Welcome to
SETTING IPC STANDARDS

HOW NANO DIMENSION IS SHAPING THE FUTURE OF AME

WITH DANA KORF

NANODIMENSION
Electrifying Additive Manufacturing®

Changing the way the world manufactures

To become the **digital manufacturing leader** through disruption of electronics & mechanical production by applying environmentally friendly & economically efficient electronics and precision additive manufacturing – resulting in the conversion of digital designs into functioning electronic and mechanical devices – on **demand, anytime, anywhere**

INNOVATIVE PRODUCTS FOR TRUE INDUSTRY 4.0 SOLUTIONS

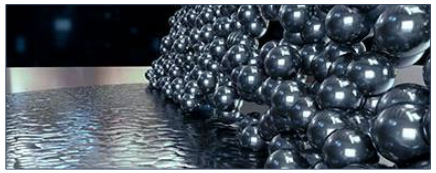
THE CRITICAL PIECES TO MANUFACTURE HIGH PERFORMANCE ELECTRONIC AND MECHANICAL DEVICES

Additive Manufacturing

DragonFly IV
Additively Manufactured Electronics

Fabrica 2.0
Micro AM

Admatec
Ceramic and Metal AM



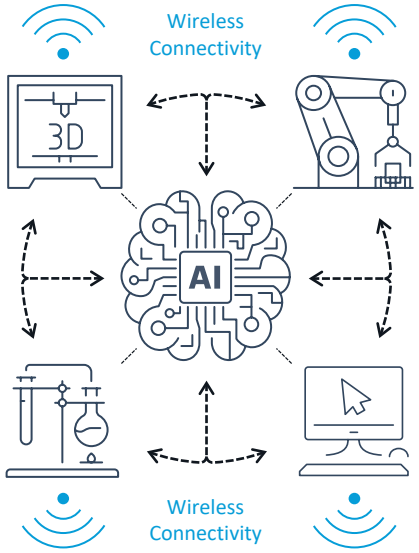
Conductive and Dielectric Inks

Ceramic

Polymer

Metal

Advanced Materials & Processes



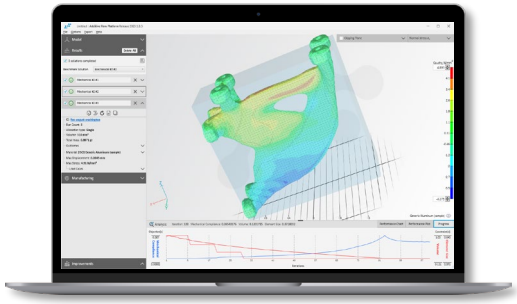
DeepCube
Deep Learning Based AI Platform

Robotics

SMT Suite of Products
Surface Mount Technology for Electronics

Digital Printing Platform
Printer control systems and software

FLIGHT Hub & Control
Design-to-Manufacturing
Testing, simulation, and management



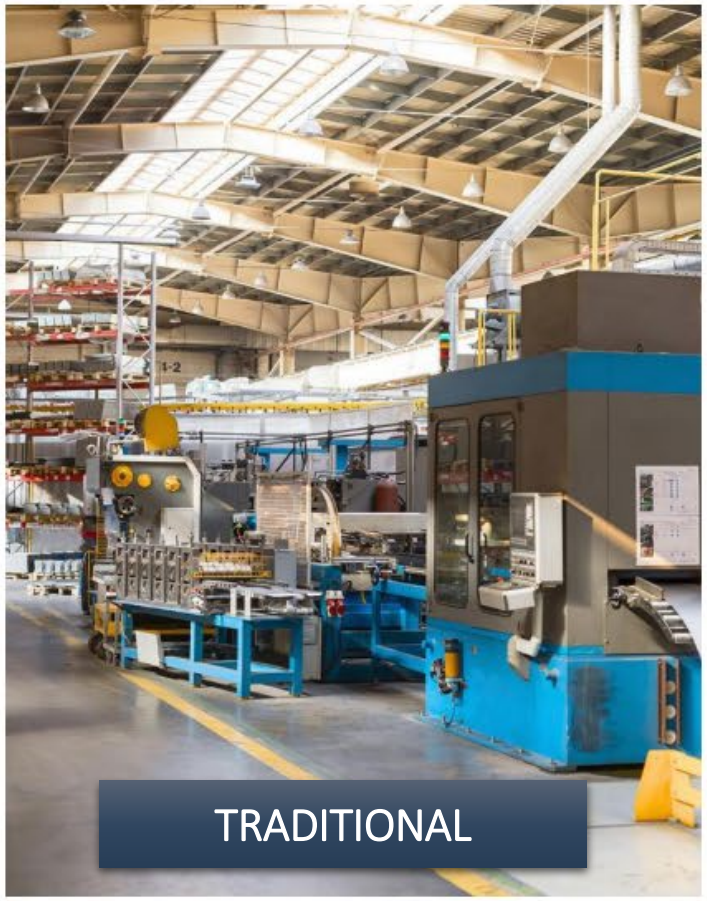
Additive Flow
Multi-Material Topology Optimization for AM, AME and Volumetric Manufacturing

