



IPC-TR-586

Immersion Silver Plating Thickness Round Robin Investigation Data Set Compendium

March 2009

A Technical Report

Association Connecting Electronics Industries



The Principles of Standardization

In May 1995 the IPC's Technical Activities Executive Committee (TAEC) adopted Principles of Standardization as a guiding principle of IPC's standardization efforts.

Standards Should:

- Show relationship to Design for Manufacturability (DFM) and Design for the Environment (DFE)
- Minimize time to market
- Contain simple (simplified) language
- Just include spec information
- Focus on end product performance
- Include a feedback system on use and problems for future improvement

Standards Should Not:

- Inhibit innovation
- Increase time-to-market
- Keep people out
- Increase cycle time
- Tell you how to make something
- Contain anything that cannot be defended with data

Notice

IPC Standards and Publications are designed to serve the public interest through eliminating misunderstandings between manufacturers and purchasers, facilitating interchangeability and improvement of products, and assisting the purchaser in selecting and obtaining with minimum delay the proper product for his particular need. Existence of such Standards and Publications shall not in any respect preclude any member or nonmember of IPC from manufacturing or selling products not conforming to such Standards and Publication, nor shall the existence of such Standards and Publications preclude their voluntary use by those other than IPC members, whether the standard is to be used either domestically or internationally.

Recommended Standards and Publications are adopted by IPC without regard to whether their adoption may involve patents on articles, materials, or processes. By such action, IPC does not assume any liability to any patent owner, nor do they assume any obligation whatever to parties adopting the Recommended Standard or Publication. Users are also wholly responsible for protecting themselves against all claims of liabilities for patent infringement.

IPC Position Statement on Specification Revision Change

It is the position of IPC's Technical Activities Executive Committee that the use and implementation of IPC publications is voluntary and is part of a relationship entered into by customer and supplier. When an IPC publication is updated and a new revision is published, it is the opinion of the TAEC that the use of the new revision as part of an existing relationship is not automatic unless required by the contract. The TAEC recommends the use of the latest revision. Adopted October 6, 1998

Why is there a charge for this document?

Your purchase of this document contributes to the ongoing development of new and updated industry standards and publications. Standards allow manufacturers, customers, and suppliers to understand one another better. Standards allow manufacturers greater efficiencies when they can set up their processes to meet industry standards, allowing them to offer their customers lower costs.

IPC spends hundreds of thousands of dollars annually to support IPC's volunteers in the standards and publications development process. There are many rounds of drafts sent out for review and the committees spend hundreds of hours in review and development. IPC's staff attends and participates in committee activities, typesets and circulates document drafts, and follows all necessary procedures to qualify for ANSI approval.

IPC's membership dues have been kept low to allow as many companies as possible to participate. Therefore, the standards and publications revenue is necessary to complement dues revenue. The price schedule offers a 50% discount to IPC members. If your company buys IPC standards and publications, why not take advantage of this and the many other benefits of IPC membership as well? For more information on membership in IPC, please visit www.ipc.org or call 847/597-2872.

Thank you for your continued support.

Immersion Silver Plating Thickness Round Robin Investigation Data Set Compendium

[For the IPC 4-14 Plating Processes Subcommittee]

Compendium Summary:

IPC 4-14 Plating Processes Subcommittee develops guidelines, test methods and techniques for evaluating process control parameters on electrolytic and electroless/immersion plating systems. The Plating Processes Subcommittee has developed the IPC-4553, *Specification for Immersion Silver Plating for Printed Boards* which sets the requirements for the use of immersion silver as a surface finish for printed boards. During a revision development phase of the specification, an investigation was initiated to understand how immersion silver plating thickness impacts solder joint integrity. The activity focused on comparing typical immersion silver plating thicknesses to extreme immersion plating thicknesses for a set of standard electronic component types used on printed boards. This technical report documents the Round Robin testing effort. The Round Robin test results were used by the 4-14 Plating Processes Subcommittee in the development of immersion silver maximum plating thickness. The Technical Report Compendium is divided into three information sets:

1. Test Vehicle Assembly Report by Celestica
2. Thermal Cycle Test Report by Rockwell Collins
3. Solder Joint Silver Content Calculations by Adtran Inc.

Compendium Acknowledgements:

The following individuals/groups were active participants in the 4-14 Plating Processes Subcommittee round robin investigation. Without their efforts, the round robin testing project would not have been possible:

- Test Plan Creation/Development: 4-14 Plating Processes Subcommittee members
- PWB Test Vehicle Contributions: Gerard O'Brien, Solderability Testing and Solutions, Inc.
- Immersion Silver Finish Contributions: 4-14 Plating Processes Subcommittee surface finish supplier representatives
- Test Vehicle XRF Measurements: Gerard O'Brien, Solderability Testing and Solutions, Inc. and Frank Ferrandino, Veeco Instruments Inc.
- PWB Test Vehicle Assembly: Gail Auyeung et al, Celestica
- Thermal Cycle Testing: David Hillman et al, Rockwell Collins
- Solder Joint Silver Content Calculations: Trevor Bowers, Adtran Inc.



**Technology Assurance Laboratory
Evaluation of Immersion Silver Boards with Different Plating
Thicknesses**

Report by: Zohreh Bagheri, B.Eng. and Polina Snugovsky, Ph.D, Sc.D Title: Global Metallurgical Consultant Signature: Date: October 19, 2006	Approved by: Marianne Romansky, Ph.D. Title: TA Lab Manager Signature: Date: October 20, 2006
---	---

**Client Information**

Client Name: Gail Auyeung
Company Name: Celestica
Address: 1150 Eglinton Ave. East
City, Province/State: Toronto, Ontario
Postal/Zip Code:
Tel: 416-448-5924 **Fax:**
Email:

ISO9001 Registered #001917

CELESTICA INC.
Technology Assurance Labs
Engineering Services
844 Don Mills Rd.
Toronto, Ontario
M3C 1V7
www.celestica.com/engineering

Contact:
Telephone: 416-448-6284
Fax: 416-448-4810

General Inquiries: 416-448-5800

Revision History			
Revision:	Created by:	Date:	Short Description
1	Zohreh Bagheri	10/19/2006	Initial report
2	Polina Snugovsky	10/19/2006	Final edit
3			

EXECUTIVE SUMMARY

Four immersion silver plated boards were submitted to the lab for evaluation. The boards were supplied from three different vendors with different silver thicknesses.

- Vendor A 3X SAC
- Vendor G X SAC
- Vendor D 3X Lead
- Vendor G X Lead

Five Pb-Free components were assembled on the boards using Sn-Pb and Pb-Free pastes. More voiding as well as Champagne voiding was seen in A3X SAC and GX SAC boards.

The intermetallic layers at the component and board sides were found to be properly formed on all boards.

There was no significant difference in microstructure formed on D3X Lead and GX Lead boards.

There were more Ag₃Sn plates and they were larger in A3XSAC than GX SAC boards.

