EVALUATION OF TECHNIQUES FOR INTENTIONAL CONTAMINATION OF PWB SUBSTRATES FOR QUANTITATIVE CLEANLINESS ANALYSES

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Outline/Agenda

- Introduction
- Methods
- Results and Discussion
- Conclusions
- Q & A

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Intentional Contamination?

- Cleanliness of high-reliability assemblies critical to prevent failure due to various electrochemical phenomena
- To help up figure out if we've done the job, we have ROSE, IC, C3, and SIR
- However, none of these methods directly quantify the contamination present on the board
  - ROSE → Resistance of an extract solvent
  - IC → Elution times of ionic species compared to a standard
  - SIR → Surface resistance over time
  - C3 → Electrical current conducted through a water extract over time

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Intentional Contamination?

- The measured property is quantified and correlated to pre-determined pass-fail criteria, NOT a surface concentration of contamination
  - Ex. A “passing” SIR result may be one that exhibits a surface resistance higher than a certain value over the course of a pre-determined amount of time

- Acceptance criteria are not:
  - based on quantified contamination
  - determined on a product-by-product basis

- They have been collectively agreed upon as an industry and written into standards documents or widely accepted literature

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Intentional Contamination?

- For tests that have already been developed, like the ones previously mentioned, there are many published references that are widely accepted
- For next-generation products, such as those that incorporate new packages, smaller components, or denser designs, those criteria may not be sufficient
- If new techniques are established to meet the heavier demands of future designs and cleaning requirements, a method for creating samples with known homogeneous levels of contamination to directly correlate surface contamination levels with the response of the technique will be required

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Coating Methods

- We can pull from literature or other industries for coating methods

Spin Coating

Source: www.amazon.com

Dip Coating

Source: www.msesupplies.com

Spray Coating

Source: www.fibreglast.com

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Coating Methods

- This work focuses on spin coating and a solvent deposition method to demonstrate the ability to homogeneously coat a PWB substrate surface with a precise quantity of contamination
  - Qualification of new or established methods
  - Support the determination of “how clean is clean enough”

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Methods – Contamination Soln.

Source: www.sigmaaldrich.com

- For the IC/C3 tests, NaCl in methanol
  - 3 solutions made between 0.002 and 0.006 g NaCl/g solution
- For the FTIR test, PDMS in hexane
  - 4 solutions made between 0.002 and 0.03 g PDMS/g solution
- Solutions made to produce typical surface concentrations of interest
  - 10 $\mu g/in^2$

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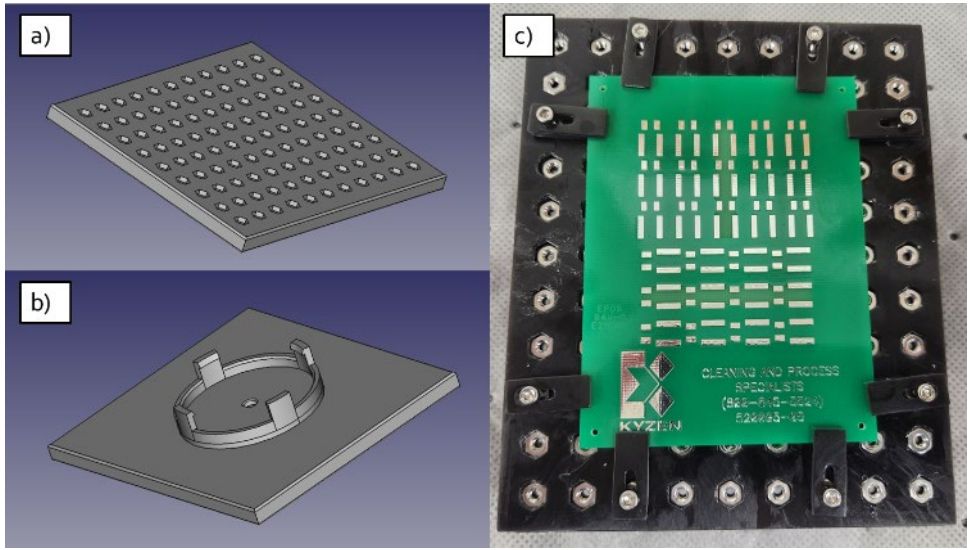
Application Methods – Spin Coat

