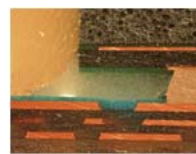


## *BGA Joint Inspection Using Dye & Pry Testing — How to Do It Yourself*



*Bob Willis*

*Bobwillisonline.com*



### *Bob Willis Involvement in Lead-Free Process Development*

*Bob Willis currently operates a training and consultancy business based in England. Bob is the Technical Manager of the SMART Group and a member of the technical committee. Although a specialist for companies implementing Surface Mount Technology Mr Willis provides training and consultancy in most areas of electronic manufacture and also conducts failure analysis and process improvement projects. In the last 12 years focusing on lead-free manufacture which has earned him the SOLDERTEC/Tin Technology Global Lead-Free Award for his contribution to the industry. He has worked with the GEC Technical Directorate as Surface Mount Co-Ordinator for both the Marconi and GEC group of companies and prior to that he was Senior Process Control Engineer with Marconi Communication Systems, where he had worked since his apprenticeship. Following his time with GEC he became Technical Director of an electronics contract manufacturing company where he formed a successful training and consultancy division. As a process engineer, he was involved in all aspects of electronic production and assembly involved in setting up production processes and evaluating materials; this also involved obtaining company approval on a wide range of Marconi's processes and products including printed circuit board manufacture for MOD and British Telecom. During the period with Marconi, experience was gained in methods and equipment for environmental testing of components, printed boards and assemblies with an interest developed in many areas of failure and defect analysis. Over the last 25 years he has been involved in all aspects of surface mounted assembly, both at production and quality level and during that time has been involved in training staff and other engineers in many aspects of modern production.*

*Mr Willis has travelled in the United States, Japan, China, New Zealand, Australia, South Africa and the Far East consulting and lecturing on electronic assembly. Mr Willis was presented with the "Paul Eisler Award by the IMF (Institute of Metal Finishing)" for the best technical paper during their technical programmes. He has conducted SMT Training programs for Texas Instruments and ran Reflow and Wave Soldering Workshops in Europe for one of the largest suppliers. Mr Willis is an IEE Registered Trainer and has been responsible for training courses run by the ICT and PCIF originally one of Europe's largest printed circuit associations. SMTA, Surface Mount Technology Association recently presented Bob with their 2008 International Leadership Award for continued contribution to industry. Bob recently accepted a IPC Committee Award for contribution to their standards. Bob has conducted workshops and set up production lines, assembly features & his "Process Advice and Defect Clinic" with all the major organisations and exhibition organisers World Wide and is known for being an entertaining presenter and the only presenter to use unique process video clips during his workshops to demonstrate each point made.*

Seminar presentation from Bobwillisonline.com



Mr Willis was Chairman of the SMART Group, European Surface Mount Trade Association from 1990-94 and has been elected Honorary President for life and currently holds the position of SMART Group Technical Manager, he also works on BSI Standards Working Parties. He is a Fellow of the Institute Circuit Technology, an NVQ Assessor, Member of the Institute of Quality Assurance and Society of Environmental Test Engineers. Bob Willis has written regular features for AMT Ireland, Asian Electronics Engineer, Circuits Assembly plus Global SMT magazines. He was responsible for writing each of the SMART Group Technology Charity reports, which were sold in Europe and America by the SMTA to raise money for worthy causes. Bob Willis helped organise the SMART Group-Lead Free Mission to Japan to examine and report on the current state of lead-free research and implementation of lead-free processes. Bob ran the SMART Group PPM Monitoring Project in the United Kingdom supported by the Department of Trade and Industry and coordinator of the LEADOUT Project for the SMART Group.

[www.ASKbobwillis.com](http://www.ASKbobwillis.com)  
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## ***BGA Joint Inspection Using Dye & Pry Testing – How to Do It Yourself***

Chairman Heather McCormick, Celestica Inc.  
Tuesday, October 26 2010

Instructor: Bob Willis, [ASKbobwillis.com](http://ASKbobwillis.com)

Today the most common methods of inspecting solder joints on Ball Grid Array (BGA), Chip Scale Package (CSP) or Flip Chip is X-ray or side view inspection using a fiber optic system. Each has its advantages and disadvantages but a combination of both is ideal provided you can justify both pieces of process equipment. One area which is still difficult to detect is the subtle open circuit caused by wetting problems on the pad surfaces or flex of the BGA or printed board. Wetting problems are more common than some people think. This is particularly true on nickel/gold finished boards. In this case the gold is dissolved into the solder during reflow as the solder wets across the pad surface but a joint can fail to form between the base nickel. This type of defect is difficult, if not impossible, to detect with either of the traditional inspection techniques.

Dye penetrants have been used for many years for a variety of applications, the most common being the testing of welded joints and castings prior to destructive analysis. They have also been used in surface coatings to detect minor imperfections. In the case of BGA, CSP and flip chip it is simple to mechanically break or flex the component from the board and check where the joint may have failed. The dye however provides a much better indicator of where complete or partial fractures may have taken place before the component is removed from the board. The surface of the joints can then be examined for dye penetration.

Benefits of destructive examination  
Why do dye and pry  
Printed board assembly preparation  
Selective the correct dye

The need for vacuum?  
Removing area array devices in one piece  
Correct identification of failure  
Common examples of failure and cure

***Webinar available online at [www.bobwillisonline.com](http://www.bobwillisonline.com)***

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just provide your email address after  
the presentation*

### *Why Do Dye & Pry?*

Can't define failure site by:  
optical or x-ray inspection  
electrical test

Cheap alternative test to undertake  
Fairly easy to obtain location of failure/damage  
Fast assessment technique in manufacture  
Often supports other environmental testing

## ***Mechanical Dye & Pry Testing***

Illustrate/record cracks in solder joints. Make visible after component removal with *D&P*

Normally used after some form of thermal or mechanical testing at PCB level

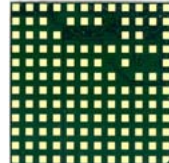
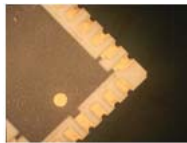
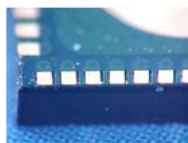
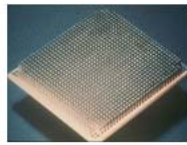
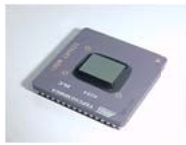
Dye penetrates cracks/gaps in bulk solder joints, interfaces or under pads on PCB

Permanent record of the failure location with either red or yellow dye colouring agent

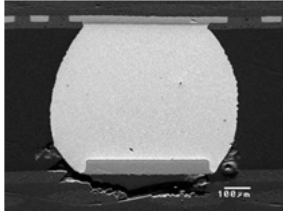
Easy to use with many area array components, more difficult with others!!!!

