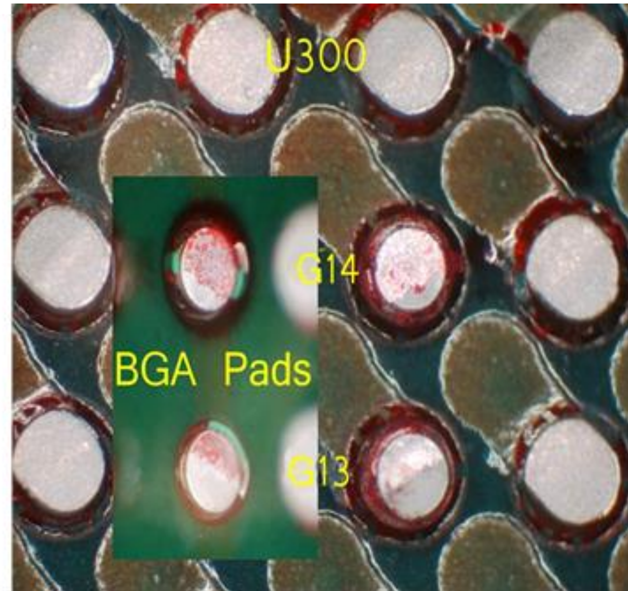
at high magnification



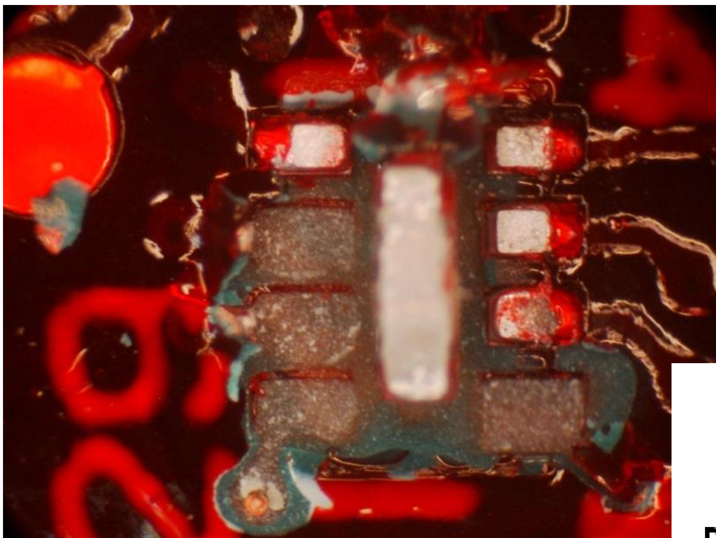


← **PHOTO 5**
Dye and Pull test of 256-I/O BGA on PCBA.

PHOTO 6 →
Fractured G13, G14 locations indicate red dye presence.