Software

DIGITAL MANUFACTURING

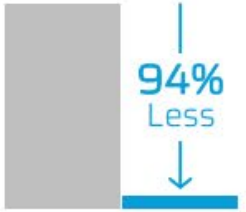
LEADERSHIP IN SUSTAINABILITY

Before



SUSTAINABLE
AM SOLUTIONS

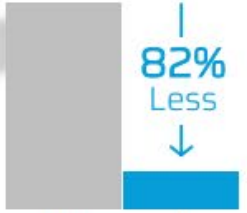
After



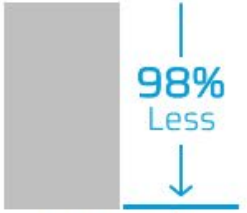
CO^2
(kg/iteration)

Water
(L/iteration)

Waste
(kg/iteration)



Chemicals
(L/iteration)



Materials
(kg/iteration)

1 Based on a 2021 study by HSSMI, a UK based sustainability consultant

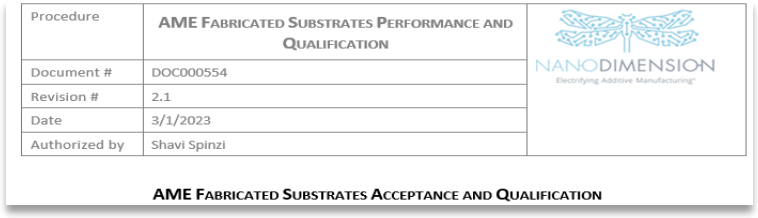
MEET DANA KORF

KEY IPC STANDARDS ACCOMPLISHMENTS

- Late 1970's - 1980's
  - IPC-316 HS Design Guide Committee Chair
  - High Speed/High Frequency General Committee Chair
  - Received IPC Distinguished Committee Service Award
- 1990's
  - Received IPC Presidents Award for High Speed/High Frequency Committee work
  - Involved in many committee's (IPC-D-356, HS/HF design and materials, D-350 Data Format)
- 2000's
  - Co-chaired iNEMI Data Convergence Committee (Used ODB++ & GENCAM to create IPC-2581 Format)
  - Participated in Design Guide and Material committees, along with IPC-2581 committee
  - Received IPC Distinguished Committee Service Award for IPC-2551 Digital Twin Standard
    - Completed in <12 months; IPC record
  - Chair AME D-67 Subcommittee and Task Groups
  - Vice Chair ASTM F24.07.06 Additive Manufacturing Electronics sub-committee

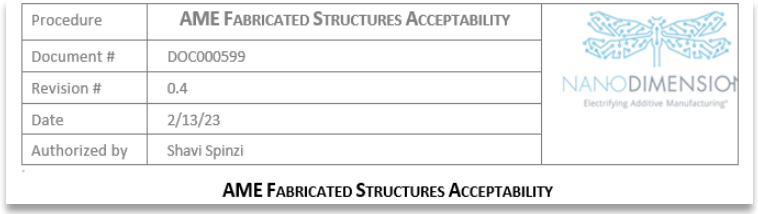
AME ACCEPTABILITY & PERFORMANCE

NANO DIMENSION LEADS THE WAY



Procedure	AME Fabricated Substrates Performance and Qualification
Document #	DOC000554
Revision #	2.1
Date	3/1/2023
Authorized by	Shavi Spinzi