Due to lack of stand off and solder joint position *D&P* is difficult with BMC/QFN/LGAs

## ***What Components Can Be Tested?***



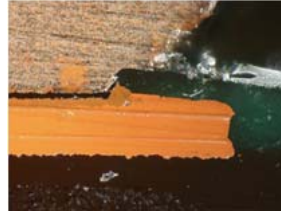
## *Practical Site Failures*



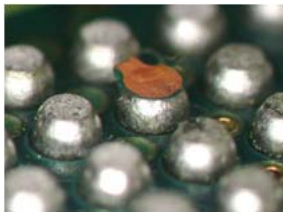
Laminate crack



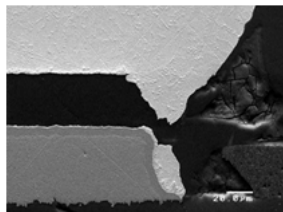
Pad separation



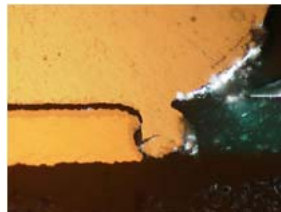
Joint crack



Component pads separating

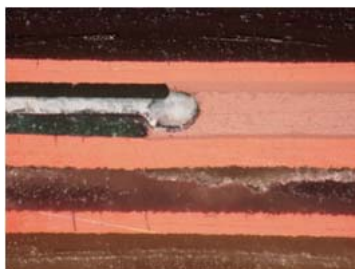


Joint crack

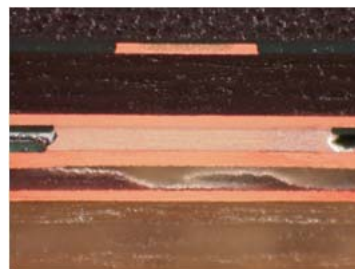


Joint crack

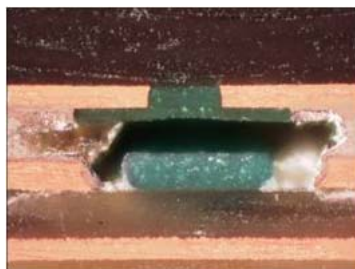
## *Practical Site Failures*



Cracking in the laminate below the pad



Cracking in the laminate below the pad

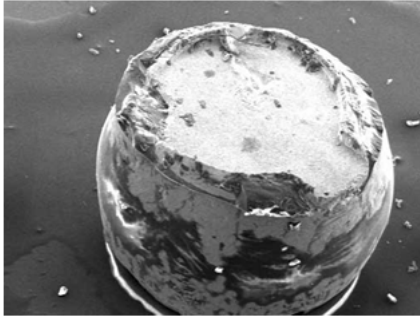


Corrosion under the package

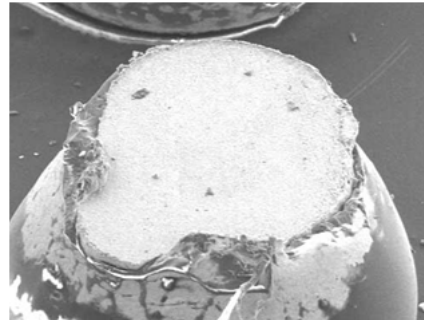


Crack after mechanical testing in corners

## *Practical Site Failures*



*F1 racing car*



## *What Do You Need?*

Sample boards

Dye penetrant (Eli Chemical Company)  
(Dyken-US market)

Protective gloves avoids red fingers

Protective coat and safety glasses

Vacuum facility

Cleaning facility

Baking oven

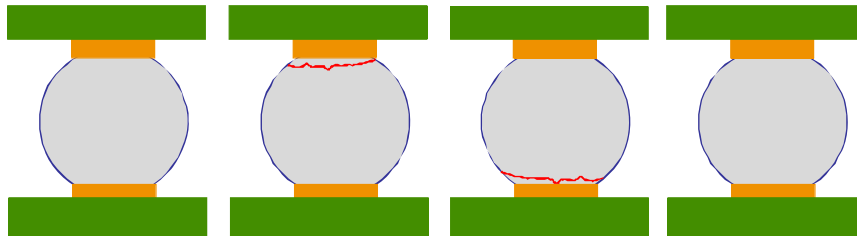
Wood chisel or level tool

Microscope & camera





## *Define Area Array Failures Sites*



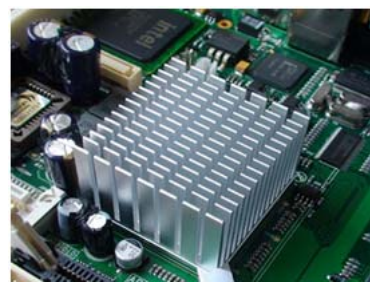
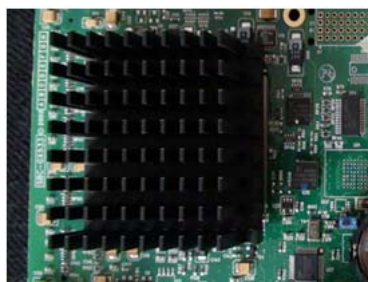
Laminate separation

Copper pad separation

BGA laminate separation

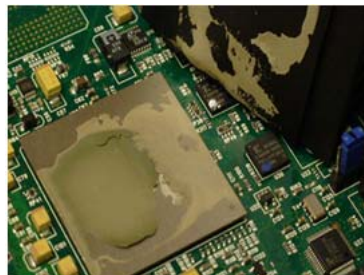
BGA pad separation

## *Practical Obstructions to Testing*

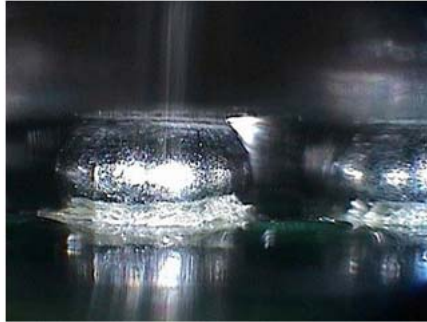


Bonded heat sinks may need to be removed to gain access for optical/x-ray inspection. This should be considered during the selection of the adhesive or bond pad material.

