Final Finish Specifications Review
IPC Plating Sub-committee 4-14

George Milad
National Accounts Manager for Technology
Uyemura International Corporation
240 Town Line Rd
Southington, CT 06489
www.uyemura.com,

Specifications are consensus documents that are agreed upon by a panel of interested industry participants composed of suppliers, manufacturers, assembly houses and end users. The IPC Plating Sub-committee 4-14, is no exception. If there is consensus then the committee documents it in a specification. In cases where no consensus is readily arrived at, the committee undergoes its own testing in what is commonly referred to as a "Round Robin" (RR) study.

In a RR study, an agreed upon test vehicle (TV) is designed and manufactured. The TVs are then sent around to the different suppliers who deposit the agreed upon thicknesses to be investigated. The TVs are collected and the deposit thicknesses are verified and documented. The TVs are then coded. The coding is done to conceal the identity of the specific supplier, to keep the evaluation objective and to ensure it is not a comparative study between different suppliers. This is followed by sending the TVs around again to the different testing sites that test for the desired attribute like soldering, contacting and wire bonding capabilities of the different finish thicknesses. The data is then collected sorted out and documented. At this point a new attempt at consensus is made and upon arrival the thickness specification is set.

Once the consensus is complete a draft of the document is prepared. The draft is then sent out for peer review. This is a very important step, where the committee members as well as any IPC member can review the document and write back to the committee suggesting technical or editorial changes. Anyone can take exception with the document. All comments are then reviewed and all issues are resolved before the final draft is issued. At this time the IPC takes on the task of publishing the document in its final format.

Specifications are reference documents to be called out by designers and original equipment manufacturers (OEMs). Designers may take exception with one or more items in the specification to ensure that the product meets the requirements of its intended use. The term "AAUBUS", (As Agreed upon between User and Supplier); is part of any specification.

The IPC Plating subcommittee 4-14 chaired by George Milad and Gerard O'Brien has been active since 2001, with Tom Newton as the IPC liaison. It has an extensive member list. The committee operates thru bi-weekly conference calls "Concalls" (one hour). All decisions are made in the concalls by those in attendance. The call minutes are documented and sent out to the entire membership, who act as checkers, to ensure that the committee is on track to meet its objectives. To date all committee activities have been voluntary and acknowledgement is in order for the members and equally important to the management of their companies that believe in the need for industry specification and allow for the voluntary time invested by their employees.

Since its inception the IPC Plating Sub-committee 4-14 has issued the following:
IPC-4552 ENIG Specification 2002
IPC-4552 ENIG Specification Amended 2012
IPC-4553 Immersion Silver specification 2005
IPC-4554 Immersion Tin Specification 2007
IPC-4553A Revised Immersion Silver Specification 2009
IPC-4552 Amended ENIG Specification 2011
IPC-4554 Amended Tin Specification 2011
IPC-4556 ENEPIG Specification 2013

IPC-4552 ENIG Specification (2002)

The ENIG IPC-4552 Specification was issued in 2002, at that time the idea of lead free (LF) had not taken hold in the industry and tin lead was the dominant assembly solder in use.
For thickness IPC-4552 stated:
The electroless nickel thickness shall be 3 to 6 µm [118.1 to 236.2 µin]
The minimum immersion gold thickness shall be 0.05 [1.97 µin] at four sigma (standard deviation) below the mean; the typical range is 0.075 to 0.125 µm [2.955 to 4.925 µin].

To arrive at these numbers the committee had conducted a series of test in a round robin study that included suppliers, PCB manufacturers, EMS providers and OEMs. The data collected is summarized in the appendix of the specification.

As the price of gold soared, there was pressure on the committee to revise the lower limits for ENIG. The ENIG specification was amended in 2012. The lower limit for thickness was reduced from 0.05 µm to 0.04 µm (1.6 µin), however some restrictions were added like ability to measure, and limited time from manufacturing to assembly as well as demonstrating the consistency and reproducibility of the plating process.

Presently the IPC-4552 A, ENIG Specification revision is in progress. The purpose is to reduce the lower limit of thickness as per the amendment and to determine if the restriction imposed earlier could be lifted. This entails a RR study and a full investigation to ensure that the lower limit will not create problems for the industry. In addition all testing will include LF solder and LF stressing conditions; both were not available when the initial IPC-4552 was issued.