AME Fabricated Substrates Acceptance and Qualification



Procedure	AME Fabricated Structures Acceptability
Document #	DOC000599
Revision #	0.4
Date	2/13/23
Authorized by	Shavi Spinzi

AME Fabricated Structures Acceptability

Procedure	AME acceptance and qualification coupons
Document #	DOC000600
Revision #	0.1
Date	11/23/22
Authorized by	Shavi Spinzi

AME acceptance and qualification coupons

DOC000554 Performance & Qualification specification

- Derived from IPC-6012E
- Updating with some requirements adjustments

DOC000599 Acceptance specification

- Derived from IPC-A-600K
- Requires many more defect and acceptable pictures

DOC000600 AME Coupon specification

- New specification (Mapped from IPC-2221A)
- Requires to totally think about X,Y,Z (non-planar w/via) routing
- Incorporating additional impedance/resistance testing

"We update as we learn. Working with OEM's, Material Suppliers, and PCB Fabrication CTO's"

- Nano Dimension

ANSI/America Makes Roadmap V 3.0

NEW REVISION RELEASED IN JULY 2023

AME is included in the 2023 ANSI/AM "*Standardization Roadmap for Additive Manufacturing*" gap analysis

- Section 2.3 "Qualification and Certification"
- Section 2.6 "Data"