It was observed that the Pb-free balls of the BGA components were not completely mixed with the Sn-Pb paste on boards D3X Lead and GX Lead.

TABLE OF CONTENTS

1.	INTRODUCTION.....	5
1.1	PRODUCT INFORMATION	5
1.2	BACKGROUND.....	5
2.	INSTRUMENTATION	5
3.	TEST PROCEDURE	6
3.1	X-RAY	6
3.2	XRF	6
3.3	CROSS-SECTIONING AND OPTICAL MICROSCOPY	7
4.	RESULTS	6
4.1	X-RAY	6
4.2	XRF	6
4.3	CROSS-SECTIONING AND OPTICAL MICROSCOPY	7
5.	APPENDIX.....	7



1. INTRODUCTION

1.1 PRODUCT INFORMATION

Product under test:

Part Name: Imm Ag boards	Part #:
Description: • Vendor A 3X SAC • Vendor G X SAC • Vendor D 3X Lead • Vendor G X Lead	
Serial #s Tested: N/A	Quantity Provided: 1 each

1.2 BACKGROUND

The boards with normal plating thickness and 3X thickness were assembled with five Pb-free components as below:

- QFP208-4
- MLFP L16
- Capacitor
- PBGA 71057
- PBGA 70796

2. INSTRUMENTATION

Description	Serial Number	Calibration Due
Nikon Microscope MM-11	MG000L3144	N/A
Phoenix X-ray	C0012469	N/A
CMI X-Ray Fluorescence	C0013492	12/01/2006



3. TEST PROCEDURE

3.1 XRF

Plating thickness measurements were done on four fiducials on each board, as the other locations were soldered. An aperture size of 2x10 mil and 1/2 inch working distance was used. A spot check for calibration confirmation was performed using a 37 μm Ag standard over Cu as the base metal. (The spot check confirmed the top layer (Ag) measurement within +/- 5% of the indicated thickness, per instrument spec).

3.2 X-Ray

Transmissive Xray examination was performed on all of the boards and components.

3.3 Cross sections

One part of each type was cut out from each board. The sections were subsequently mounted in the potting media and prepared for metallurgical observation. The preparation involved diagonal cutting on PBGA 70796 and straight cutting on all other parts followed by grinding on 120, 600, 1200 grit SiC papers. Fine polishing was accomplished using 6 and 1 micron diamond slurries. The final step involved polishing with colloidal silica to expose intermetallic particles in the bulk and intermetallic layers at the interfaces.

4. RESULTS

4.1 X-Ray

The x-ray analysis showed some voiding in the joints, and more in A3X SAC and GX SAC than D3X Lead and GX Lead. (small components like MLF L16 and the capacitors show more voiding).

4.2 XRF

Table 1 below is a summary of plating thickness measurements.

Table1. Plating thickness measurement in μm Ag.

Board ID	Fiducial 1	Fiducial 2	Fiducial 3	Fiducial 4
A3X SAC	36.9	30.8	31.3	38.0
GX SAC	14.8	13.3	12.8	13.2
D3X Lead	11.8	13.0	9.5	13.0
GX Lead	13.5	14.5	10.5	12.6



4.3 Cross-sectioning and Optical Microscopy

The microstructural observation revealed the following:

- Pb-free samples displayed a typical microstructure.
- The microstructure of the QFPs, capacitors and MLFP L16 parts of D3X Lead and GX Lead boards were typical of assemblies made using Sn-Pb eutectic paste.
- Partial mixing of SAC BGA balls with Sn-Pb paste was observed on all BGAs of D3X Lead and GX Lead boards.
- The microstructure of mixed technology joints consisted of Cu-Sn and Ag-Sn particles, Sn dendrites and interdendritic Pb phases.
- Needle-like Ag_3Sn intermetallics were found in A3X SAC and at lower levels in GX SAC. They were also larger in size in A3X SAC.
- Champagne voiding was seen in some of the joints of A3X SAC boards (specifically in MLFP L16). Figures 11, 18-24 in optical images.