BTC JOINT ASSESMENT



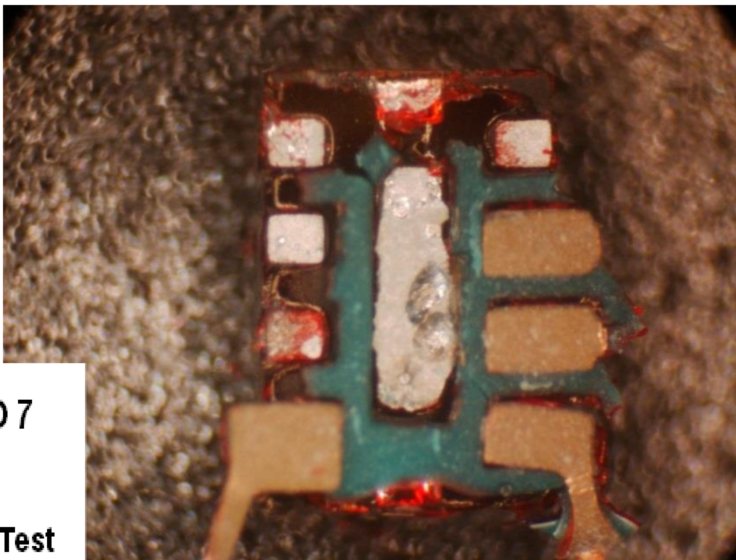


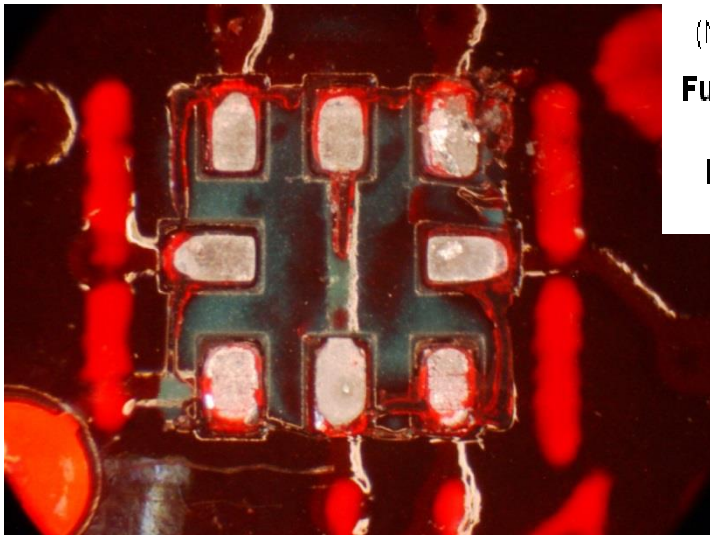
PHOTO 7

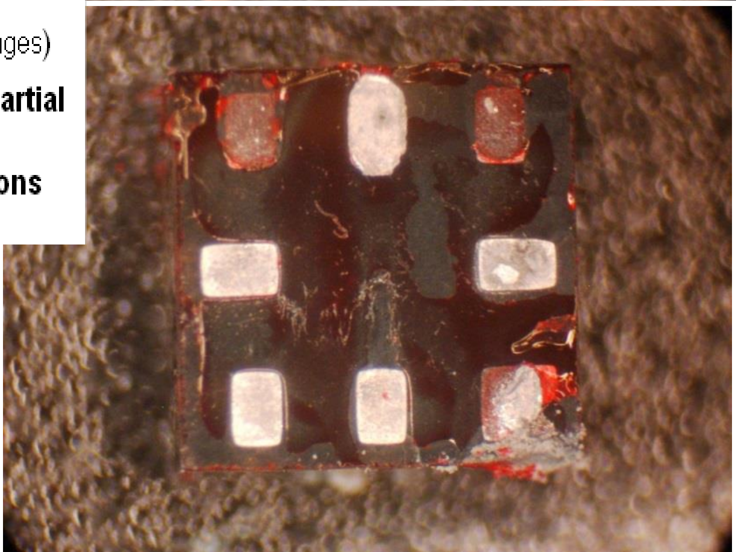
BTC

Dye-Pull Test

(Mirror images)

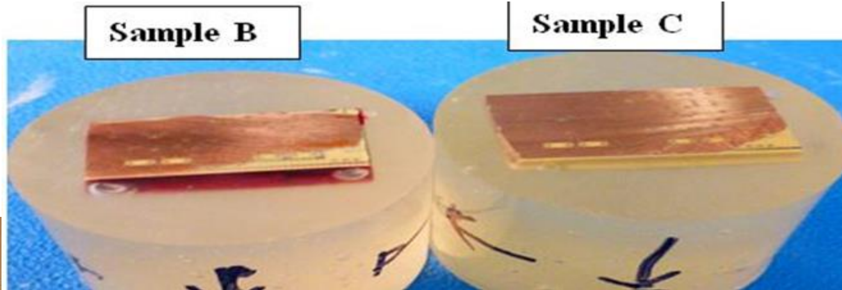
Full and Partial Joint Formations





DYE PENETRATION WITH SECTIONING

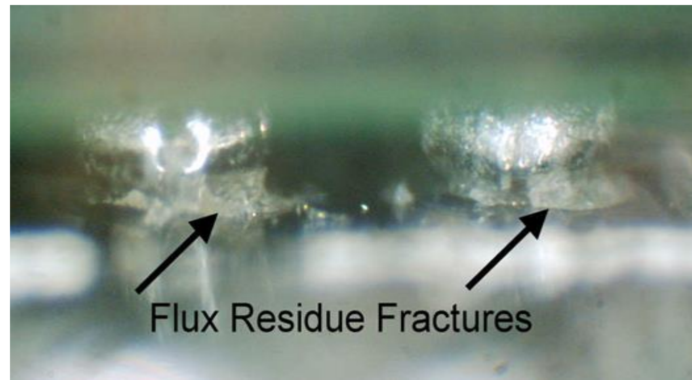
PHOTO 8
Layer
Separation
analysis with
combination
of Dye-Pull
and
Sectioning
techniques.



red tint

SUMMARY

- Dye-Pull Failure Analysis involves immersion of subject CCA area in dye to facilitate penetration in all fractures and cracks.
- The CCA processed with “No Clean” solder chemistry requires an extra effort to removal any remaining flux residues around joints to achieve good dye penetration in narrow regions.



- To avoid “false” assessment by Dye-Pull, a follow up analysis by cross-section is a common practice.

Reference: [1]IPC-TM-650 2.4.53 IPC Bottom Termination Components Task Group(5-22k)