Advanced Trouble Shooting & Defect Analysis of Printed Circuit Boards

SYLLABUS

In the highly competitive printed circuit board fabrication industry, profitability accrues to those that can produce high-reliability interconnect devices along with very high yields. For this reason, it is critical that engineers and operators directly involved in fabrication, assembly, and purchasing of printed boards possess the knowledge and skills to manufacture printed circuit boards and assemblies of the highest yields and reliability. This requires a conceptual and practical understanding of materials, chemical processes, and equipment parameters, as well as how these may affect printed circuit board quality.

Taught by an IPC-certified industry expert with more than 40 years of experience in the field, this 16-hour course utilizes interactive webinars, on-demand recordings, and job-specific exercises to facilitate mastery of the key concepts required for successful printed circuit board trouble shooting and defect analysis.

COURSE OBJECTIVE

After completing this course, you will be able to:

- Identify and correct control processes that negatively affect circuit board quality
- Establish the root cause of potential defects to minimize and prevent loss of quality
- Recognize the interrelationships of PCB materials, processes, and equipment and how these relationships affect PCB and PCA quality
- Identify the root cause and corrective action for PCB defects, such as interconnect separation, delamination, wedge voids, plating folds, microvoids, surface pitting, and hole wall pull-away
- Identify the root cause and corrective action for electrodeposition defects, such as mouse bites, pitting, and domed or crown plating
- Identify the root cause and corrective action for solderability and assembly-related issues, such as outgassing, black pad, creep corrosion, and blow holes

TOPICS PER COURSE MODULE

MODULE 1: INTRODUCTION AND OVERVIEW OF MATERIALS AND COPPER FOILS

- Course Overview
- Introduction to Troubleshooting:
    - Plan-Do-Check-Act
    - Use of Fishbone Diagrams
- How PCBs are Made:
    - Process flow

        - Innerlayer fabrication and lamination
        - Outerlayer fabrication
        - Acceptance
- Materials and Copper Foils:
    - Raw material factors
    - Construction factors
    - Glass weave
    - Unwoven glass
    - Resign systems and properties:
        - CTE
        - Tg
        - Td
        - Impedance
        - Dk/Df
    - Copper foils and glass styles:
        - How these are manufactured
        - Different copper foil types
        - Raw material and construction factors

Assignment:

- Module 1 Quiz

MODULE 2: INNER PROCESS FLOW, SURFACE PREP, AND PHOTORESIST LAMINATION

- Innerlayer Prep and Dry Film Lamination:
    - Surface preparation:
        - Mechanical vs. chemical surface prep
        - Issues related to surface preparation
    - Dry film lamination mechanics:
        - Hot roll laminator
        - Condition of the rollers
    - Critical lamination parameters:
        - Temperature
        - Pressure
        - Exit temperature
    - Defects related to surface preparation and resist lamination

Assignment:

- Module 2 Quiz

MODULE 3: EXPOSURE, DEVELOPMENT, AND IMAGING DEFECTS

- Dry Film Resist Exposure:
    - Exposure basics
    - Contact and off contact
    - Exposure energy
    - Use of step tablets
    - Laser direct imaging
- Resist Developing:
    - Process control
    - pH

- Resist loading
- Equipment considerations
- Concept of break point
- Defect analysis

Assignment:

- Module 3 Quiz

MODULE 4: INNERLAYER RESIST STRIPPING AND ETCHING

- Etching:
  - Alkaline ammoniated
  - Cupric chloride
  - Process controls
  - Over etching
  - Line width reduction
  - Undercut vs. etch factor
  - Other etching-related defects
- Resist Stripping:
  - Mechanism
  - Filtration methods
- Defects Related to Stripping:
  - Scumming
  - Over exposure
  - Other defects
- Other Topics:
  - Resist lock-in
  - Incomplete etching and stripping
  - Effects on downstream processes

Assignment:

- Module 4 Quiz

MODULE 5: OXIDE, LAMINATION AND MATERIALS

- Laminate, Copper Foils, and Material Selection:
  - Material properties
  - Electrical properties
- Innerlayer Adhesion Promotion:
  - Interlaminar bond strength
  - Treatment methods and process variables
- Lamination:
  - Lay-up and tooling
  - Press parameters
  - Temperature controls
- Common MLB Issues:
  - Delamination
  - Misregistration
  - Break-out
  - Resin recession

        - Other
    - Drilling/Via Formation:
        - Drill machine variables
        - Critical drilling concepts (feeds, speed, chip load)
        - Drill bit mechanics and design
        - Common drilling-related defects
        - Drilling rules of thumb

Assignments:

- Module 5 Quiz

MODULE 6: DRILLING, DESMEAR, AND PTH METALIZATION

- Hole and Via Preparation:
- Desmear/Etchback Options:
    - Alkaline permanganate
    - Plasma
    - Etchback vs. desmear
    - Effect of different materials
- Defects Related to Desmear/Etchback:
    - Incorrect desmear parameters
    - Wedge voids
    - Plating voids
    - Lack of plating adhesion/blisters
    - Inadequate smear removal and effect on plating quality
    - Other anomalies related to desmear/etchback
- PTH Metallization:
    - Process overview
    - Operating variables and effect on plating
    - Control parameters
- Defect Discussion:
    - Voids
    - Hole wall pullaway
    - Interconnect defect
    - Other plating anomalies related to PTH processing

Assignments:

- Module 6 Quiz

MODULE 7: ELECTROPLATING, PATTERN DEFINITION, AND STRIP-ETCH-STRIP

- Electroplating Key Variables:
    - Mechanics
    - Chemistry
    - Electrical
- Pattern and Panel Plating:
    - Lamination, exposure, and developing
    - Image and developing defect
    - Proper exposure and developing parameters

        - Surface prep issues
- Plating Distribution and Throwing Power
- Pulse Plating vs. DC
- Special Topics:
    - Copper via fill plating
    - Copper wrap
- Electroplating-Related Defects:
    - Poor plating distribution
    - Corner and barrel cracking
    - Grain structure changes
    - Non-uniform plating
    - Peeling copper
    - Blisters
    - Weak knee
    - Dog boning
- Strip-Etch-Strip:
    - Resist Removal problems
    - Resist entrapment
    - Resist lock-in
    - Over- and under-etching
    - Etch factor vs. undercut
    - Etch resist attack/copper oxidation
    - Metal stripping issues
    - Extraneous Copper

Assignments:

- Module 7 Quiz

MODULE 8: SOLDERMASK AND SOLDERABLE FINISHES

- Liquid Photoimageable Soldermask:
    - Application methods
    - Critical parameters:
        - Wet mask thickness
        - Tack dry
        - Exposure
        - Development
        - Final Cure
- Soldermask Defects:
    - Mask peels
    - Mask is dull
    - Over and under develop/exposure
    - Poor coverage over plated circuits
    - Incompatibility with solderable finishes
    - Other soldermask-related defects
- Solderable Finishes:
    - Solderability characteristics
    - Final finish overview (what types and where best used)

- Solderability defects related to final finishes
- Other defects (black pad, brittle fracture, microvoids, and creep corrosion)
- Trench-etch
- Copper corrosion
- Other

FINAL EXAM

Participants must complete the Final Exam with a passing score of 80% to access and download their Advanced Trouble Shooting & Defect Analysis of Printed Circuit Boards Certificate. Students may attempt the exam up to three (3) times. Please note that a third and final attempt is permitted after 24 hours of the second attempt.

COURSE RESOURCES

Everything you need to successfully complete the Advanced Trouble Shooting & Defect Analysis of Printed Circuit Boards course is included and available on the IPC EDGE Learning Management System.

MODULE COMPONENTS AND REQUIREMENTS

The Advanced Trouble Shooting & Defect Analysis of Printed Circuit Boards course provides engaging videos and quizzes designed to help you learn, remember, and apply the knowledge and skills you will need to excel as an electronics assembly engineer. Each module is composed of the components described in Table 1.