In addition, the revision of IPC-4552 A would include the following:

- Test method for stripping Immersion gold during failure analysis.
- Test method for determining the phos content of electroless nickel
- Acceptability criteria for nickel corrosion (Black Pad)

IPC-4553 Immersion Silver specification (2005)

The specification for immersion silver was issued in 2005. At that time there were 2 distinct types of immersion silver that were commercialized. One type could only produce a thin deposit of silver and the other produced a thicker deposit. As both had market penetration the committee had to specify the two types. The initial 4553 specification stated the following for thickness of deposit:
Thin Silver: 0.05µm (2µ") minimum at -2σ from process mean as measured on a pad of area 2.25²µm (3600² mils). Typical value 0.07µm (3µ") to 0.12µm (5µ")
Thick Silver: 0.12µm (5µ") minimum at -4σ from process mean as measured on a pad of area 2.25²µm (3600² mils). Typical value of 0.2µm (8µ") to 0.3µm (12µ").

The IPC 4553 Silver specification was unique:

- There were two thicknesses specified
- There is no upper limit in the specification
- The pad size for measuring thickness was defined

IPC-4553 A Immersion Silver specification (2009)

Over the next couple of years the supply of the "Thin" silver dwindled and was replaced by the "Thick" version. It was necessary for the committee to revise the specification. The Rev A had two important revisions. The first was the elimination of the terms "Thin" and "Thick" and to specify a single thickness. The second was to set an upper limit for immersion silver thickness.
Thickness specification of immersion silver IPC-4553 A states:
0.12 µm [5 µin] minimum to 0.4 µm [16 µin] maximum at ± 4σ from process mean as measured on a pad of area 2.25 mm² or 1.5 mm X 1.5 mm [approximately 0.0036 in² or 0.060 in X 0.060 in]; typical value between 0.2 µm [8 µin] to 0.3 µm [12 µin].

IPC-4554 Immersion Tin Specification 2007

For immersion tin the committee specified a lower limit for thickness. The relatively thick value of 1 micron was chosen to ensure that enough virgin tin would be available at the surface for soldering after storage. It is well understood that tin forms an intermetallic (IMC) layer with the underlying copper, and that this layer continues to grow in thickness over time.

The immersion tin thickness will be:
1.0 µm (40µ") minimum at -4σ from process mean as measured on a pad of area 2.25²µm (3600² mils). Typical value of 1.15µm ((46µ") to 1.3µm (52µ").

The immersion tin Specification IPC-4554 was amended in 2011. The amendment addressed solderability testing and specified the allowed stress testing conditions for the deposit and the type of fluxes to be used for both tin/lead and LF testing.

IPC-4556 ENEPIG Specification 2013

This is the last specification issued by the committee. The document produced is very comprehensive and includes a wealth of information from the RR studies that were conducted. The Appendix contains a documentation of these studies; each authored by the principle who conducted the testing.

It also includes a section on the proper methods of equipment setup for a reliable measurement of very thin layers of metal deposits.

The thickness specification for ENEPIG states
Nickel: 3 to 6 µm [118.1 to 236.2 µin] at ± 4 sigma (standard deviations) from the mean. Palladium: 0.05 to 0.15 µm [2 to 12 µin] at ± 4 sigma (standard deviations) from the mean.
Gold: 0.025µm [1.2 µin] at - 4 sigma (standard deviations) below the mean.
All measurements to be taken on a nominal pad size of 1.5 mm x 1.5 mm [0.060 in x 0.060 in] or equivalent area,

IPC-4555 OSP Specification

It is noteworthy that the committee had spent considerable time working an organic solderability preservative (OSP) specification that was designated IPC-4555. After more than one year of struggling with the specification nothing was issued. There was no consensus arrived at. Mostly this was due to the wide assortment of organic products that were used for solderability preservation for the various application; each with its own thickness recommended values.

Conference call are held every other Wednesday at 11:00 am EST. All participation is welcome.

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An Overview of IPC Plating Specification Completions, Revisions and Future Plans

George Milad

Uyemura International Corporation

IPC APEX Las Vegas, NV 2014

UYEMURA USA

IPC Specifications
Plating Subcommittee 4-14

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IPC Specifications
Plating Subcommittee 4-14

Specifications are consensus documents

They are agreed upon by a panel of interested industry participants composed of

1. **Suppliers,**
2. **Manufacturers,**
3. **Assembly houses**
4. **End users (OEM).**

The IPC Plating Sub-committee 4-14, is no exception.

IPC Specifications
Plating Subcommittee 4-14

If there is consensus then the committee documents it in a specification.