5. X-ray and Optical Images

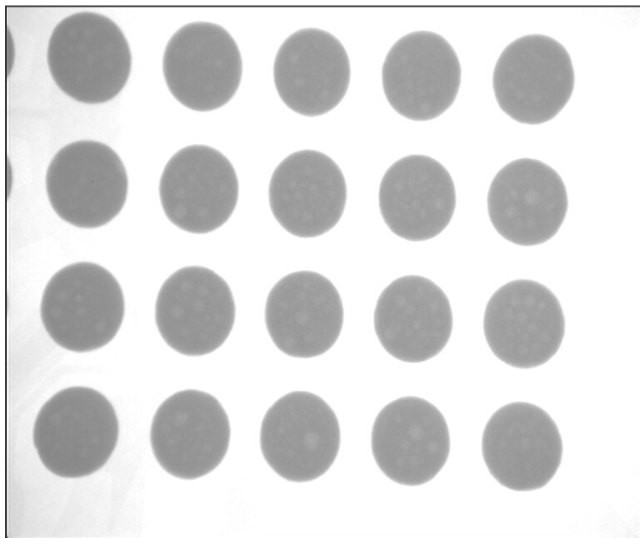


Figure 1. A3X SAC,70796,2

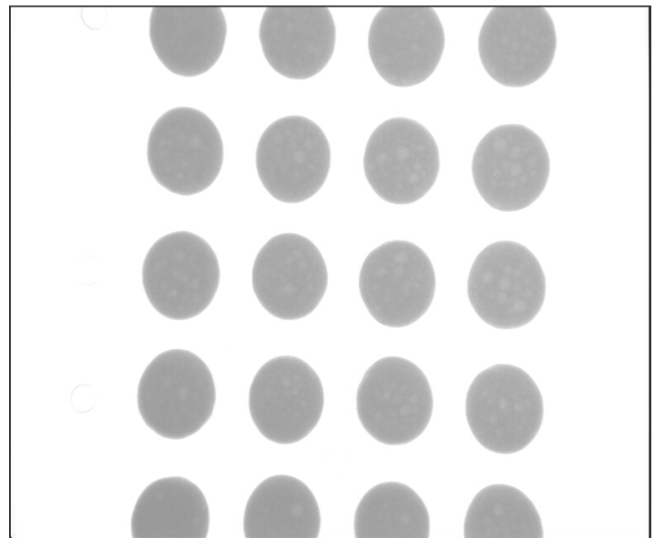


Figure 2. A3X SAC,70796

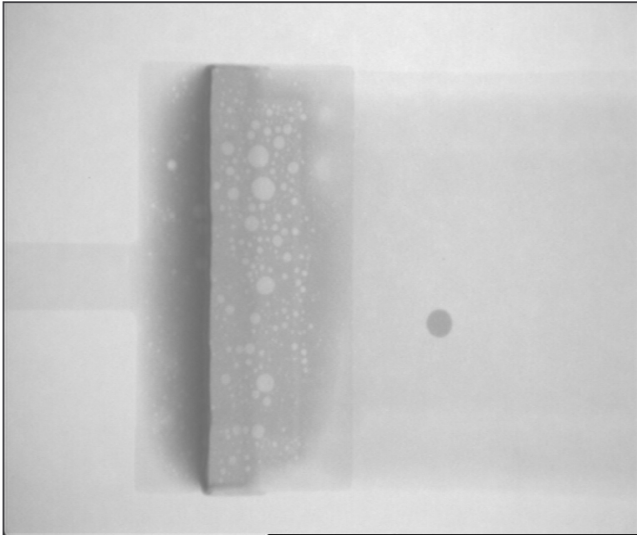


Figure 5. A3X SAC,cap,2

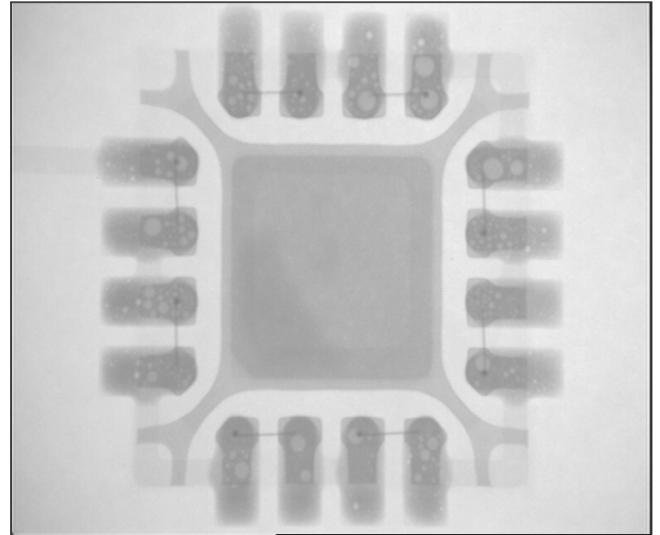


Figure 6. A3X SAC,MLFP1

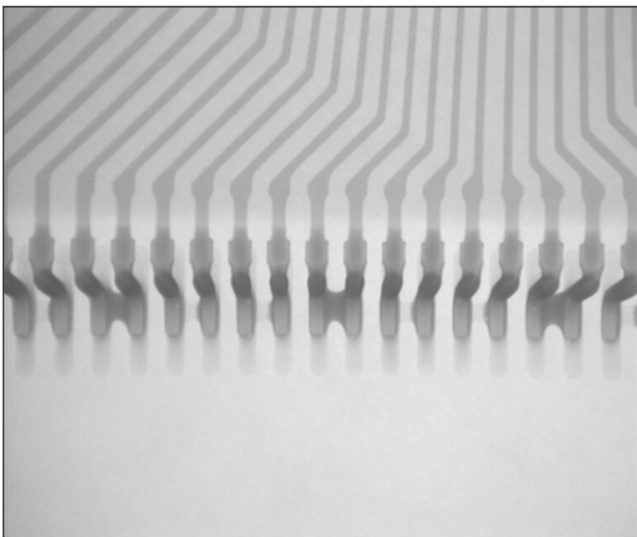


Figure 7. A3X SAC,QFP208,1

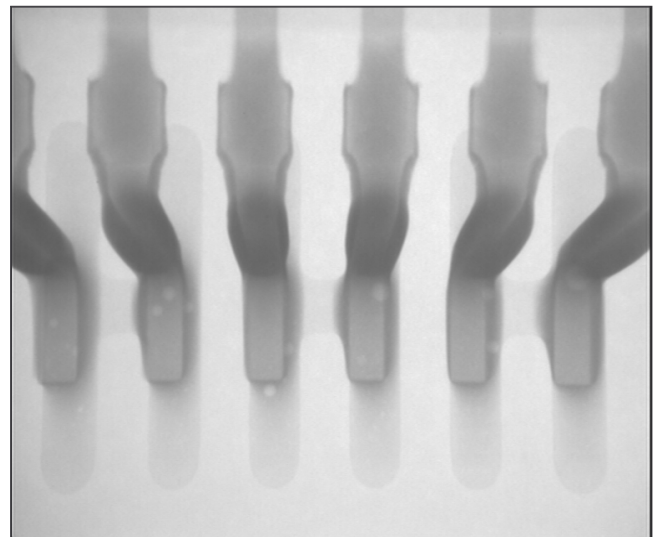


Figure 8. A3X SAC,QFP208,2