Don't let contractors change it!!!!

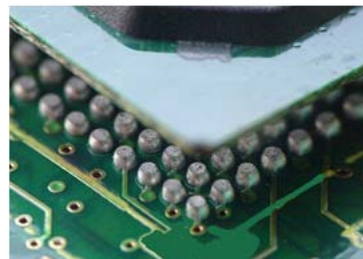
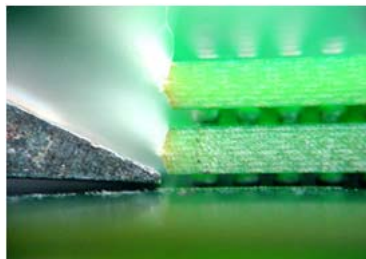
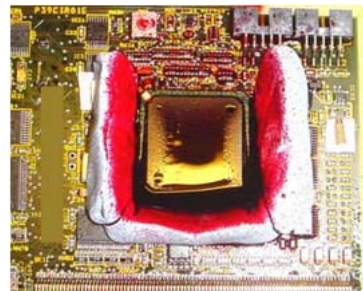


## *Dye Penetration Testing*

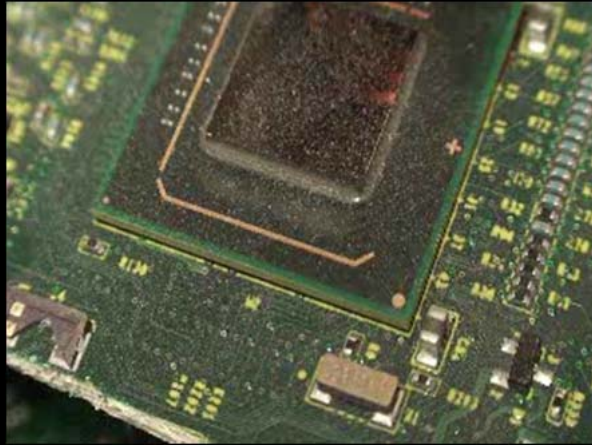


Care needs to be taken when using dye as excessive flux residues can prevent penetration and lead to failures not being detected. Any conformal coating needs to be removed completely from under the BGA, underfill can also be an issue to the testing procedure