In cases where no consensus is readily arrived at, the committee undergoes its own testing in what is commonly referred to as a "Round Robin" (RR) study.

Plating Subcommittee 4-14
Round Robin Investigation

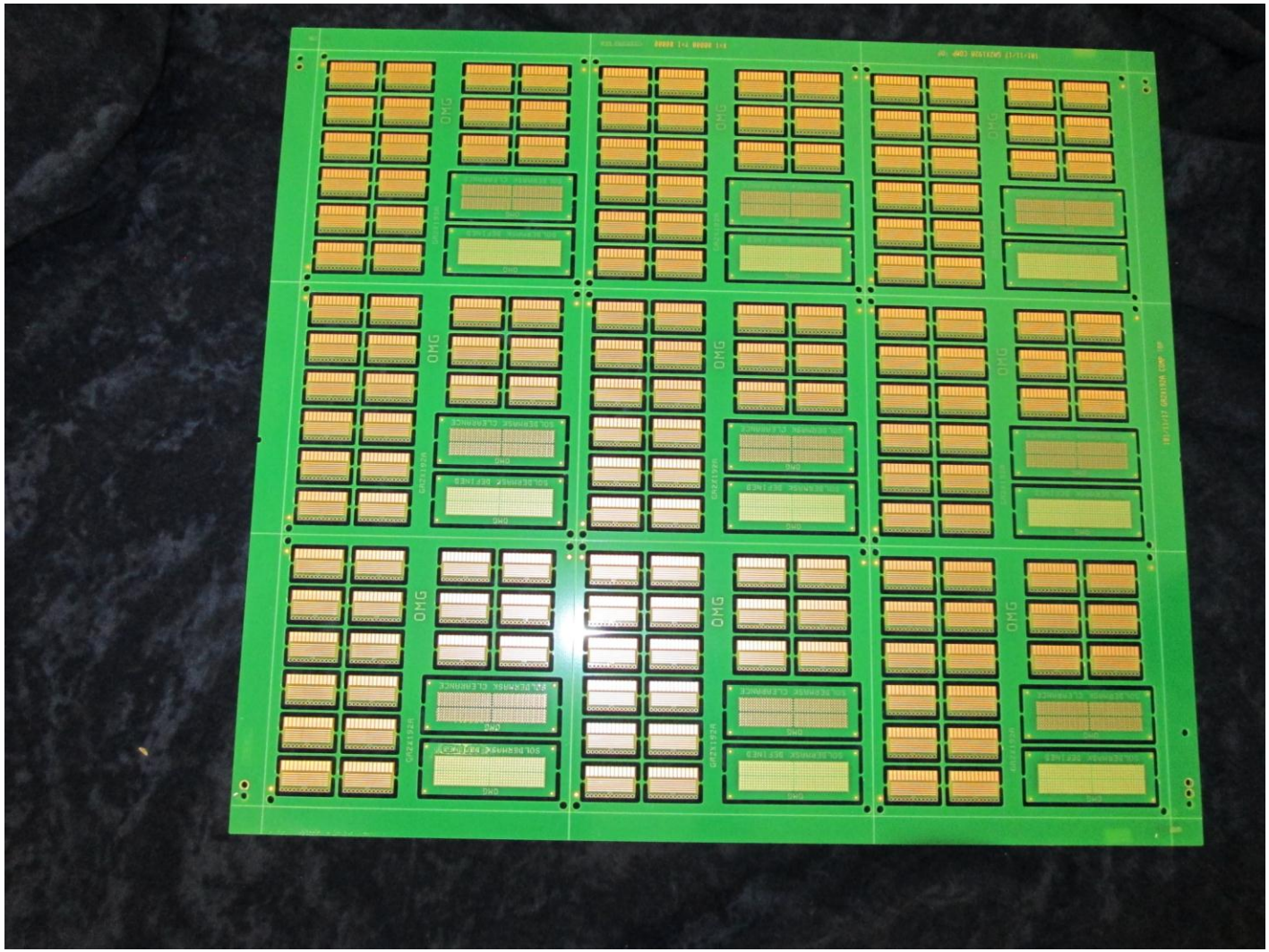
In a RR investigation, an agreed upon test vehicle (TV) is designed and manufactured.