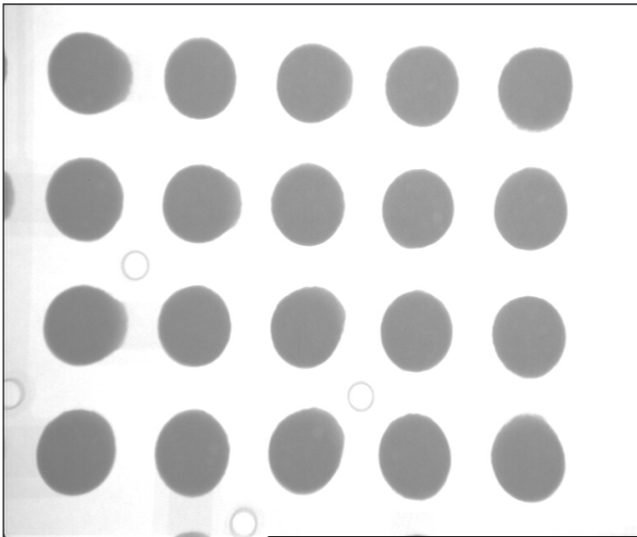


Figure 9. D3X Lead,70796

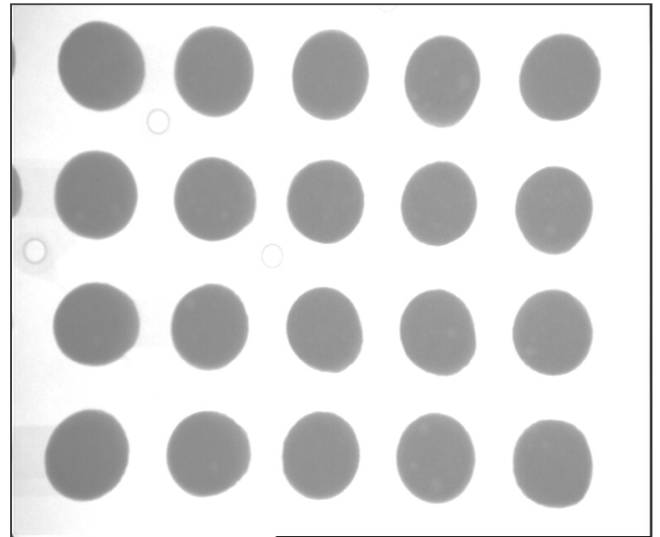


Figure 10. D3X Lead,71057

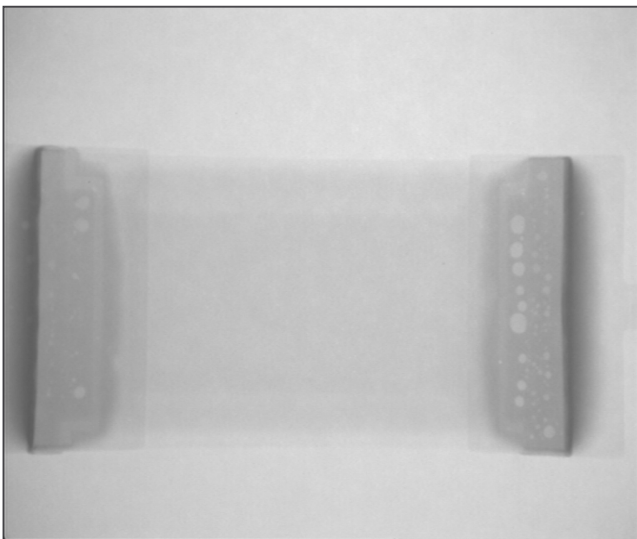


Figure 11. D3X Lead,cap,1

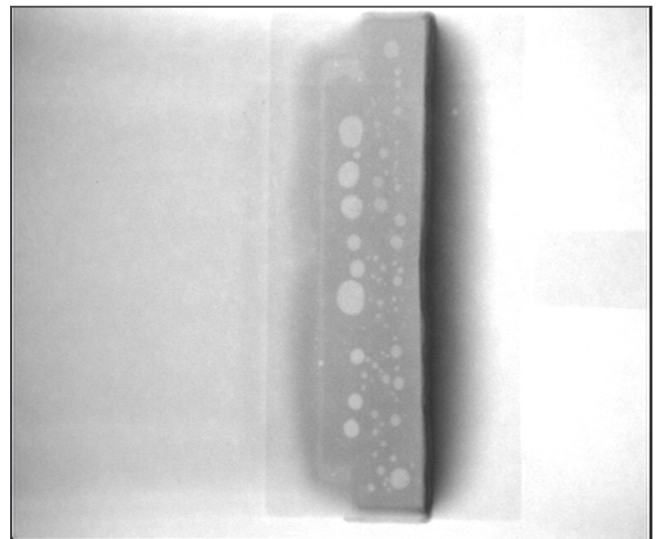


Figure 12. D3X Lead,cap,2

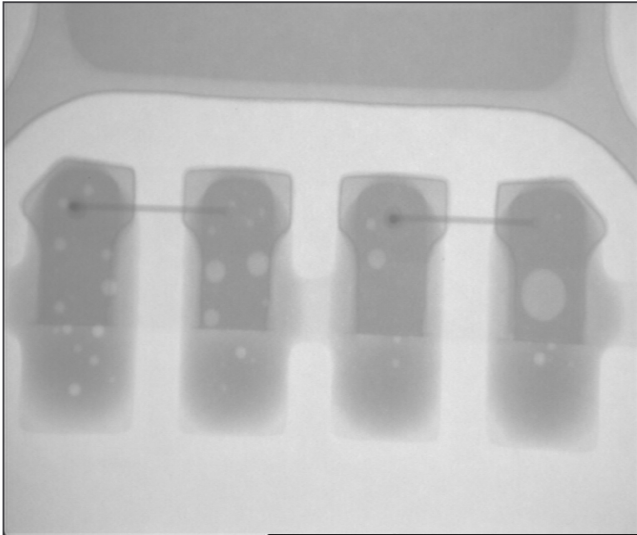


Figure 13. D3X Lead,MLFP1

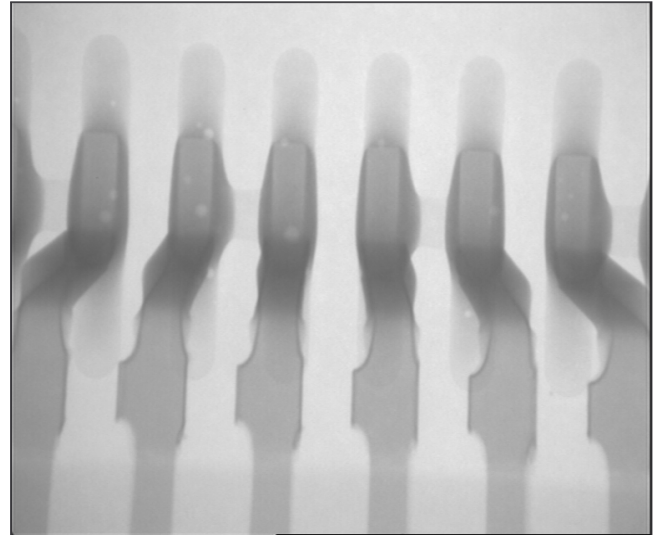


Figure 14. D3X Lead,QFP208

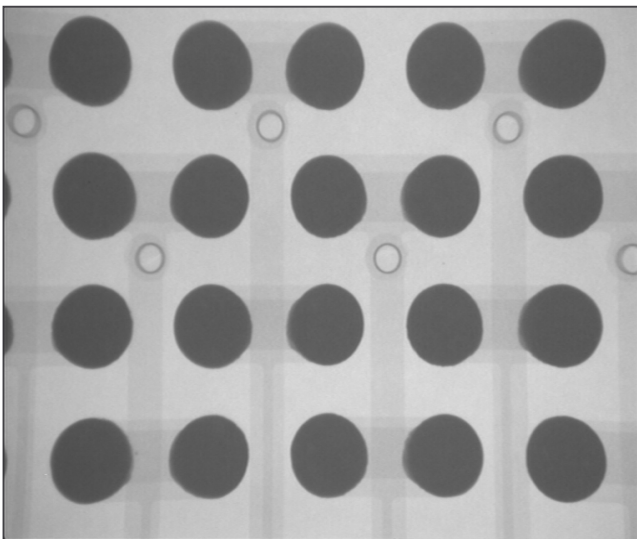