- Spin coating was carried out with a modified stir plate
  - The ceramic plate was removed, and a custom chuck was 3D-printed to interface with the spinning magnet.
- Boards were covered with the solutions and spun at 400 RPM for 30 seconds



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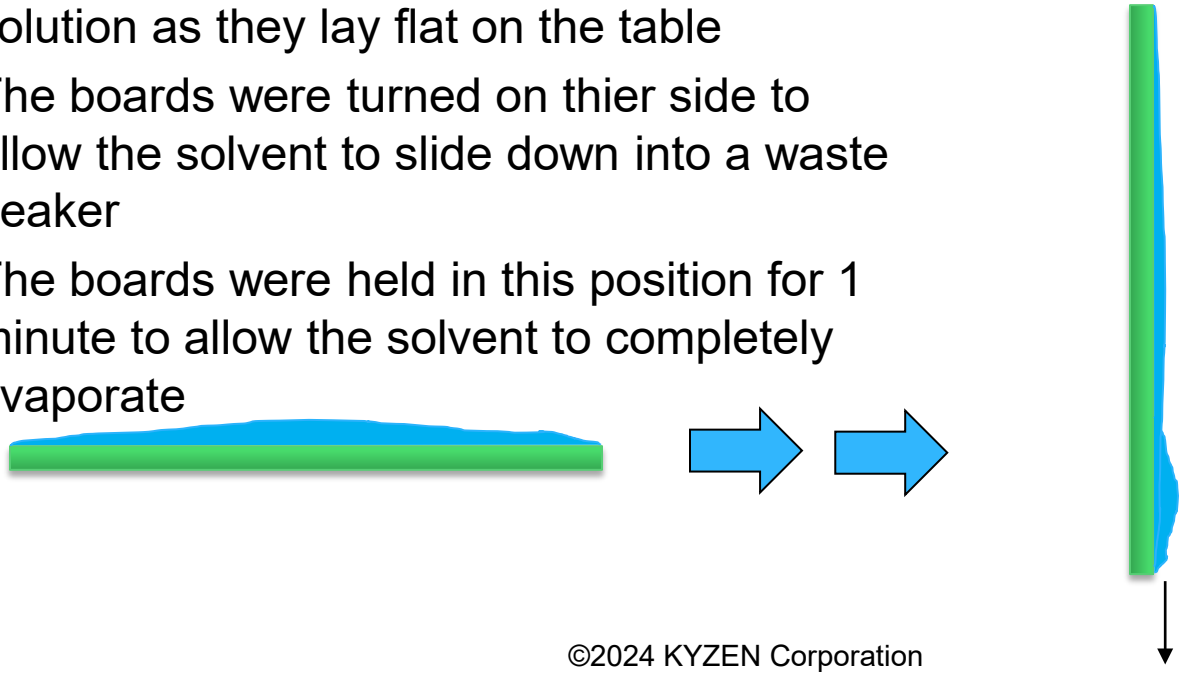
Application Methods - Deposition

- Boards were completely covered with the solution as they lay flat on the table
- The boards were turned on thier side to allow the solvent to slide down into a waste beaker
- The boards were held in this position for 1 minute to allow the solvent to completely evaporate



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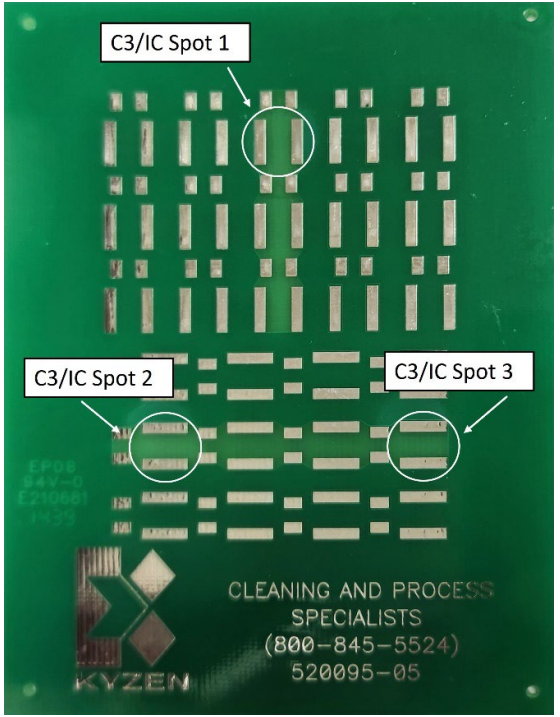
Methods – C3 and IC