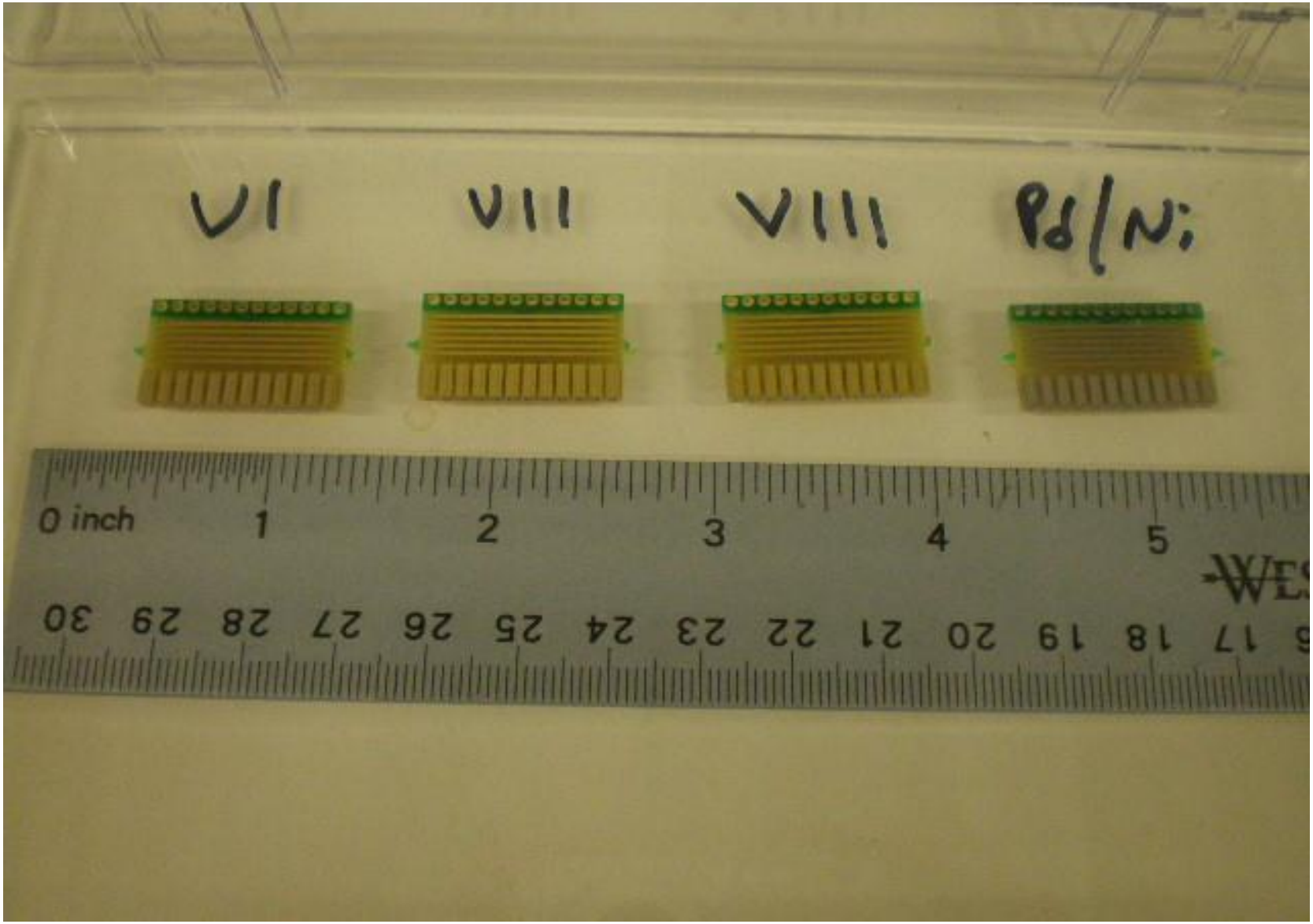
TVs are then sent around to the different suppliers who deposit the agreed upon thicknesses to be investigated.

The TVs are collected and the deposit thicknesses are verified and documented.

The TVs are then coded.

The Test Vehicle




VI
VII
VIII
Pd/Ni
0 inch
1
2
3
4
5

Plating Subcommittee 4-14
Round Robin Investigation

The TVs are sent around again to the different testing sites that test for the desired attribute like soldering, contacting and wire bonding capabilities of the different finish thicknesses.

The data is then collected sorted out and documented.

At this point a new attempt at consensus is made and upon arrival the thickness specification is set.

Plating Subcommittee 4-14
The Document

Draft

After consensus is complete a draft is prepared.