Figure 15. GX lead,70796

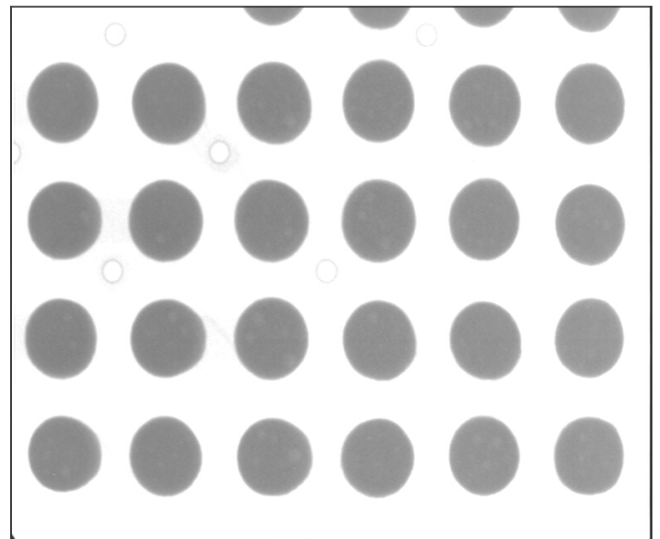


Figure 16. GX lead,71057

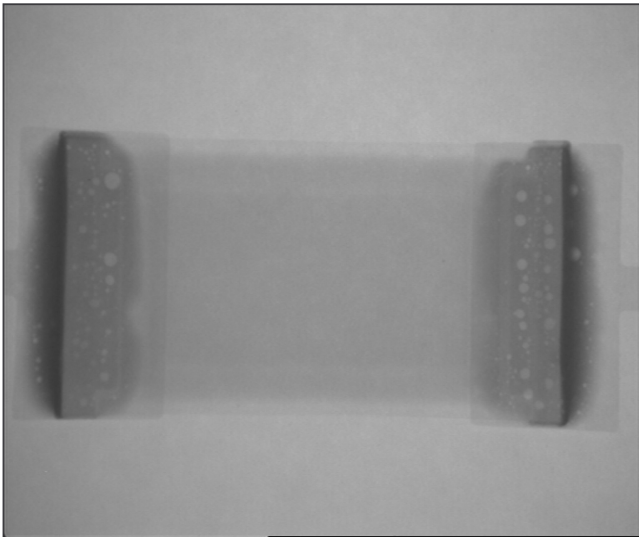


Figure 17. GX lead, cap, 1

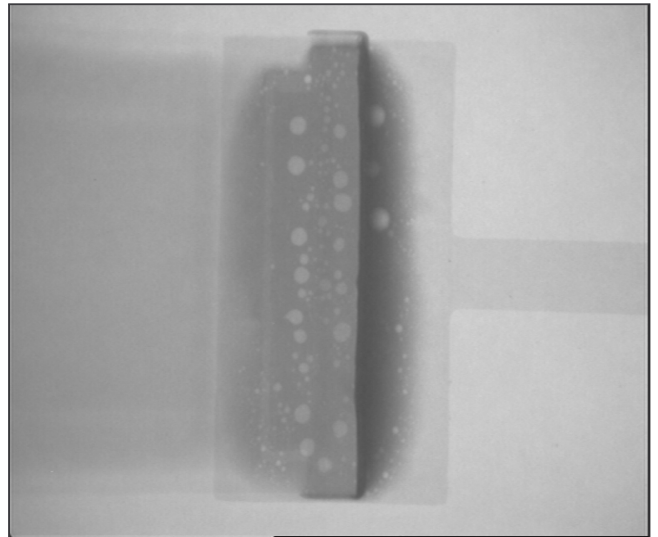


Figure 18. GX lead, cap, 2

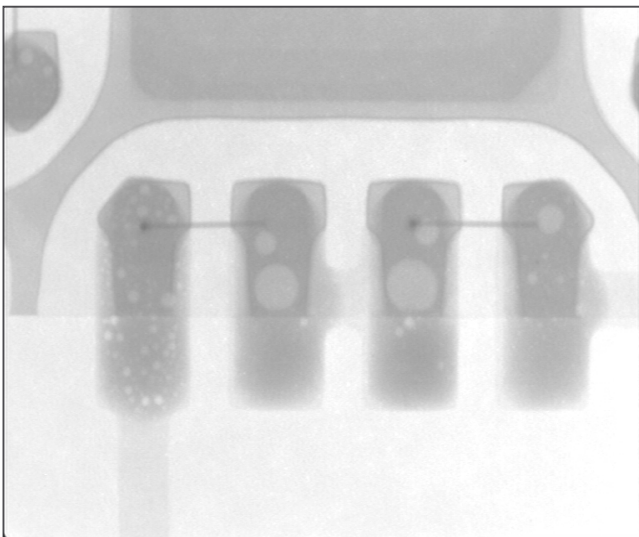


Figure 19. GX lead, MLFP1

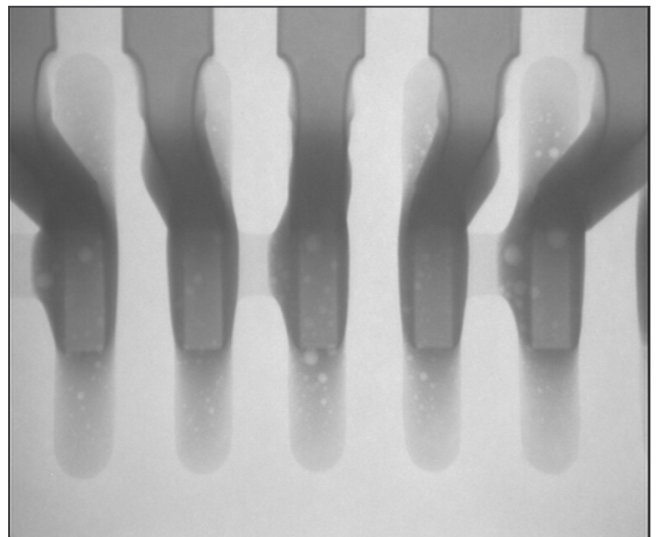


Figure 20. GX lead, QFP208, 2

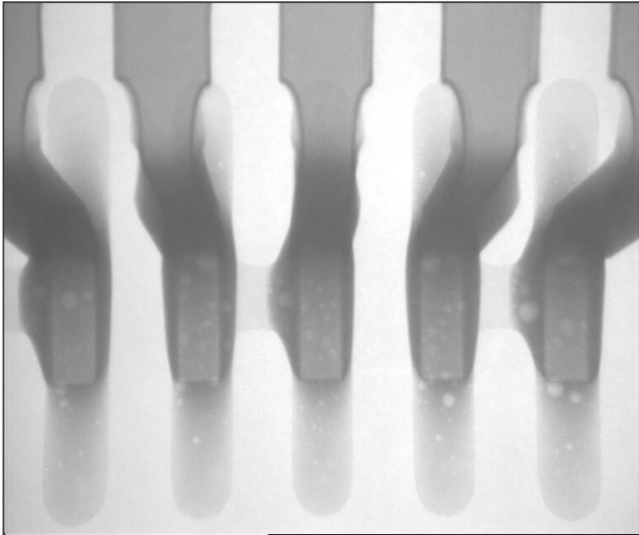


Figure 21. GX lead,QFP208