- C3 was carried out on a C3 Benchtop Critical Cleanliness Control Unit
- Boards were tested at three specific locations
- After testing, the C3 extracts were collected in IC vials and analyzed via IC
- IC was carried out on a Dionex IC-5000 system setup for cations and anions



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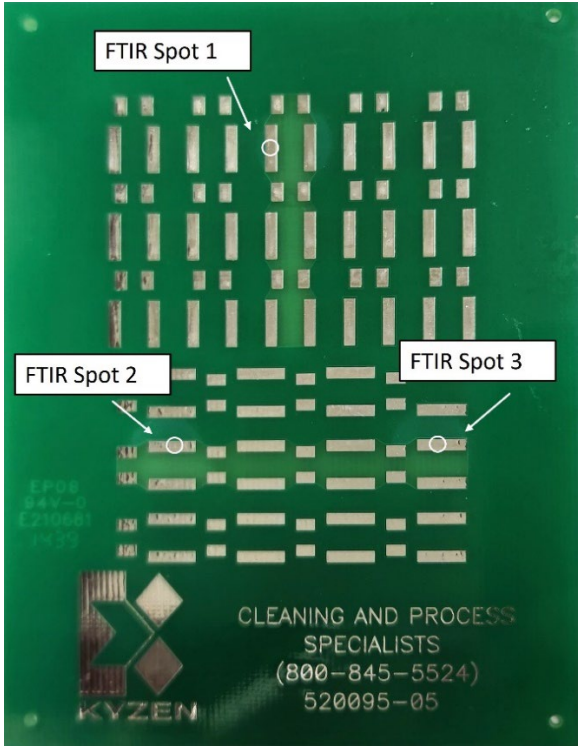
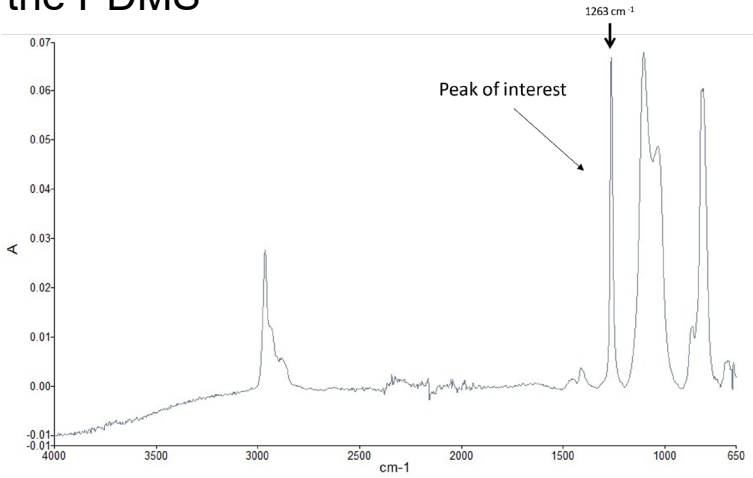
Methods – FTIR



- Perkin-Elmer ATR-FTIR w/ diamond crystal
- The pads were aligned with the crystal and spectra were collected and manually baselined
- Peak at 1263 cm-1 associated with the Si-C stretch of the PDMS



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Experimental Considerations

- Used unpopulated boards
  - Components would impede the transport of the solvents
  - Soldering would contamination
- The sampling locations on the board were chosen to be as far apart as possible
- Solvent and contamination selection
  - Low surface tension – cannot use water
  - High solubility – cannot use IPA
  - Methanol and hexane were chosen
- NaCl and PDMS were chosen as they represent typical contamination present in electronic manufacturing