Table 1. Module Components and Description

Module Component	Description
Module Sections	Video segments, including text and graphics that explain the key points of the Module content.
Module Post-Quiz	Five to 10-question quiz designed to help you confirm what you know, identify areas that still need work.

STUDY TIPS

1. **Use the Learning Objectives**. Refer to the Module learning objectives often.

   Why? Keeping the learning objectives fresh in your mind supports your ability to stay focused on those aspects of the training that will help you achieve the learning goals for the Module.

2. **Quiz yourself.** After you complete a Module, ask yourself questions such as: ***What are the key ideas? What terms or ideas are new to me? How do these ideas relate to what I already know?*** Then, check the Module content to see how well you did.

Why? Quizzing yourself allows you to identify what you ***really*** know and what you still need to work on.

3. **Quiz yourself periodically.** After you engage with the Module content, quiz yourself and review your answers. Wait a couple of days and quiz yourself again without first reviewing the material.

   Why? Regular self-quizzes help you connect the content to what you already know and what you've thought about since you first learned that content. Tying the content to these other bits of knowledge in your brain makes it easier to recall when you need to apply it on the job later. Research also shows that the effort required to recall what you've learned entrenches it more firmly into your long-term memory than if you were to re-read or highlight the same material.

4. **Mix it up.** When you quiz yourself, mix in topics or questions from different Modules. Online or homemade flashcards can make this fun. Just remember to keep the cards you get right in the rotation even if they appear less often.

   Why? It may be more difficult than practicing one subject at a time, but mixed practice has two distinct advantages. First, because it is more complex and requires more effort, mixed practice more effectively stores the content in your long-term memory. Practicing a lot of the same thing often makes you feel like you've mastered the content, but it's quickly forgotten because you are relying on your short-term memory. Second, in real-life you often have to deal with different types of problems in no particular order. In other words, to be successful, it's better to practice like you play—or work!

5. **Express it in your own words.** Explain the new content to somebody in your own words, or write a summary of each Module, adding images and examples that help you better understand and remember the content.

   Why? Learning, which is ***acquiring knowledge and skills that are easily retrieved from memory so you can address problems and opportunities***, is very much about connecting new stuff to the older stuff already stored in your memory. Therefore, learning the same topic will be a little different for everybody because each one of us is connecting the new knowledge to different old knowledge. In other words, the most durable kind of learning happens when you connect new content with objects, people, and experiences that are meaningful to ***you***. One of the most effective ways to do that is to express newly learned material in your own words.

6. **Dive in.** Read the Module learning objectives, then try to explain the key ideas. How do these ideas relate to what you already know?

   Why? It may seem silly to try to answer a question or solve a problem before being taught how, but you are much more likely to learn and remember the solution if you try to work

your way through it first. In fact, a wide range of experts, from farmers and mechanics to physicists and mathematicians, have sought their answers through a mixture of dogged research and trial and error. Trying to figure something out before you know too much about it puts all your past knowledge to work in search of answers, heightening your awareness of what you do and do not know about the topic at hand. When you hit on those answers, the new knowledge easily and firmly connects to the related concepts and experiences in your memory because you have been actively remembering them.

Even if you are not right on every count, the effort will have primed your brain to find, learn, remember, and recall the Module content that is new to you.

7. **Take time to think about it.** While doing some routine task like walking the dog, jogging, or washing the dishes, take a few minutes to think about a recent learning experience. ***What are the main ideas and how do they relate to my work? Can I apply what I've learned to improve my job performance?*** If you've already tried to apply what you've learned at work, ask what went well and what went poorly. What do you need to learn or do to get better results the next time?

   Why? Thinking about how your past experiences and current knowhow relate to what you've recently learned helps to connect and store this new knowledge in your long-term memory so that it is easy to recall when needed. Considering how well you learn something or how well you apply that learning at work will help you identify effective learning and workplace strategies. Think about an especially successful learning or work experience. What was different about those experiences? How can you take what worked and apply it to this situation?