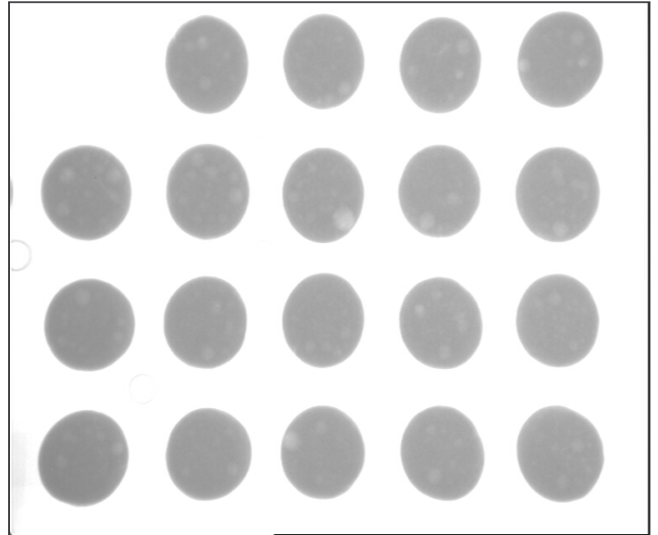


Figure 22. GX SAC,70796

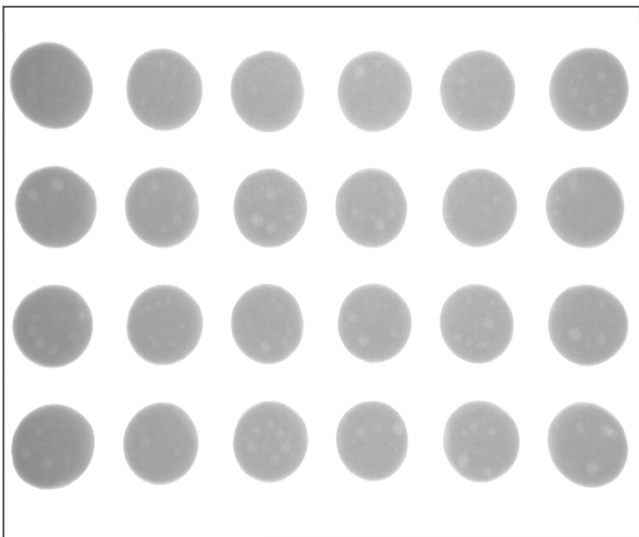


Figure 23. GX SAC,71057

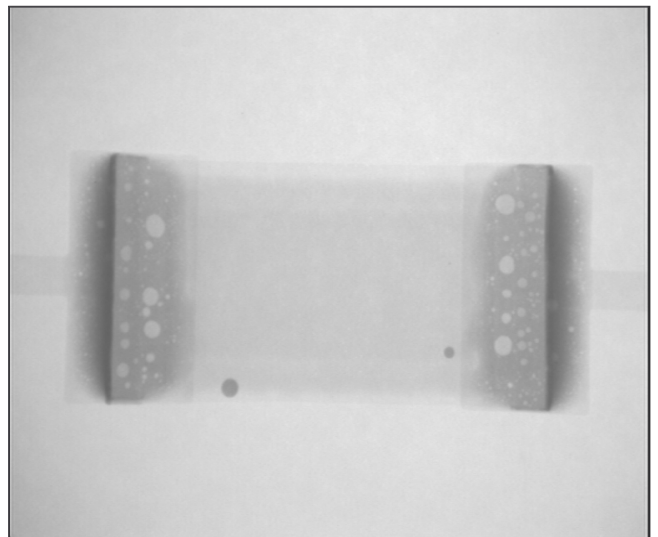


Figure 24. GX SAC,cap,1

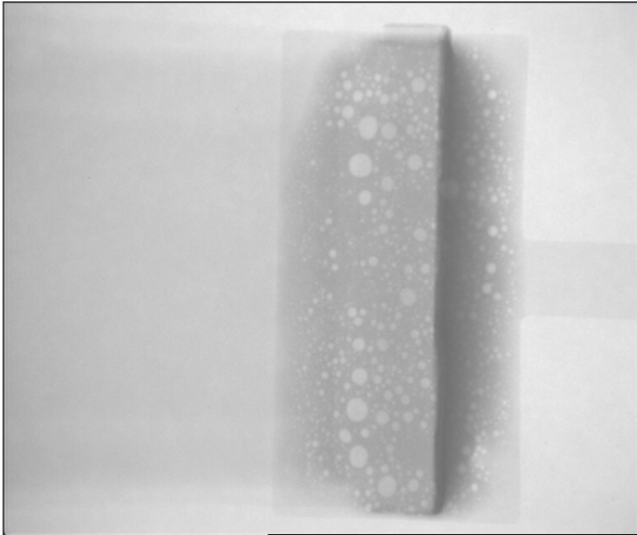


Figure 25. GX SAC, cap, 2

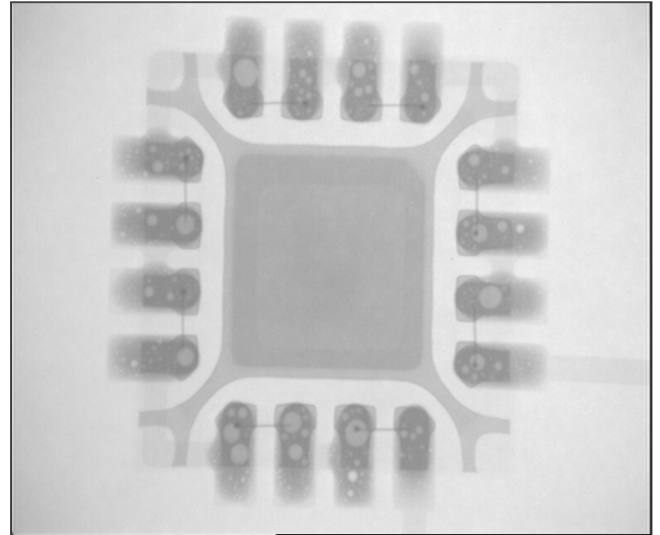


Figure 26. GX SAC, MLFP1

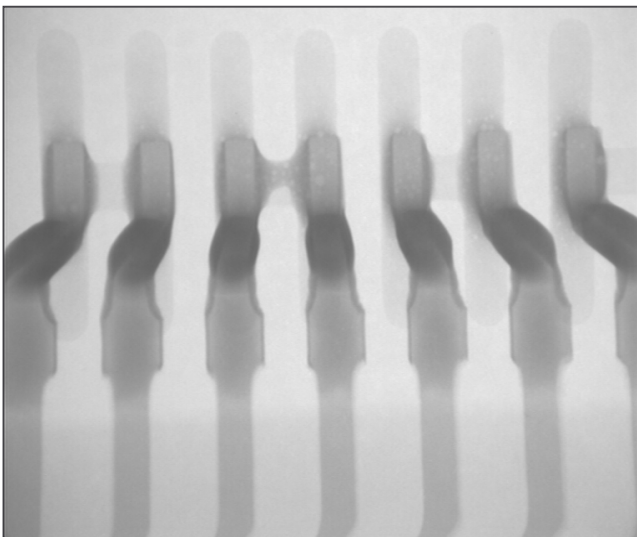


Figure 27. GX SAC, QFP208, 1

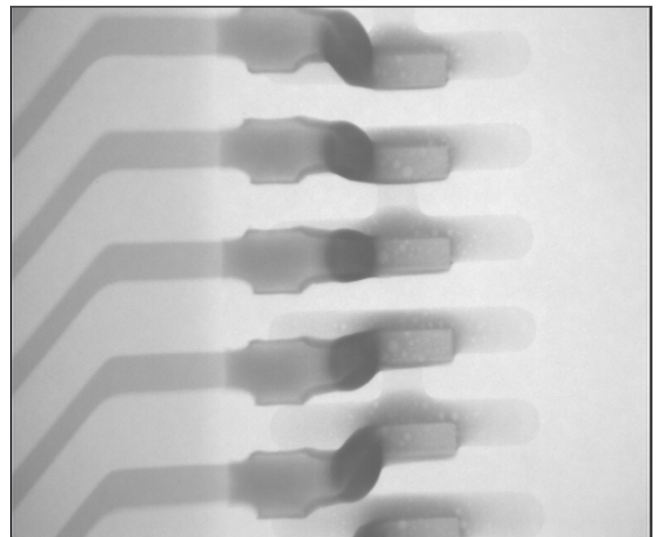


