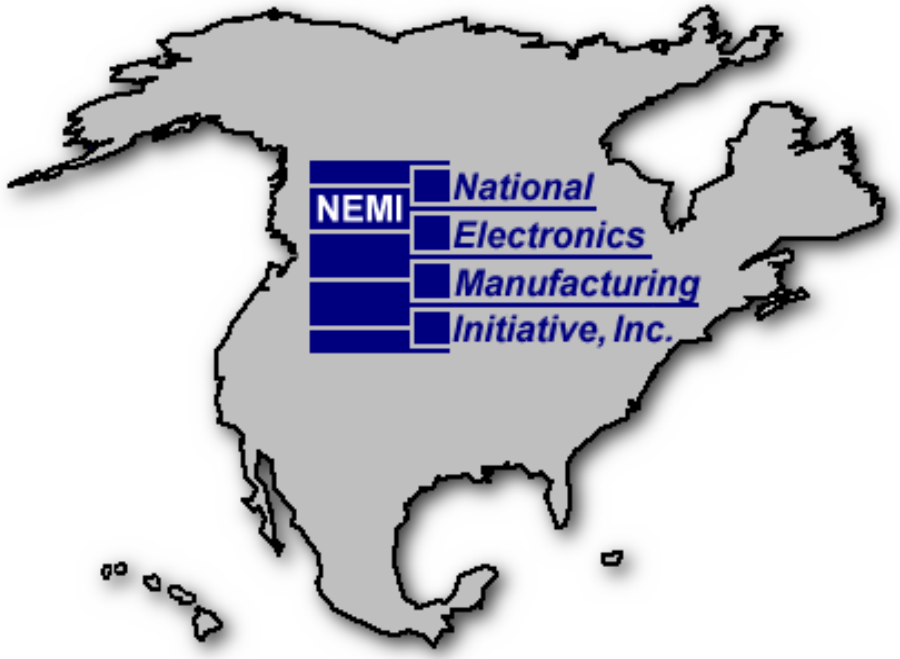

Whisker Fundamentals Modeling Group
DOE

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First Iteration of Proposed DOE

- This presentation is an outline of possible variables for the DOE open for discussion in the afternoon forum
- We are trying to provide Systematic approach to incorporate the survey results into fundamental study of whisker phenomenon.
- We will develop DOE matrix for plating process conditions to evaluate the effect of fundamental parameters of whisker growth.

Topics from Fundamental Group Survey Results

- Internal stress as a driving force for whisker growth
- Substrate Material
- Substrate Preparation
- Electrolyte Types
- Electrolyte Operating Conditions
- Deposit Composition
- Deposit Thickness
- IMC
- Impurities/inclusions
- Other Factors

Proposed Substrate Material

- OLIN 194
- Phosphor Bronze
- Copper
- Alloy 42
- Coating on passive components with Ni plating underlayer

Proposed Substrate Preparation

- Coupons prior to stamping mounted on rotating disc electrode with silver paste
- Annealed/not annealed
- Industry standard pre-treatment procedure (descaling, activation, etc.)

Proposed Electrolyte Types

- Sn Bright MSA based
- Matte MSA based
- Sn Sulfate based
- Sn mixed acid
- Sn-Pb matte MSA based
- Cu added to Bright Sn MSA based
- Cu added to Matte Sn MSA based

Proposed Deposit Thickness

- **1 um**

  This thickness behaves differently than thicker coatings because of the effect of IMC and epitaxial deposit structure

- **3 um**

  Close to real life thickness of 3 to 5 um for connector applications

- **10 um**

  Close to real life thickness of 10 to 12 um for leadframe applications

Note: 1 um equals 40 microinches

Proposed Electrolyte Operating Conditions

- **SET Condition- Control agitation with rotating cathode at one rotation speed**

- **SET Condition- Temperature at 40C (or set by bath supplier)**
- **(recrystallization temp of Sn is 51.3 C)**

- **Variable - Current Densities at 5 and 15 ASD for both SnCu and Sn**

Proposed Deposit Composition

- Pure Sn
- Sn-Cu (important to understand the difference between co-deposited Cu and Cu diffused from substrate)
- Pb-Sn (90/10) as a control

Other Factors to Consider

Impurities -

- **Water (everyone needs to measure resistance)**
- **Filtration of bath - set a filter size to remove SnO_2.**
  Variable: Use two Teflon based filters - high 10 um and a low 0.2 um
- **Plating efficiency will be measured during plating and associated with hydrogen incorporation in the deposit**

Objectives of DOE

- Choose 2-level factorial DOE
- Variables:
  - Deposit thickness: 1 (or 3) and 10 micron
  - Current density: 5 ASD and 15 ASD
  - Substrate annealing: Yes and No
  - Filtration (inclusions): Yes and No
- Need to choose a few combinations of substrate+chemistry and apply the DOE matrix

Responses/Observables for DOE

- **Internal stress after plating and its change during aging**
  - **need to choose a method to measure IS (XRD, MicroDAC, Moiré, etc.)**
  - **can measure IMC growth at the same time by either stripping remaining tin and taking SEM pictures or FIB (both destructive methods and require additional coupons)**
- **Whisker inspection**
  - **will use the accelerated test proposed by the main Committee (first DOE)**
  - **will follow the suggestions for handling samples and SEM inspection from the first DOE**
- **Need to discuss methods for characterization of crystalline defects and inclusions**

Summary

- Choose Fundamental Group Survey responses as factors in whisker study
- For DOE Factorial Matrix proposed four plating parameters at two levels
- Need to choose a few combinations of substrate+chemistry and apply to the DOE Matrix
- Fundamental parameters and DOE Matrix will be discussed in the afternoon forum