8. **Limit your study time.** Work through relatively small amounts of information in 20- or 30-minute sittings rather than long, continuous study sessions.

   Why? Our brains can only process so much information at a time. Learning is more effective when you give your brain a little time to sort and transfer information from working memory to long-term memory. If you take on too much at a time, or proceed too quickly, you may overload your working memory and forget important parts of the content before they are committed to your long-term memory.

9. **Sleep.** Be sure to get the right amount of sleep. You may be able to function with less, but most healthy adults should get between 7 and 9 hours of sleep each night. Teens and children require more.

   Why? Your brain uses down time to sort through the day's input, dumping the unnecessary bits and integrating newly learned material with what we already know. While you sleep, the rest of your body goes about repairing tissue, generating new cells, and eliminating toxins. Research shows that healthy sleeping habits lead to improved

mood, weight loss, increased ability to learn and retain information, and better performance.

10. **Cut out distractions.** Set aside your smartphone, and resist answering emails, surfing the Net for your next purchase, or checking in on your Facebook page.

11. **Focus on one thing at a time.** Effective multitasking is a widespread myth. Research shows that multitaskers had a very difficult time sorting through irrelevant material and were outperformed by more singularly focused people across many different measures.

    Why? Aside from compromising the quality of your work, distractions and multitasking take a big bite out of the limited amount of time you have to get things done. Every time you switch tasks, you waste time getting yourself started on the new task and restarting the one you stopped. Research shows that task switching can eat up to 25% of your time depending on the complexity of the tasks. Twenty-five percent represents 10 hours of a 40-hour work week!

12. **Believe in yourself.** It's important to realize that you can literally increase your brain power and become an expert at whatever you put your mind to. You are not stuck with some finite amount of intellectual ability at birth. In other words, if you think you can or think you can't, you're right.

    Why? Research has proven that the human brain is malleable. It grows new and faster connections through the effort of learning. If you feel that you are "bad" at something like math or gardening, you can become much better with deliberate and persistent study and practice. If you haven't had much success until now, you may have been using poor study strategies. For example, extensive research has shown that multiple re-readings in close succession, highlighting, and continually poring over notes are time-consuming strategies that yield poor results at the cost of the more effective strategies described here. However, it's important that you adjust your mindset to truly take these facts into account. A learning setback is not a result of limited intelligence. It simply means that you may have to change strategies, increase focus, get creative, or work harder. It's also important to remember that learning things in a permanent and easily retrievable way requires effort.

    The authors of ***Make It Stick: The Science of Successful Learning*** describe how the effort you put into the study strategies described above lead to meaningful learning:

    > Effortful recall of learning…requires that you "reload" or reconstruct the components of the skill or material anew from long-term memory rather than mindlessly repeating them from memory. During this focused, effortful recall, the learning is made pliable again: the most salient aspects of it become clearer, and the consequent reconsolidation helps to reinforce meaning, strengthen

connections to prior knowledge, bolster the cues and retrieval routes for recalling it later, and weaken competing routes.

RESOURCES:

Andreatta, B. (2016). ***Wired to grow: Harness the power of brain science to master any skill.*** Santa Barbara, CA: Seventh Mind Publishing.

Brown, P. C., Roediger, H. L., & McDaniel, M. A. (2014). ***Make it stick: The science of successful learning.*** Cambridge, MA: The Belknap Press of Harvard University Press.

Carey, B. (2015). ***How we learn: The surprising truth about when, where, and why it happens.*** New York, NY: Random House.

Dweck, C. S. (2008). *Mindset: The new psychology of success.* New York, NY: Ballantine Books.

Keller, G. W., & Papasan, J. (2013). ***The one thing: The surprisingly simple truth behind extraordinary results.*** Hudson Bend, TX: Bard Press.

IPC EDGE LEARNING MANAGEMENT SYSTEM

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