Roadmap is available from ANSI or America Makes

UL – BLUE CARD APPROVAL

UL796 UPDATE

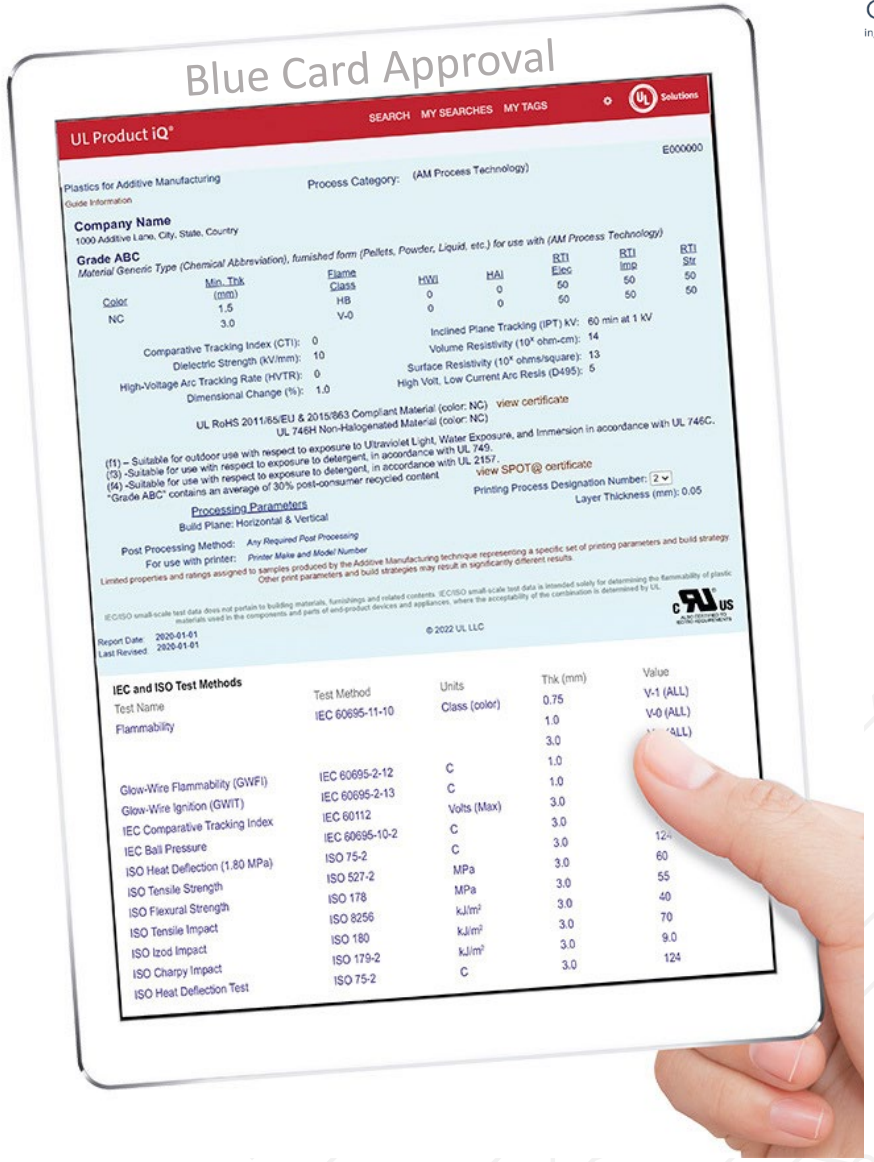
PROPOSAL

1.5 The evaluation of printed wiring boards that are produced using additive manufacturing (AM) processes, commonly referred to as 3D printing, are to be evaluated under the appropriate clauses of this Standard based on the board application.

1.6 For constructions and materials not specifically addressed in this Standard:

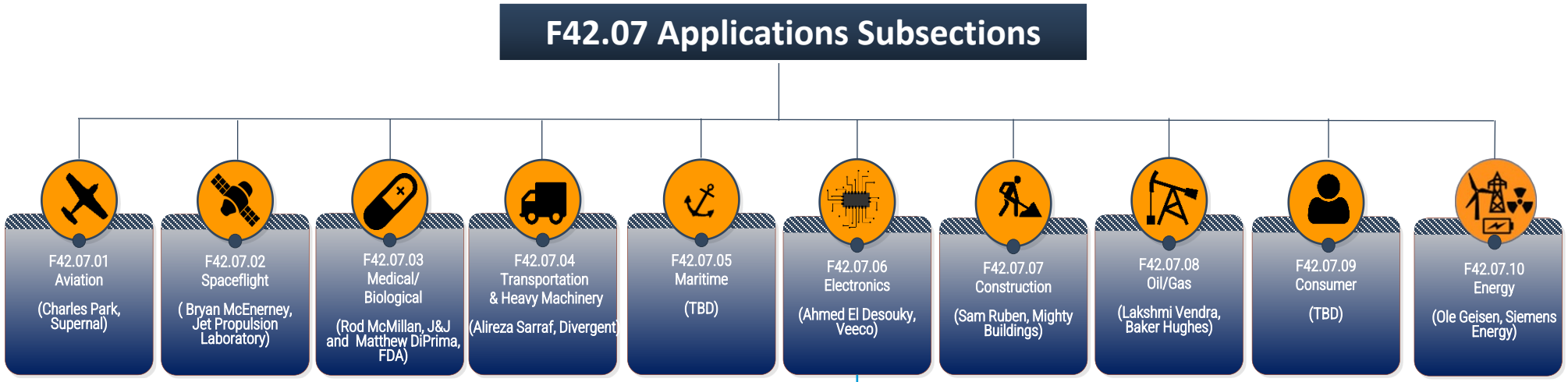
- The printed wiring board should provide safeguards not less than that generally afforded by this document and the principles of safety contained herein. This includes printed wiring boards with technologies, materials, or methods of construction, including the manufacturing process, not specifically addressed in this document.
- Propose for discussion with the Technical Committee the need for additional detailed requirements to address a new situation in a timely manner.

- Blue Card process for additively manufactured plastic parts
  - Tied to AM machine, materials, and manufacturing process
- Proposed UL796 modification by Crystal Vanderpan