	IPA	Methanol
Solubility of NaCl	0.03 g/L	11 g/L

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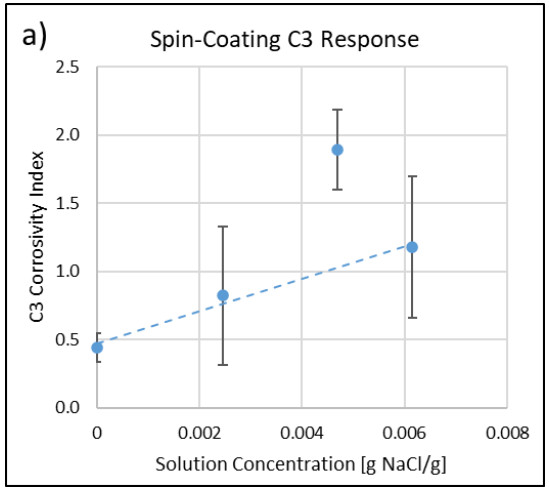
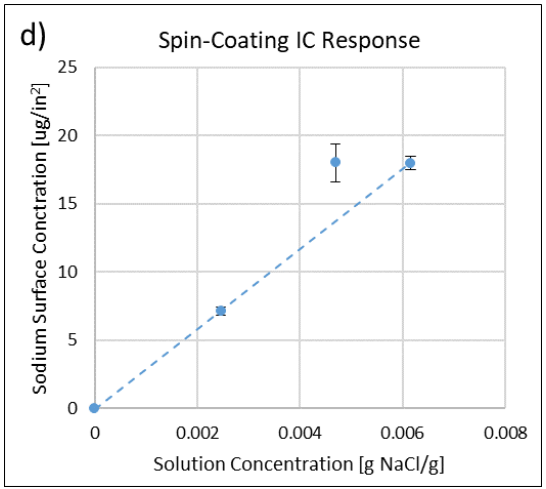
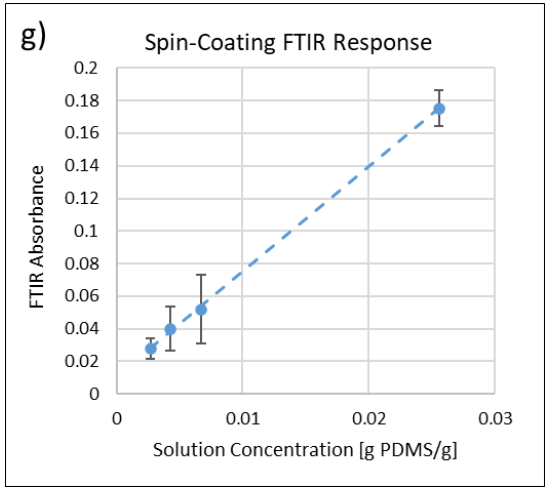
Results – Spin Coating

- Each measurement technique has widely different homogeneity
- Average standard deviation in C3 is 13% of the largest measurement → Not good for quantifying concentration
- Average standard deviation in IC is 3% of the largest measurement
- Average standard deviation in FTIR is 7% of the largest measurement → Semi-quantitative







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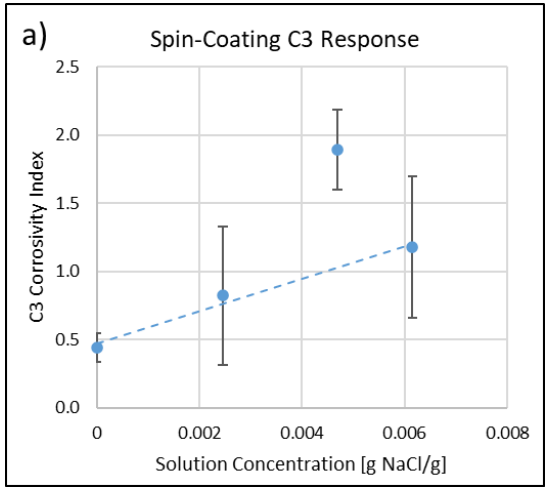
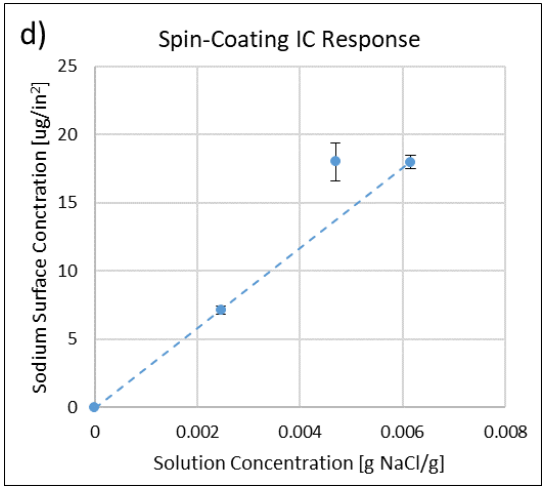
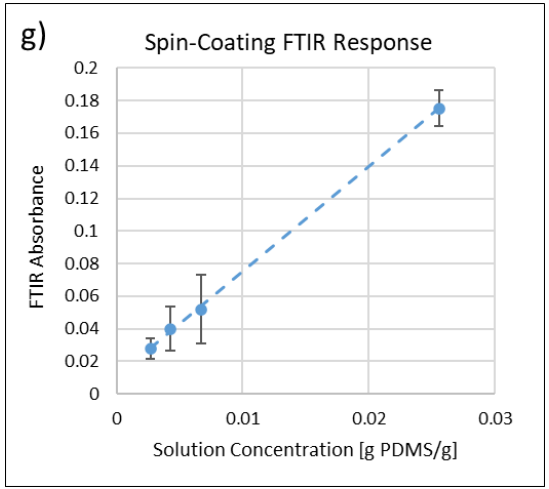
Results – Spin Coating