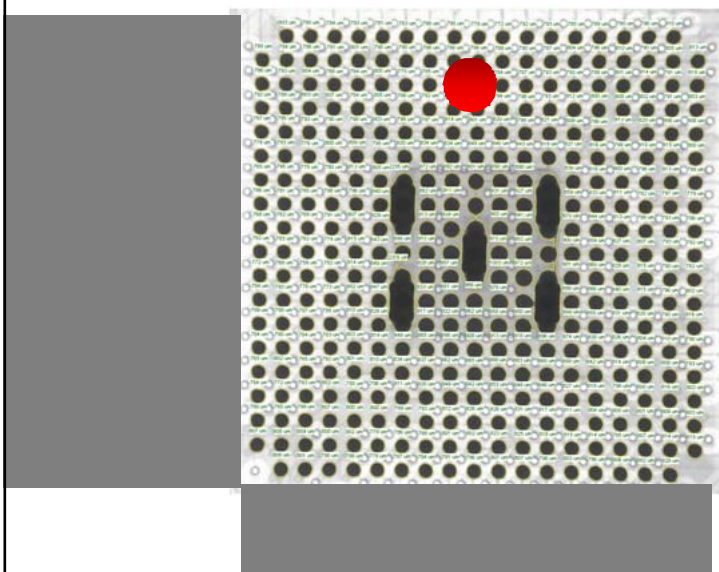
## *Dye Penetration Testing*



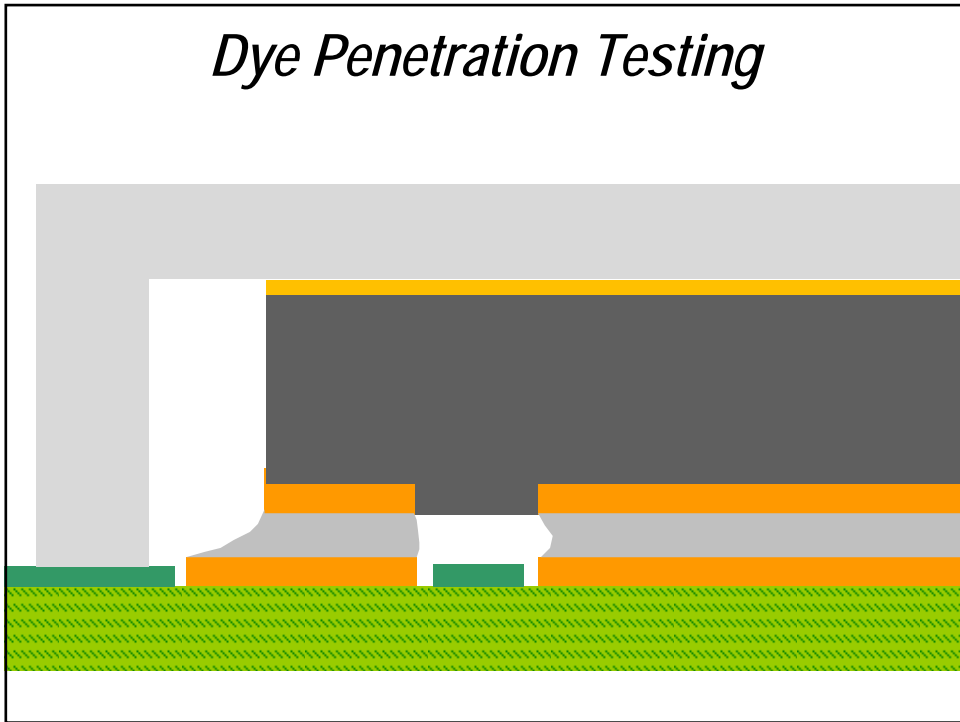




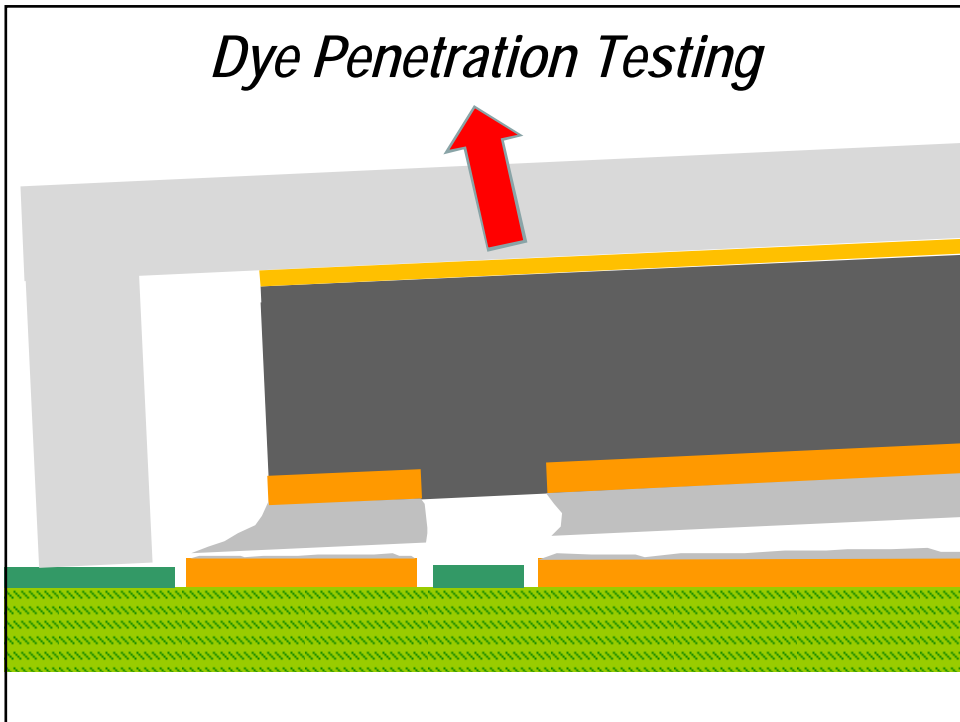
### *Define Area Array Failure Sites*



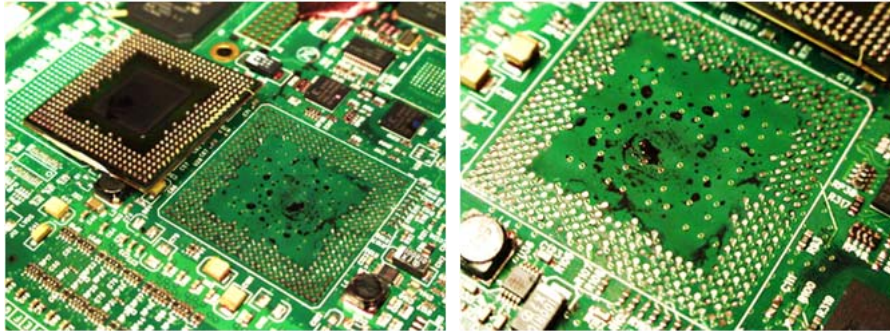
## *Dye Penetration Testing*



## *Dye Penetration Testing*



## *Inspection after Component Removal*



Ideally the surface of the component and board surfaces will be clean with no excess dye after the cleaning process. In the example above the non populated area does have dye still on the surface of the board which may be due to the stand off height or the cleaning process.