ASTM F42 ADDITIVE MANUFACTURING COMMITTEE

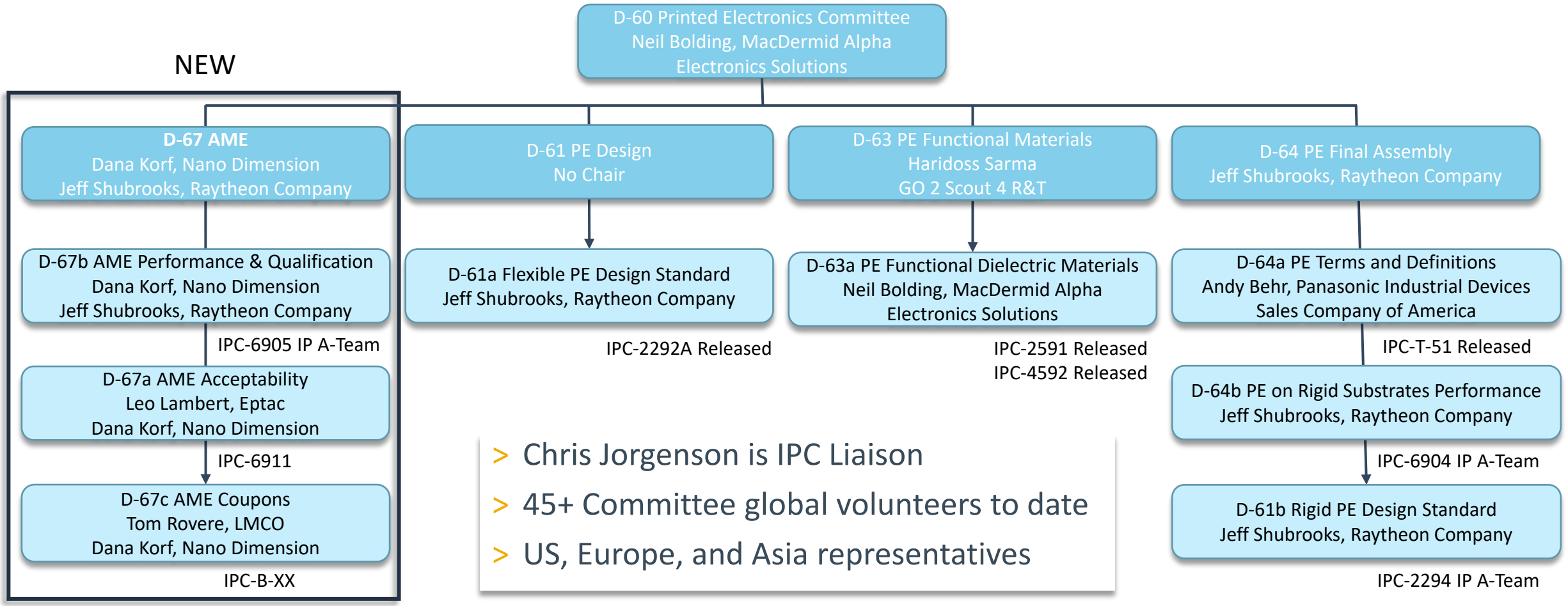
NANO DIMENSION IS THE VICE CHAIR OF THE F42.07.06 ELECTRONICS SUBSECTION



We are in initial discussion on how to integrate with IPC D-67 AME standards development

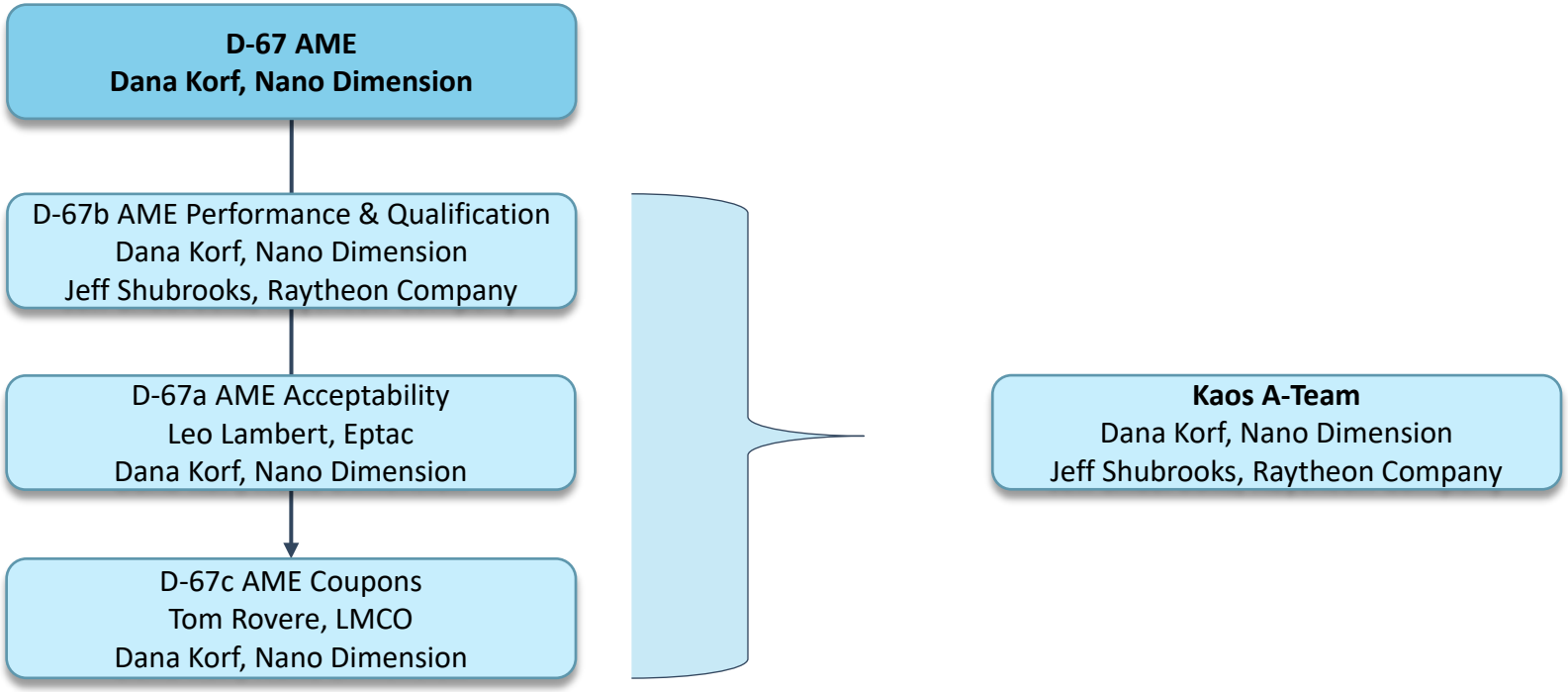
07.06 Chair:
Ahmed El Desouky, aeldesouky@veeco.com
07.06 VC:
Dana Korf, dana.korf@nano-di.com