Figure 28. GX SAC, QFP208, 2

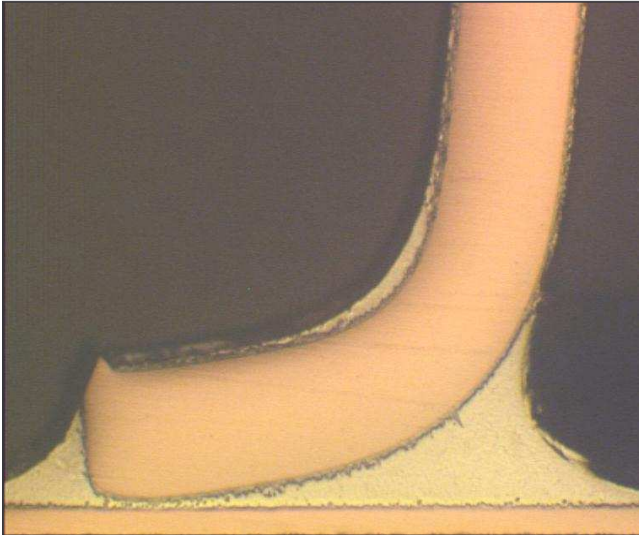


Figure 1. A3X, SAC,QFP208,100x

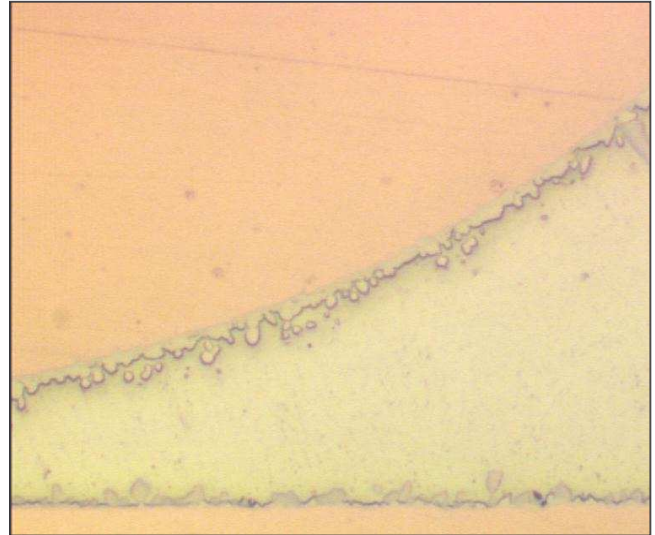


Figure 2. A3X, SAC,QFP208,400x,2

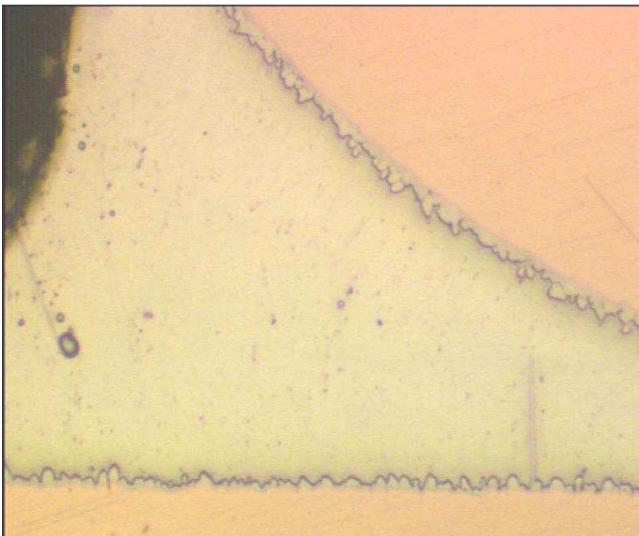


Figure 3. A3X, SAC,QFP208,400x



Figure 4. A3X,SAC,70796,400x,top

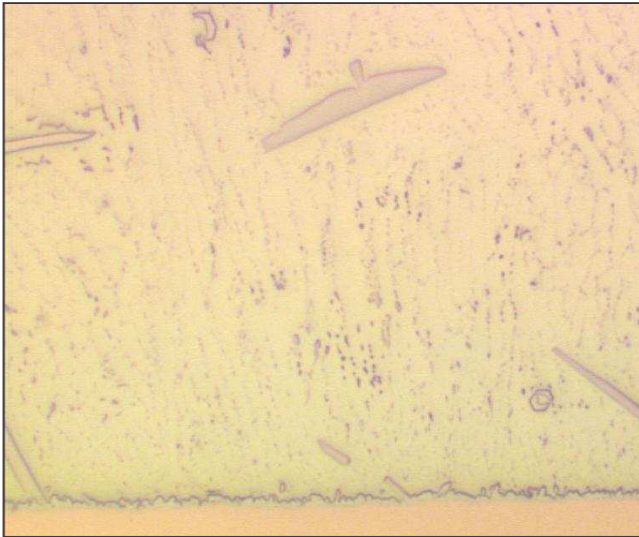


Figure 5. A3X,SAC,70796,400x

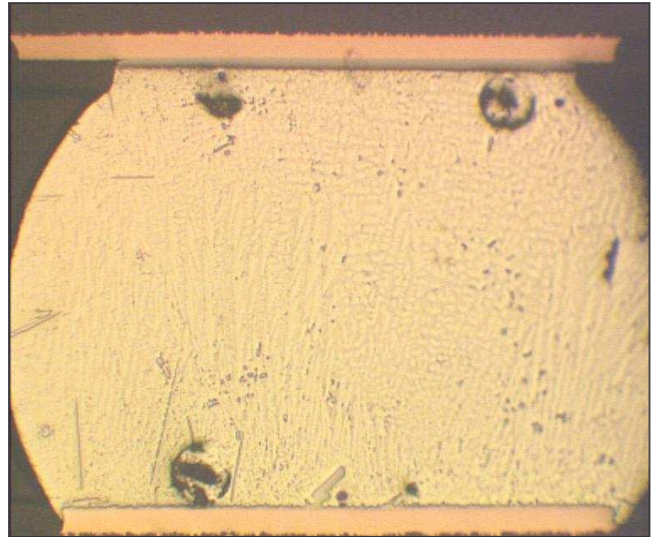