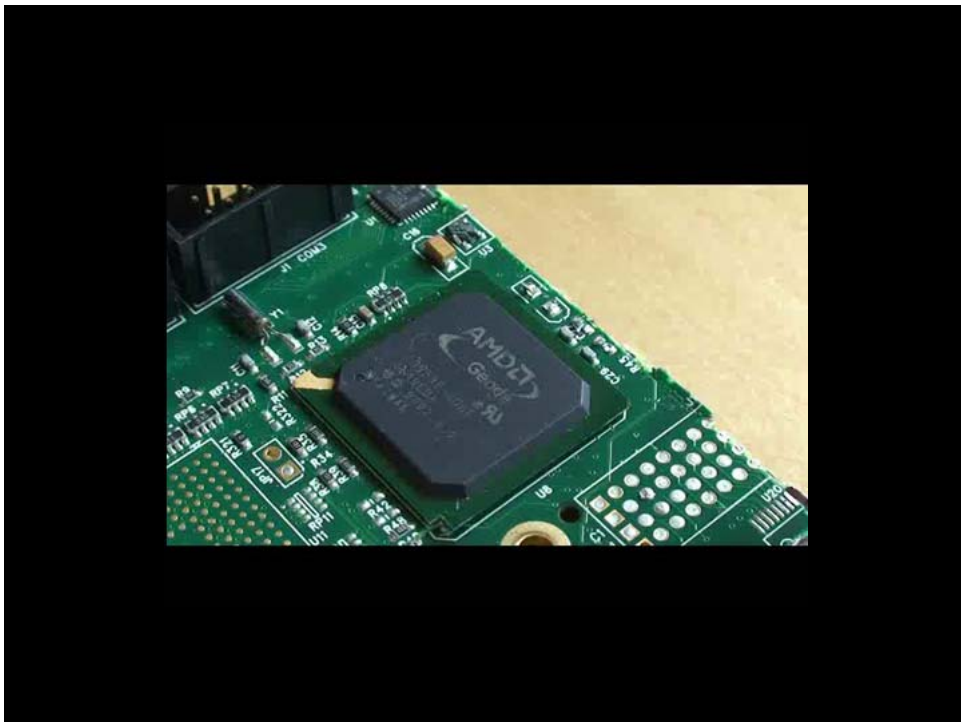
## *Vacuum Chamber*



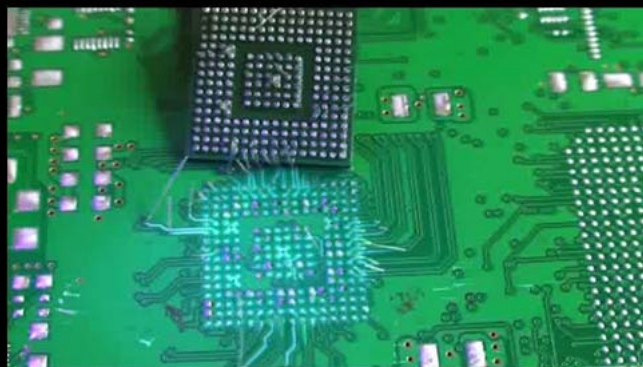
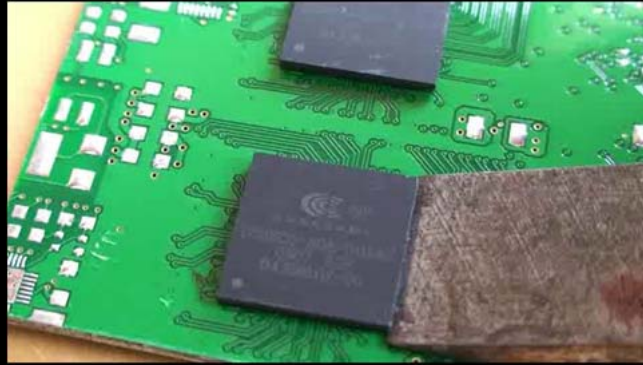
Defined in most procedures to aid the dye penetrate into cracks in the joints and under pads that have separated.

Used on all customer sponsored projects for D&P





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### *Dye Coverage at Failure Location*



Define some assessment reference for logging failure site coverage 75% or greater



50%



25% or less

This is not a criteria just a suggested reference

### *Dye Failure Type & Location*

Failure type

PCB Pad

PCB joint

Component pad

Component joint

Failure location

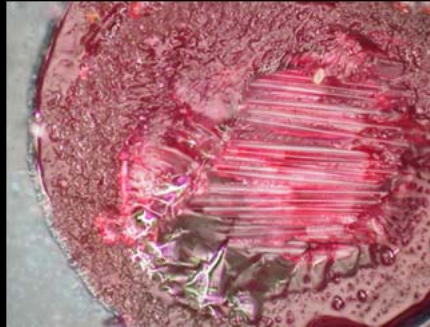
A1

A2 etc

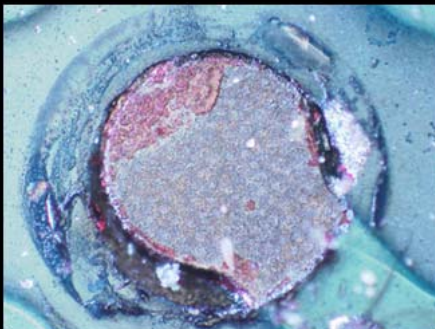
A 10x10 grid of squares. The bottom-left corner, consisting of a 3x3 block of squares, is shaded red. The remaining 77 squares are white.



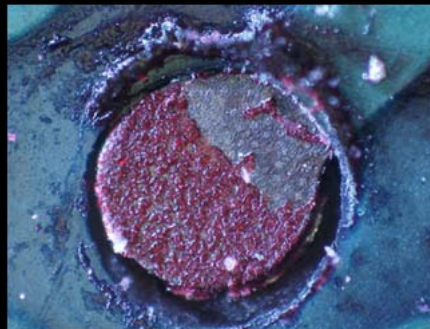
Dye around the pad and in the solder mask aperture. There is no evidence of the pad failure prior to dye application



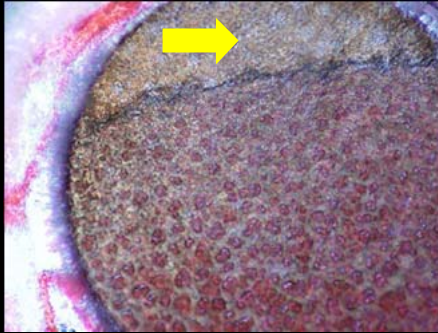
Dye under the pad and in the solder mask aperture. There is evidence of the pad failure prior to dye & pry



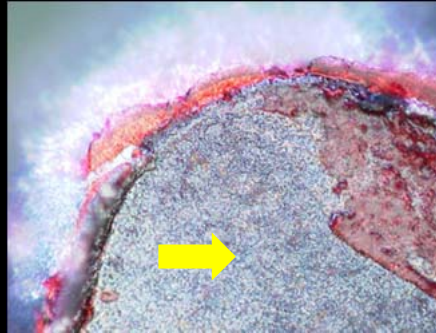
Dye on the pad surface indicating partial joint separation from the pad



Dye on the pad surface indicating joint separation from the pad



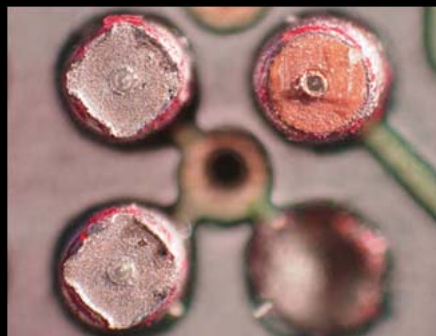
Dye on the bottom surface of the ball indicating joint separation from the pad



Dye on the bottom surface of the ball indicating partial joint separation from the pad

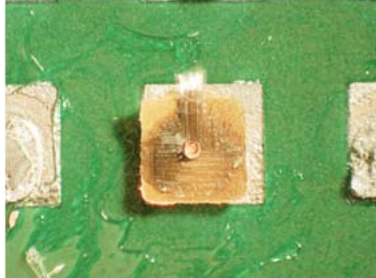


Dye visible around the ball and on solder mask which has not been cleaned effectively. There is no evidence of failure after the testing procedure