IPC D-60 COMMITTEE STRUCTURE



- Chris Jorgenson is IPC Liaison
- 45+ Committee global volunteers to date
- US, Europe, and Asia representatives

D-67 TASK GROUPS/"KAOS" A-TEAM



- A-team is meeting bi-weekly with planned draft submission to committee in Feb2024
- Kaos A-team is composed of 12 industry volunteers
- Coupons and Acceptability requirements will emerge from IPC-6905 discussions

PE VERSUS AME PROCESS CATEGORIES

Printed Electronics (PE)[1]	Additive Manufacturing (AM) [2]
Atomized Spray Coating	Binder Jetting
Flexographic Printing	Direct Energy Deposition
Gravure Printing	Material Extrusion
Inkjet Printing	Material Jetting
Micro-dispensing	Powder Bed Fusion
Slot-die Coating	Sheet Lamination
Screen Printing	Vat Photopolymerization

References:
(1) IPC: IPC-2291
(2) ISO/ASTM: 52900

- PE and AM are often called “3D Printing”
- D-67 goal is to produce process agnostic standards
- Potentially combine Rigid, Flex, and Rigid-Flex, into same document

PROPOSED AME DEFINITION

- **ASTM 52900: Additive Manufacturing**: "Process of joining materials to make parts from 3D model data, usually layer upon layer, as opposed to subtractive manufacturing and formative manufacturing methodologies."

- **AME: Additively Manufactured Electronics**: "Fully Additively Manufactured 3D electronic structures which may include formed, unpackaged, and/or packaged circuit components."
  - AME Type 1: Using fully additive manufacturing processes to fully build 3D electronic structure with formed electronic components.
  - AME Type 2: Using fully additive manufacturing processes to fully build a 3D electronic structure with formed, embedded unpackaged, and/or embedded packaged components.

AME Definition is under development by IPC

IPC-6905 AME PERFORMANCE AND QUALIFICATION

- Based on IPC-6012E, IPC-6013E and IPC-6017A with only formed components
- 80% complete draft A-team standard
  - Requires some requirements adjustments
  - Will challenge requirements that have been around for >60 years

