# Advanced Troubleshooting & Defect Analysis of Printed Circuit Boards

# SYLLABUS

## INSTRUCTOR INFORMATION


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Availability: Usually available between 6 p.m. and 9 p.m., Eastern Standard Time. You may leave a message anytime.

## PROGRAM DESCRIPTION

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 four-week program 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.

## LEARNING AND PERFORMANCE OBJECTIVES

The IPC Advanced Troubleshooting and Defect Analysis course is designed to provide participants with the knowledge and skills necessary to identify printed circuit board defects and determine corrective action. Upon completion, participants 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

## COURSE STRUCTURE

- Instructor and participants meet online twice per week from the comfort of their own home or office
- Participants can view recorded online sessions to review course content and class discussions
- Participants apply key concepts to create a real-world design from concept to completion
- Participants apply key concepts to resolve real-world issues each week
- Participants complete weekly multiple-choice quizzes to master concepts and practice skills in real-world contexts
- Course materials are accessible 24/7 on the new IPC Edge Learning Management System
- The course can be accessed on virtually any device with an Internet connection and major web browser, including Chrome, Firefox, Safari, Edge, and Internet Explorer

## IPC STANDARDS COVERED (PROVIDED WITH COURSE)

- IPC-A-600K: ACCEPTABILITY OF PRINTED CIRCUIT BOARDS
- IPC-6012E: QUALIFICATION AND PERFORMANCE SPECIFICATION FOR RIGID PRINTED BOARDS
- IPC-6013E: QUALIFICATION AND PERFORMANCE SPECIFICATION FOR FLEXIBLE/RIGID-FLEXIBLE PRINTED BOARDS

## COURSE SCHEDULE

**WEEK 1:**

**Session 1: Introduction and Overview of Materials and Copper Foils**
**Session 2: Preparing the Surface for Imaging & Surface Preparation and Resist Lamination**

We will begin **Session 1** with an overview of the class schedule and discuss options for accessing class material and course assignments. Then, we will focus on the basic steps involved in the PCB manufacturing process and do a deep dive into materials, laminates, and copper foils. **Session 2** will cover surface preparation for the process of creating circuits within the layers of a printed circuit board and the defects that can occur during this process. Following a thorough discussion of surface preparation, we will look at the key parameters involved in photoresist lamination.

### Session 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
- Inner layer fabrication and lamination
- Outer layer fabrication
- Acceptance

- Materials and Copper Foils:
  - Raw material factors
  - Construction factors
  - Glass weave
  - Unwoven glass
  - Resin 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:**

- Session 1 Quiz
  - Submit by Week 1, Session 2

**Session 2: Preparing the Surface for Imaging & Surface Preparation and Resist Lamination**

- Inner layer 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

**Assignments:**

- Quiz: Session 2
  - Submit by Week 2, Session 3

**WEEK 2:**

**Session 3: Exposure, Development, & Imaging Defects**
**Session 4: Innerlayer Resist Stripping, & Etching**

Session 3 will focus on photoresist exposure and development as well as the defects attributed to these two processes. In Session 4 we will explore the processes and defects related to inner layer inner layer resist stripping and etching.

**Session 3:**

- 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

**Assignments:**

- Session 3 Quiz
    - Submit by Week 2, Session 4

**Session 4:**

- 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
    - Effect on downstream processes

**Assignments:**

- Session 4 Quiz
    - Submit by Week 3, Session 5

**WEEK 3:**

**Session 5: Oxide, Lamination, and Materials**
**Session 6: Drilling, Desmear, and PTH Metallization**

Session 5 will cover the multilayer lamination process including inner layer adhesion promotion, lay-up, and tooling. Lamination cycles and process parameters, lamination defects, and critical material properties will also be covered in detail. Session 5 will conclude with a discussion of via formation, including laser and mechanical drilling. Session 6 will build on the key concepts presented in Session 5. This includes desmear; metallization; critical success factors for reliable and void-free metallization; and how to enhance PTH, via, and interconnect long-term reliability.

**Session 5:**

- 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:**

- Session 5 Quiz
    - Submit by Week 3, Session 6
- Case Study 1: Case of Delamination
    - Submit by Week 3, Session 6

**Session 6:**

- Hole and Via Preparation
- Desmear/Etch-back 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 pull-away
    - Interconnect defect
    - Other plating anomalies related to PTH processing

**Assignments:**

- Session 6 Quiz
    - Submit by Week 4, Session 7
- Case Study 2: The Hole Truth
    - Submit by Week 4, Session 7
- Case Study 3: Several Degrees of Separation
    - Submit by Week 4, Session 7

**WEEK 4:**

**Session 7: Electroplating, Defects, and Strip-Etch-Strip**
**Session 8: Soldermask and Solderable Finishes**

In Session 7, we will discuss the finer points of electroplating copper and tin. The main focus will be on cosmetics, plating distribution, physical deposit properties, and long-term reliability. We will also cover strip-etch-strip related issues in root cause analysis and factors leading to over-etching, undercut, and etch-resist breakdown. Session 8 will begin with liquid photoimageable soldermask and the SMOBC process, including soldermask surface preparation and application steps, such as exposure, development, and final cure. No discussion on printed circuit board trouble shooting and defect analysis would be complete without a deep dive into solderable finishes and solderability. The presentation will include a brief overview of solderable finishes and their application as well as solderability defects related to each process.

**Session 7:**

- 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:**

- Session 7 Quiz
    - Submit by Week 4, Session 8
- Case Study 4: Plating Nodules and Where They Come From
    - Submit by Week 4, Session 8 (we will review in the class)

**Session 8:**

- 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:**

- Complete final exam after Session 2 or a defined exam time during the last week of the course.
- Completion of the program with a score of 70% or higher on the final exam is required to earn a certificate of completion.
- Attempts allowed: 2. Grading method: Highest grade.