Peer Review

1. **The draft is then posted for peer review.**
2. **Any IPC member can review the document and suggest technical or editorial changes**
3. **All comments are then reviewed and <u>all issues are resolved</u> before the final draft is issued.**

Publication

At this time the IPC takes on the task of publishing the document in its final format.

Plating Subcommittee 4-14
The Committee

Active since 2001

Co-chaired by George Milad and Gerard O'Brien

IPC liaison is Tom Newton

An Extensive Member List.

- OEMs
- Assembly Manufacturers
- Board manufacturers
- Suppliers
- Labs and Consultants

Plating Subcommittee 4-14
Member Companies 1 of 2

OEM and CM

Lockheed Martin. Raytheon, Oracle, Adtran, Rockwell Collins, Heweltt Packard, Alcatel-Lucent, Dell, St Jude Medical, Delphi, Schneider Electric, Continental Corporation, Panasonic, IBM, Northrop Grumman, BAE Systems, Honeywell, Boeing, Tyco Electronics, Peregrine Semiconductor, Space Systems /Loral, Amonix, Celestica, Winstron

Plating Subcommittee 4-14
Member Companies 2 of 2

Board Manufacturing

Viasystems, TTM, I3, Molex, Superior Processing, Alternate Final Finishing,

Suppliers

Macdermid, OMG, Uyemura, Atotech, Cookson Electronics, MEC, ECI Technology, Kulick & Sofa, Metalor, Fischer Technology, Hesse-Mechatronics, H_zO

Labs and Consultants

ST and S Group, Sandia labratories, DFR Solutions, TAS Consulting

Plating Subcommittee 4-14
Member Companies

Operation

- The committee operates thru one hour bi-weekly conference calls.
- All decisions are made in the concalls by those in attendance.
- The call minutes are documented and circulated.

Acknowledgement

To date all committee activities have been voluntary and acknowledgement is in order for the members and equally important to their management that allow for the voluntary time invested by their employees.

IPC Specifications
Plating Subcommittee 4-14

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- IPC-4556 ENEPIG Specification 2013

Plating Subcommittee 4-14

IPC-4552 ENIG Specification (2002)

The ENIG IPC-4552 Specification was issued in 2002,
No lead free (LF) solder in use.

For thickness IPC-4552 stated :

- ***The EN thickness shall be 3 to 6 µm [118.1 to 236.2 µin]***
- ***The minimum IG thickness shall be 0.05 [1.97 µin]***
- ***At four sigma (standard deviation) below the mean;***
- ***The typical range is 0.075 to 0.125 µm [2.955 to 4.925 µin].***

Plating Subcommittee 4-14

IPC-4552 ENIG Specification (2002)

To arrive at these numbers

- **The committee had conducted a series of test in a round robin (RR) study**
- **The study included suppliers, PCB manufacturers, EMS providers and OEMs.**
- **The data collected is summarized in the Appendix of the specification.**

Plating Subcommittee 4-14

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- **The data collected is summarized in the Appendix of the specification.**

Plating Subcommittee 4-14

IPC-4552 ENIG Amended Spec (2012)

The lower limit for thickness was reduced from 0.05 µm to 0.04 µm (1.6 µin)

With Restrictions:

- **Limited time from manufacturing to assembly**
- **Demonstrate the consistency of the plating process.**
- **Ability to measure low Gold thickness**

Plating Subcommittee 4-14

IPC-4552 Rev-A ENIG Specification

The IPC-4552 A, ENIG Specification Revision is in progress.

The Purpose

- **Attempt to reduce the lower limit of thickness.**
- **Determine if the restrictions could be lifted.**
- **This entails an extensive RR study**
- **Testing to include LF solder and LF stressing conditions**

Plating Subcommittee 4-14

IPC-4552 Rev-A ENIG Specification

The revision of IPC-4552 A would include the following Additional Documents:

- Test Method (TM) for stripping Immersion gold during failure analysis
- Test Method (TM) for determining the phos content of electroless nickel
- Acceptability criteria for nickel corrosion (Black Pad)

Plating Subcommittee 4-14

IPC-4553 Immersion Silver (2005)

- In 2005 there were 2 distinct types of commercialized immersion silver with different thickness recommendations, referred to as “Thin” and “Thick”.

- Each required its own thickness specification.