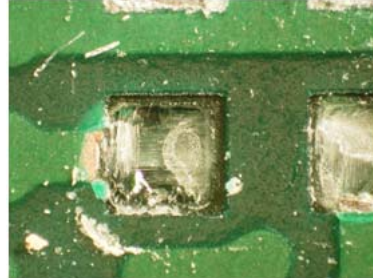


Dye visible around the ball and on solder mask which has not been cleaned effectively. There is no evidence of failure from the dye & pry test

## *Mechanical Dye & Pry Testing*



Pad separation from component



Pad separation from PCB substrate

Examples of pad separation from the BMC body and PCB laminate after dye & pry testing of the assembly, no dye marks no problem on parts



Video of testing parts after liquid nitrogen immersion for 3-4min based on procedure in IPC 7093

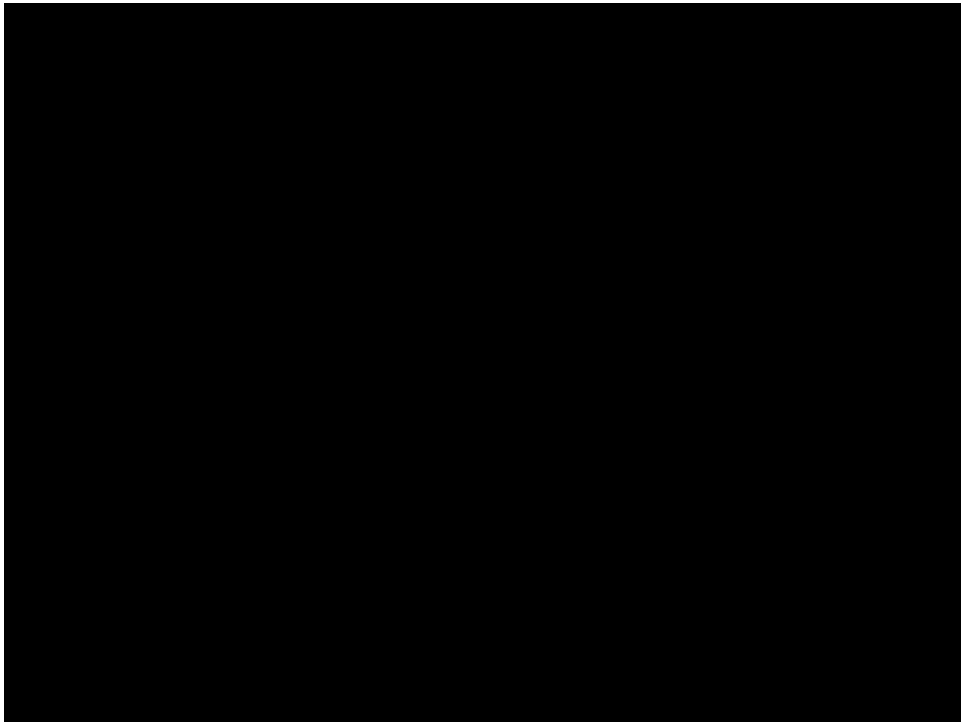


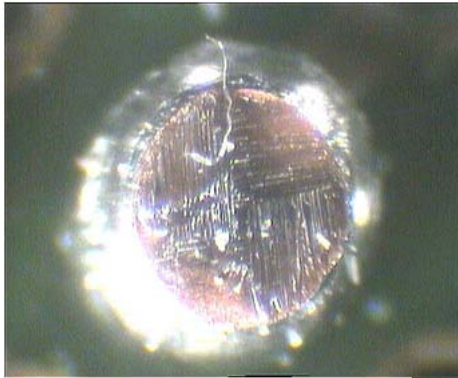


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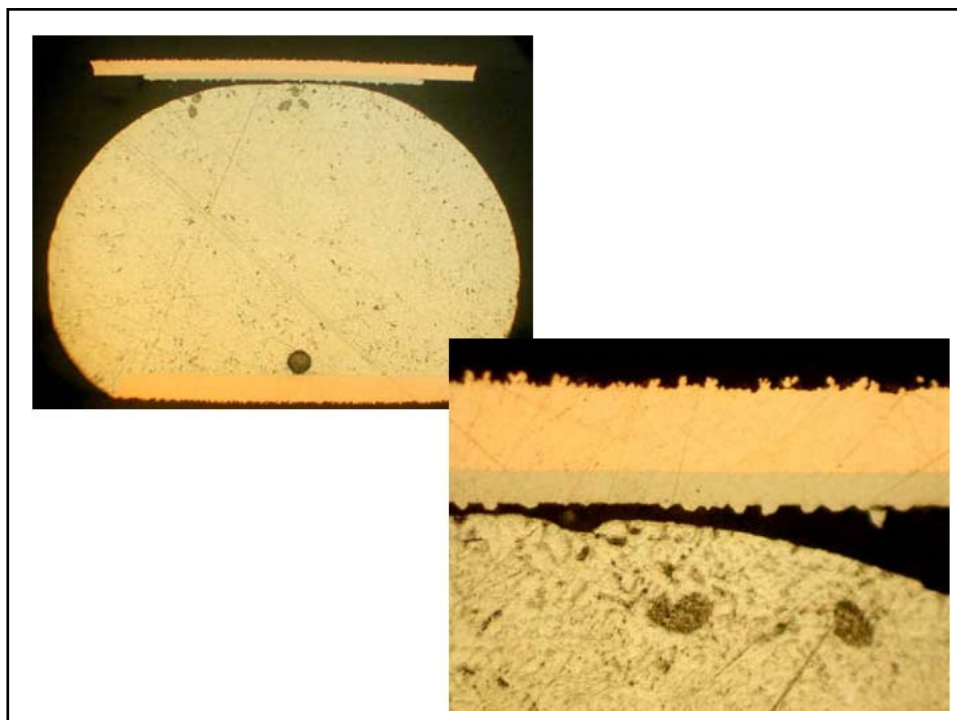
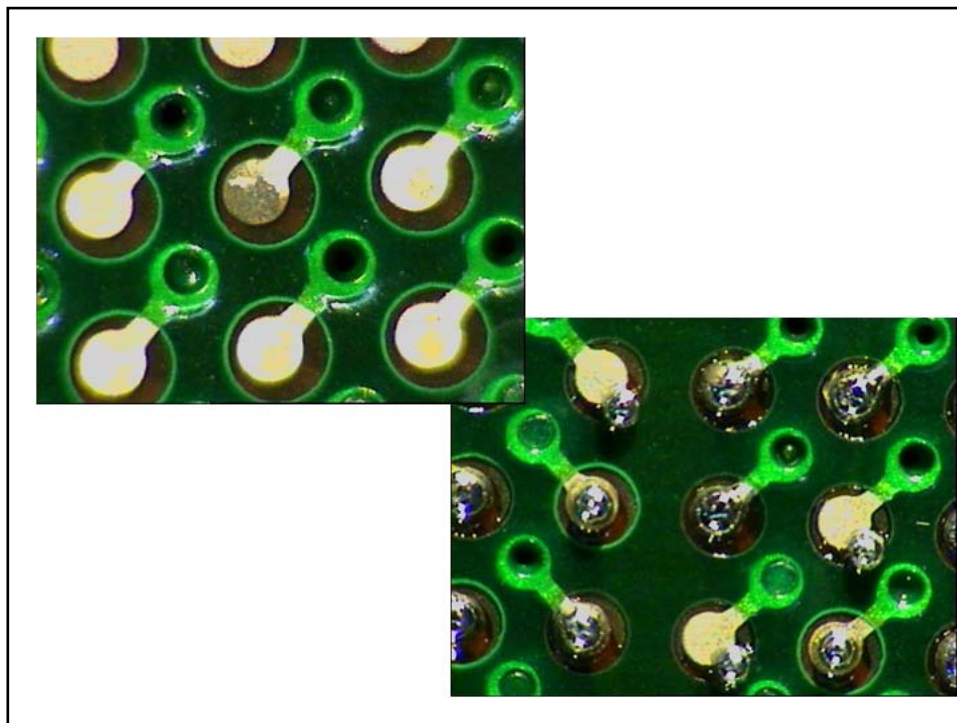