IPC-6012E AND IPC-6905 KEY DIFFERENCES

- 6012E requirements that are not applicable to AME technology:
  - Copper foils, cores, reinforced cores, or prepregs (Top 5 PCB defect)
  - Lamination
  - Secondary surface finishes (may change in future)
  - Copper hole or surface plating (including VIPPO) (Top 5 PCB defect)
  - Laser ablated or mechanically drilled holes (including back drilling, secondary drilling, or stacking) (Top 5 PCB defect)
  - Secondary dielectric's (solder mask, via fill, legend)
  - Drilling to internal land pattern mis-registration (Top 5 PCB defect)
  - Reduction of multiple processing steps, chemistries, and equipment interactions
  - Internal metal cores

Approximately 50% less defect categories

NEW AME REQUIREMENTS OUTSIDE OF IPC-6012E

- Slice-slice delamination
- Slice-slice voids
- Slice-slice cracks
- Off-axis conductor thermal stresses
- Significantly less handling damage to conductors and dielectrics (Top 5 PCB defect)
- Reference Functional Material standards (IPC-4591 & IPC-4592)
- Lower temperature thermal stress testing
- Adhesive bonding for embedded and surface components
- Conductor pillars and walls
- Conductor to Dielectric Overlap "Roughness“
- Cleanliness between prints (slice-slice)

FLEX AND RIGID-FLEX PROPOSED ADDENDUM

- An analysis proposes the following additional sections to IPC-6905 to incorporate Flex and Rigid-flex configurations:
  - [Modify] Additively Manufactured Electronics Types
  - [NEW] Flexible Zone
  - [NEW] Flexible Zone Performance Requirements
  - [NEW] Transition Zone, Rigid Area to Flexible Area
  - [NEW] Bending and Flexibility Endurance
- Proposal based on comparison of IPC-6012E and IPC-6013E standards
- This will not be considered during the initial IPC-6905 release. Save for 6905A version?

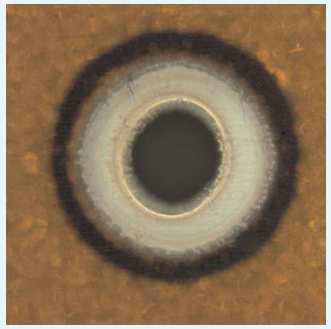
AME allows Rigid, Flexible, and Rigid-flex substrates created on same machine

IPC-B-XX PROPOSED AME COUPONS (NUMBER IS TBD)

IPC Coupon	Section	AME Coupon	AME Description
E	5.1	MIR	Moisture and Insulation Resistance
P	5.2	PS	Peel Strength
AB/R, A/R, B/R	5.3	REG	3DT Z-axis Registration & Hole Thermal Stress
D (OBS)	5.4	RES	Conductor Resistance
H	5.5	SIR	Surface Insulation Resistance (SIR)
G	5.6	SM	Solder Mask
W	5.7	SMT	Surface Mount Solderability
S	5.8	THS	Hole Solderability
D	5.9	TS	Thermal Stress Daisy-chain 3DT
Z	5.10	ZS	Stripline Family
N/A	5.11	ZC	Coax
N/A	5.12	ZT	Twisted Pair

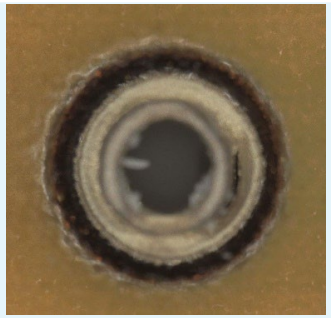
- IPC-2221 2D Gerber based coupons are not applicable in a 3D space
- Propose to use AMF, 3MF, STL, or another format
- Possible to combine tests into fewer coupons
- May need more sections for non-PE processes

IPC-6911 AME ACCEPTABILITY



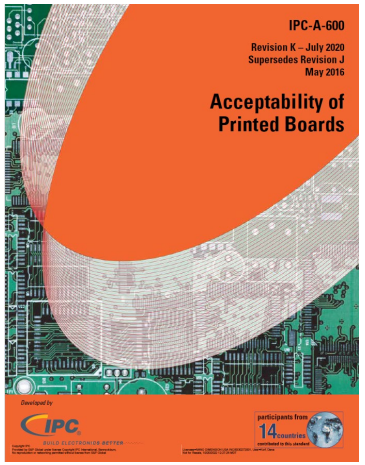
Acceptable Condition

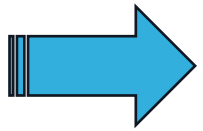
- Nodules or rough coating that do not reduce the hole diameter below the minimum limits defined in the procurement documentation.