- With the exception of one board, the response of each technique is linear with respect to concentration
- Spin-coating exhibits good homogeneity and linearity
- When considering which analytical technique to utilize when alibrating, IC appears to have the best sensitivity for this type of analysis and will result in much less variation between samples







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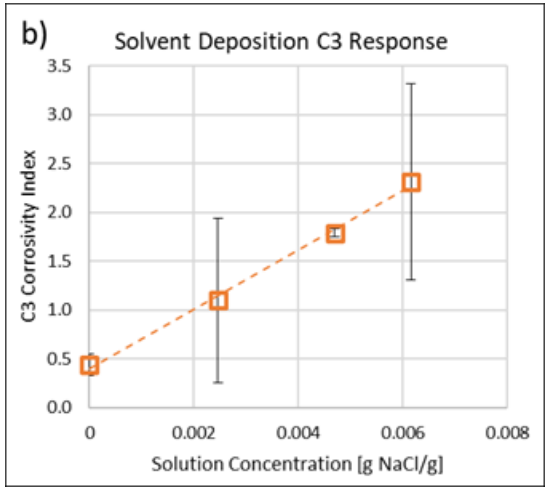
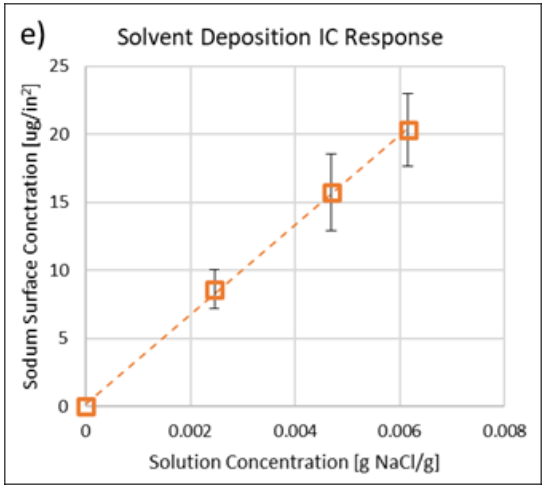
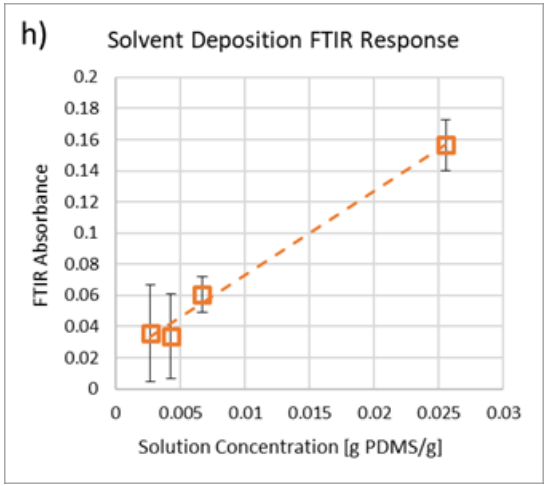
Results – Solvent Deposition

- Average standard deviation in C3 is 50% of the maximum range of the data
  - Note that two of the samples had significantly higher variability than the others
- Average standard deviation in IC is 10% of the largest measurement
  - More than twice as high as the variation among the spin-coated samples
- Average standard deviation in FTIR 12% of the maximum data point in the data set.