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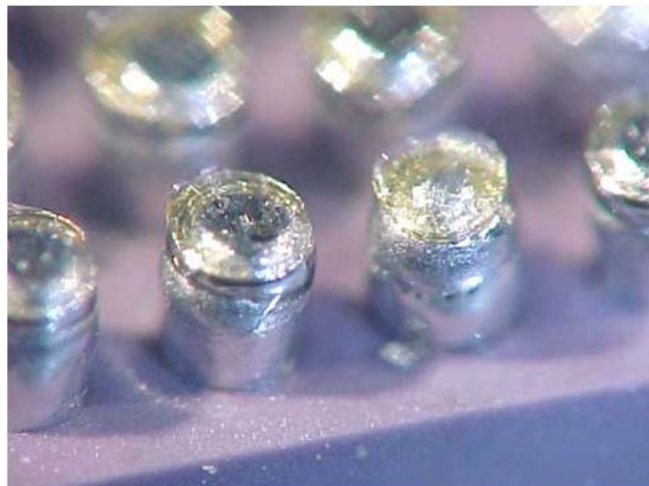
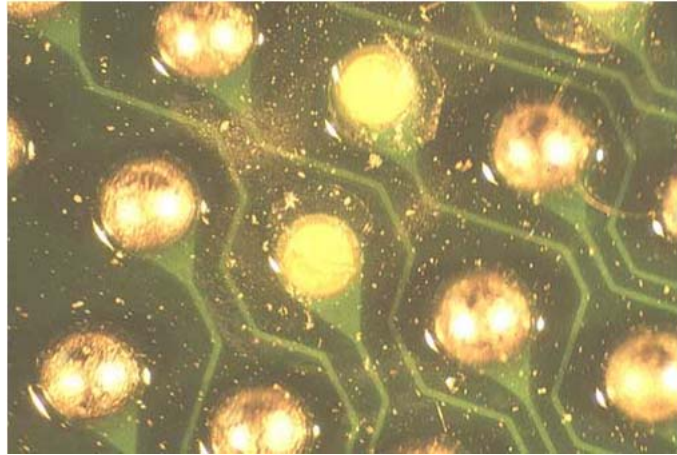




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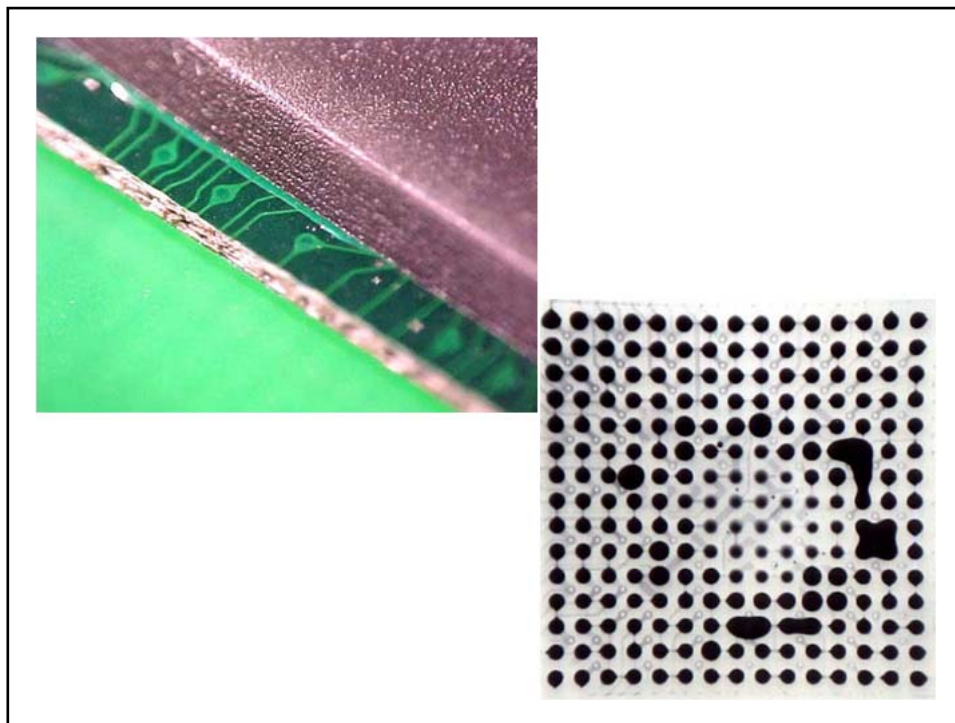