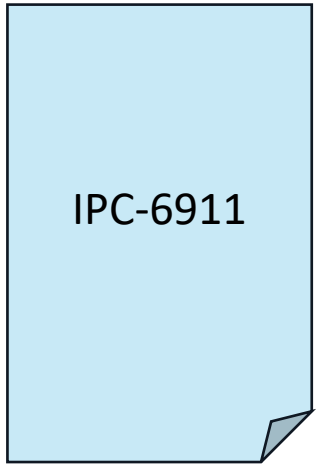


Nonconforming

- Observed conditions either do not meet or exceed above criteria.

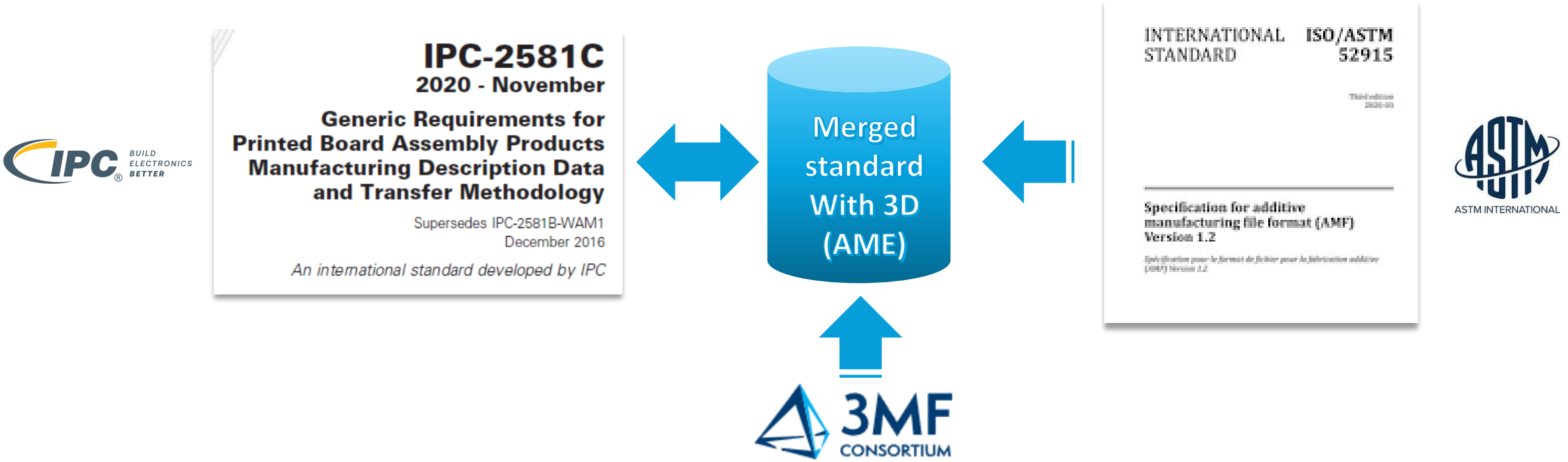






- Based on IPC-A-600K standard
- Requires many more defect and acceptable pictures
- May require additional sections for non-PE processes

3D AME DATA FORMAT



- ISO/ASTM 52915 (AMF) and IPC-2581 (DMFX) are both industry standards
- Discussing with both IPC and ISO/ASTM TC261 Working Group 64 about creating a merged standard
- Also discussing with 3MF Consortium merging 3MF data format with IPC-2581
- The goal is to **generate data transfer format with CAD/CAM software before AME reaches high volume**

CONTACT IPC IF YOU WOULD LIKE TO PARTICIPATE

Call For Participation: AME Standards Projects

By Admin User

IPC has received proposals for three new projects for additively manufactured electronics (AME):

- A standard to establish and define the qualification and performance requirements for additively manufactured electronics
- A visual inspection standard to describe the target, acceptable, and nonconforming conditions that are either externally or internally observable on additively manufactured electronics
- New test coupons to support the qualification and performance requirements standard

Notify Chis Jorgenson (ChrisJorgenson@IPC.org) to participate in sub-committees

NANODIMENSION
Electrifying Additive Manufacturing

THANK YOU

@nano-dimension

@3Dpcb

www.nano-di.com