- The initial 4553 specification stated the following for thickness of deposit

Plating Subcommittee 4-14

IPC-4553 Immersion Silver (2005)

Two Thickness Specification:

Thin Silver *: 0.05µm(2µ") minimum at -2σ from process mean as measured on a pad of area 2.25²µm (3600² mils). Typical value 0.07µm (3µ") to 0.12µm (5µ")*

Thick Silver*: 0.12µm (5µ") minimum at -4σ from process mean as measured on a pad of area 2.25²µm (3600² mils). Typical value of 0.2µm (8µ") to 0.3µm (12µ").*

Plating Subcommittee 4-14

IPC-4553 A Immersion Silver (2009)

A single Thickness Specified

- ***0.12 µm [5 µin] minimum to 0.4 µm [16 µin] maximum at ± 4σ from process mean***
- ***As measured on a pad of area 2.25 mm² or 1.5 mm X 1.5 mm [approximately 0.0036 in² or 0.060 in X 0.060 in.***
- ***Typical value between 0.2 µm [8 µin] to 0.3 µm [12 µin].***
- ***An Upper Limit was set.***

Plating Subcommittee 4-14

IPC-4554 Immersion Tin (2007)

For immersion tin the committee specified a lower limit for thickness. The relatively thick value of 1 micron was chosen to ensure that enough virgin tin would be available at the surface for soldering after storage.

It is well understood that tin forms an intermetallic (IMC) layer with the underlying copper, and that this layer continues to grow in thickness over time.

Plating Subcommittee 4-14

IPC-4554 Immersion Tin (2007)

The immersion tin thickness will be:
1.0 µm (40µ") minimum at -4σ from process mean as measured on a pad of area 2.25²µm (3600² mils). Typical value of 1.15µm ((46µ") to 1.3µm (52µ").

The immersion tin Specification IPC-4554 was amended in 2011. The amendment addressed solderability testing and specified the allowed stress testing conditions for the deposit and the type of fluxes to be used for both tin/lead and LF testing.

Plating Subcommittee 4-14

IPC-4555 OSP Specification (No Date)

After more than one year of struggling with specification IPC-4555; organic solderability preservative (OSP). Nothing was specified.

There was no consensus arrived at.

Mostly this was due to the wide assortment of organic products that were used for solderability preservation for the various application; each with its own thickness recommended values.

Plating Subcommittee 4-14

IPC-4552 ENEPIG Specification (2013)

This is the last specification issued by the committee. The document produced is very comprehensive and includes a wealth of information from the RR studies that were conducted.

The Appendix contains a documentation of these studies; each authored by the principle who conducted the testing.

It also includes a section on the proper methods of equipment setup for a reliable measurement of very thin layers of metal deposits.

Plating Subcommittee 4-14

IPC-4552 ENEPIG Specification (2013)

Appendices 1 thru9

1. Chemical Definitions and Process Sequence; Martin Bayes Dow Chemical Company
2. Round Robin Test Summary; George Milad Uyemura International Corporation
3. ENEPIG PWB Surface Finish XRF Round Robin Testing; Gerard O'Brien S T and S Group.
4. Factors Affecting Measurement Accuracy of ENEPIG Coatings by XRF; Frank Ferrandino, Calmetrics Inc.
5. ENEPIG PWB Surface Finish Wetting Balance Testing; Gerard O'Brien – President S T and S Group.
6. Solder Spread Testing; Brian Madsen, Continental
7. ENEPIG PWB Surface Finish Shear Test Project; Dave Hillman,et al.Rockwell Collins Inc.
8. Gold Wire Bonding; Stephen Meeks St Jude Medical
9. XRF Thickness Measurements of thin Au and Pd (ENEPIG): Recommendations for Instrumentation (Detectors) and their Limitations; Michael Haller Fischer Technology

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IPC-4552 ENEPIG Specification (2013)

The thickness specification for ENEPIG states

Nickel: 3 to 6 µm [118.1 to 236.2 µin] at ± 4 sigma (standard deviations) from the mean.

Palladium: 0.05 to 0.15 µm [2 to 12 µin] at ± 4 sigma (standard deviations) from the mean.

Gold: minimum 0.025µm [1.2 µin] at - 4 sigma (standard deviations) below the mean.

All measurements to be taken on a nominal pad size of 1.5 mm x 1.5 mm [0.060 in x 0.060 in] or equivalent area.

IPC Specifications
Plating Subcommittee 4-14

Committee conference calls are held every other Wednesday at 11:00 am EST.

Call in Number is 847 597 2999
Pass Code is 013 98 92 #

Everyone is welcome to participate.

A notification e-mail is sent out before each conference call

IPC Plating Committee 4-14

Thank You

George Milad

gmilad@uyemura.com

IPC APEX Las Vegas, NV 2014

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