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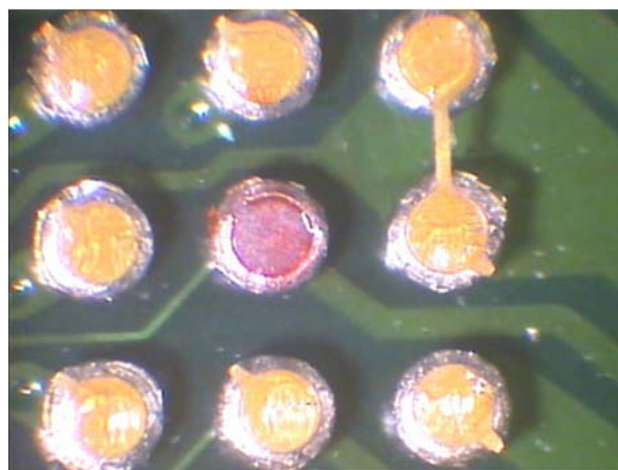


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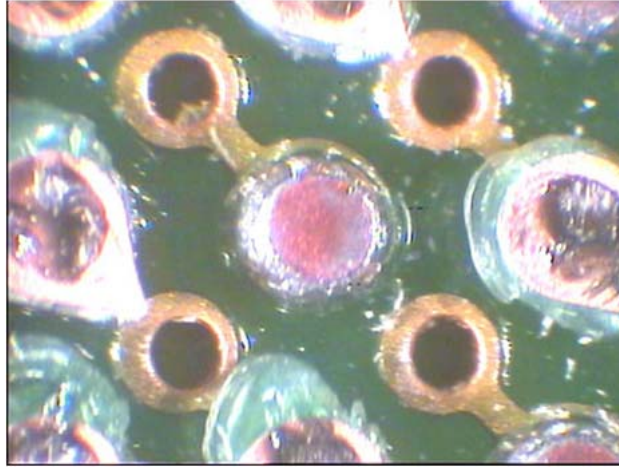


## *Dye Penetration Testing*

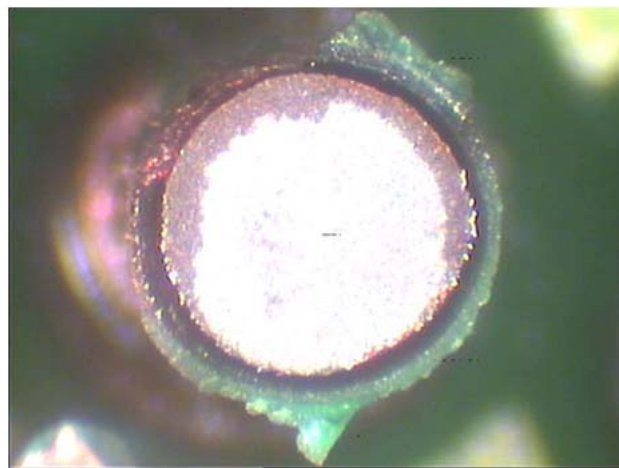




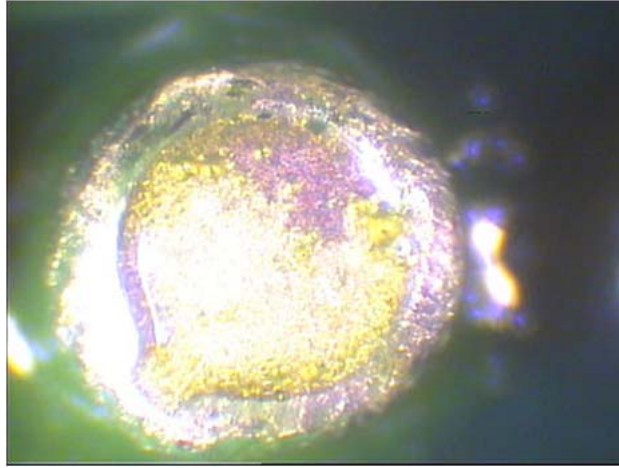
## *Dye Penetration Testing*



## *Dye Penetration Testing*



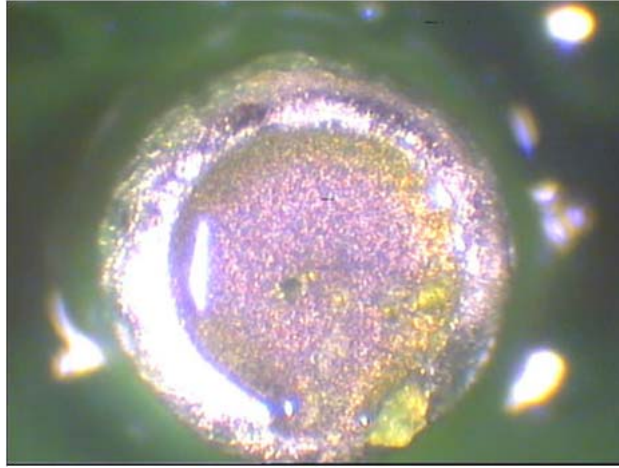
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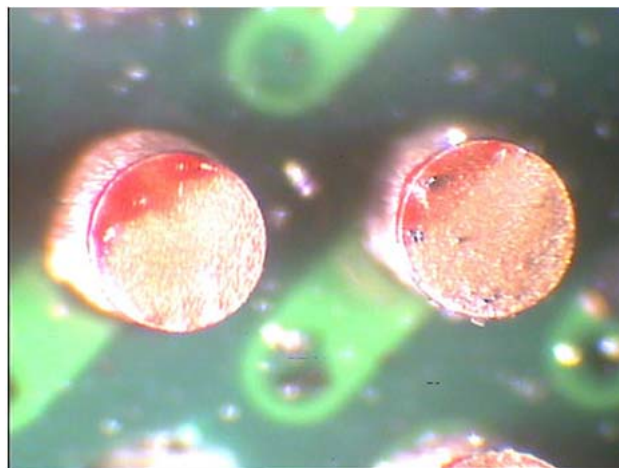
## *Dye Penetration Testing*



## *Dye Penetration Testing*



## *Dye Penetration Testing*



## *Dye Penetration Testing*