Figure 6. A3X,SAC,70796,center ball,100x,2

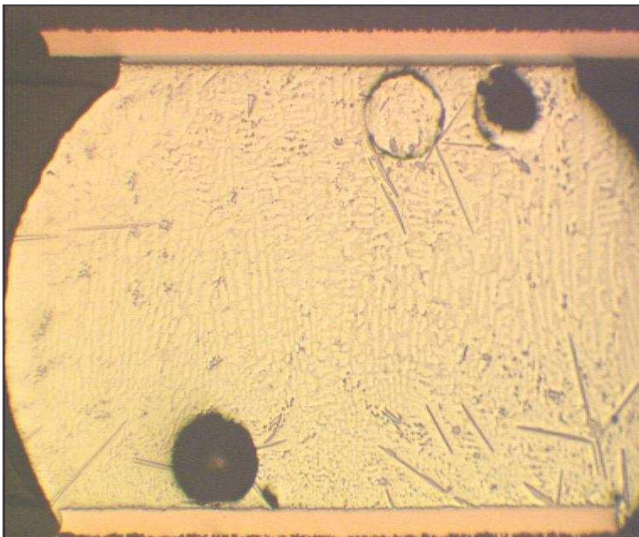


Figure 7. A3X,SAC,70796,center ball,100x

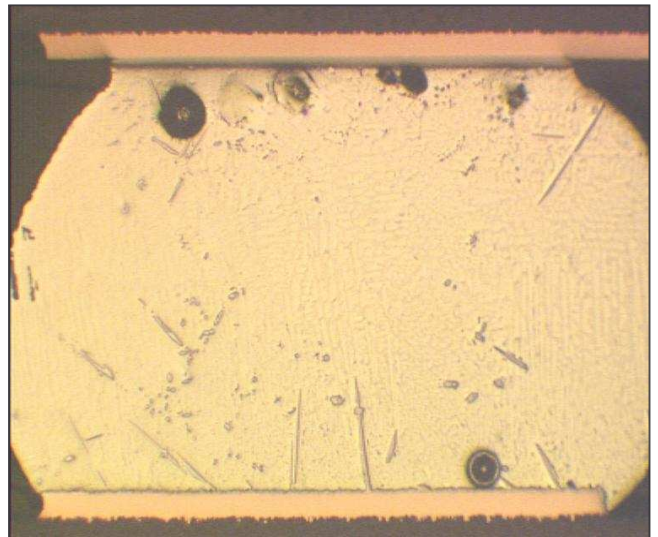


Figure 8. A3X,SAC,70796,corner ball,100x

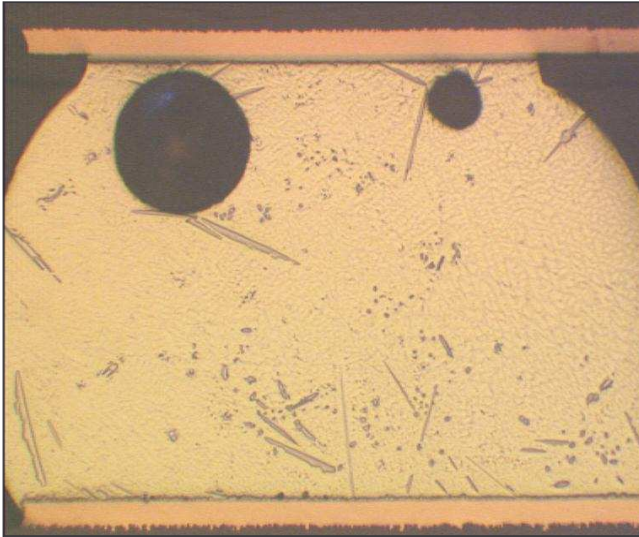


Figure 9. A3X,SAC,71057,100x,2

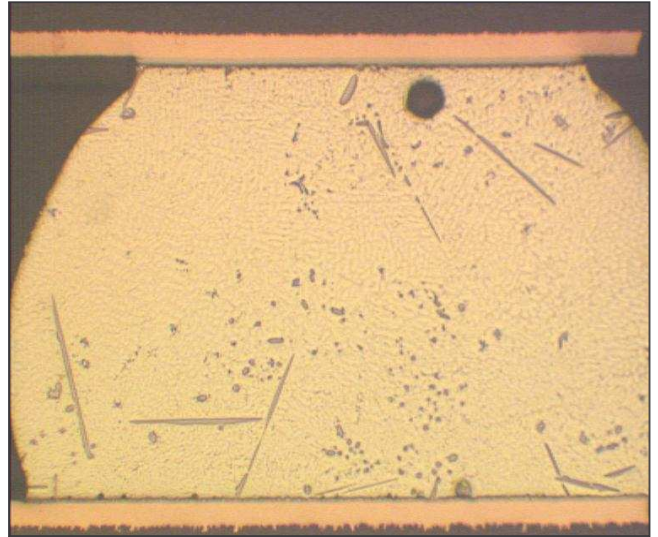


Figure 10. A3X,SAC,71057,100x

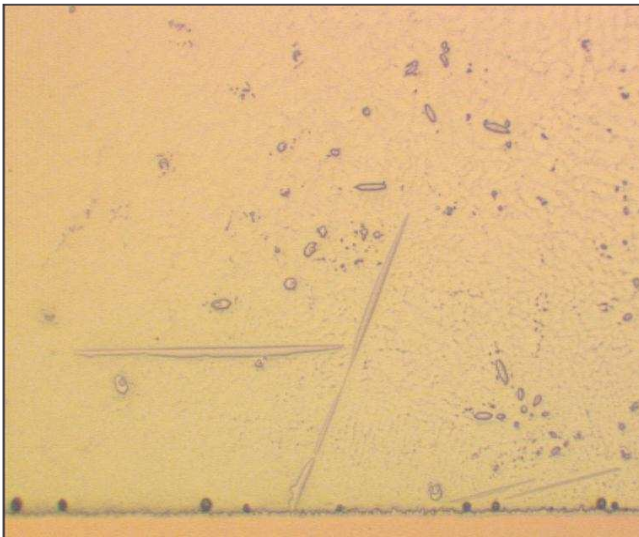


Figure 11. A3X,SAC,71057,200x



Figure 12. A3X,SAC,71057,25x,2