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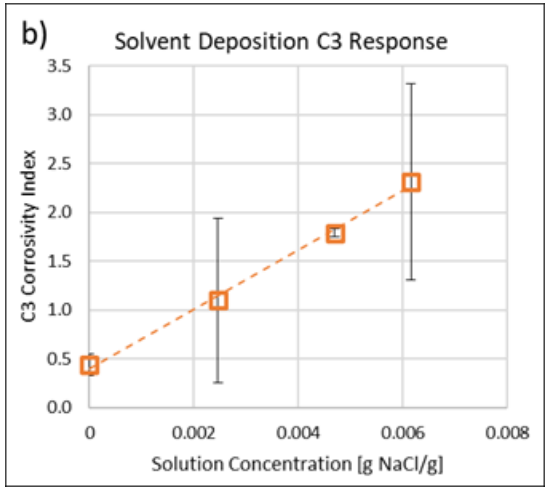
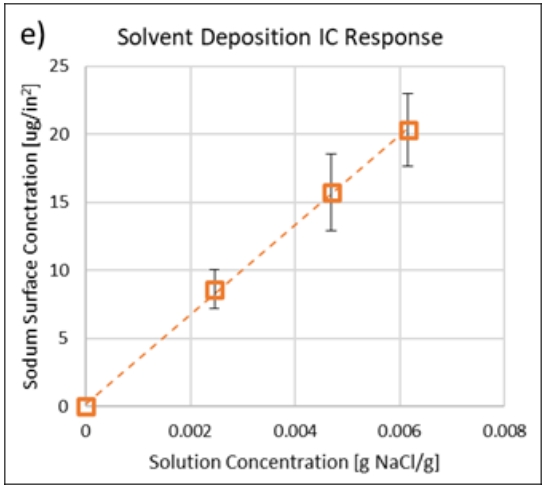
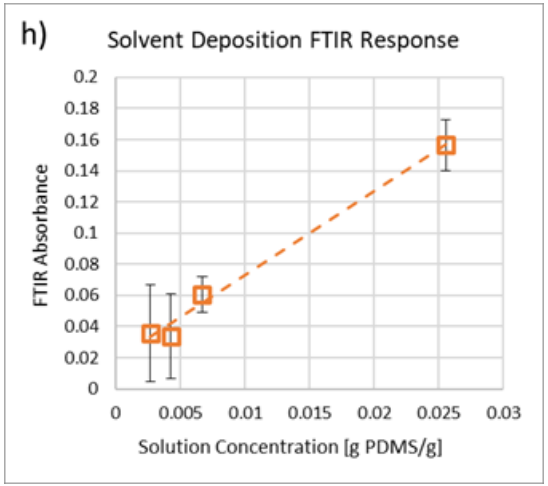
Results – Solvent Deposition

- All exhibited linear behavior with respect to the concentration of the contamination solution used







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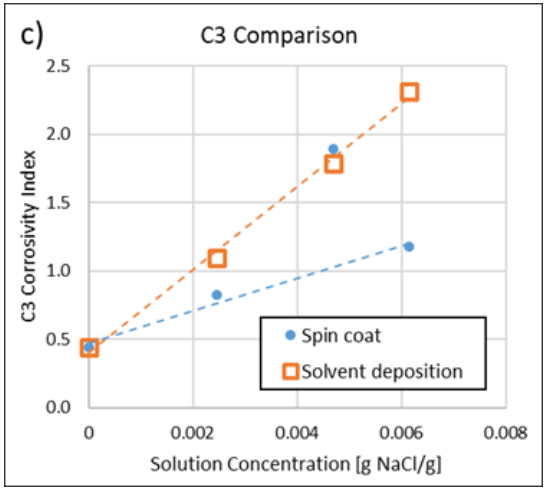
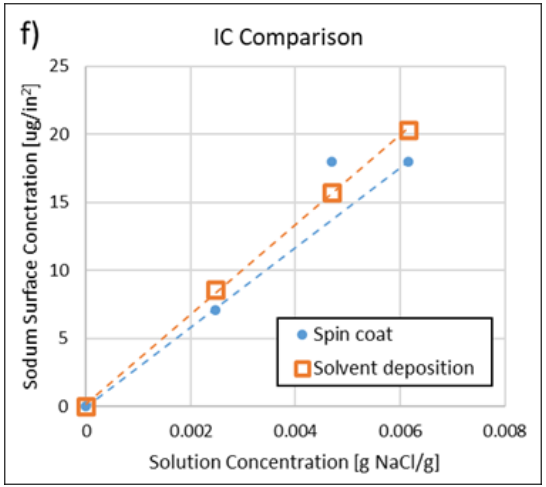
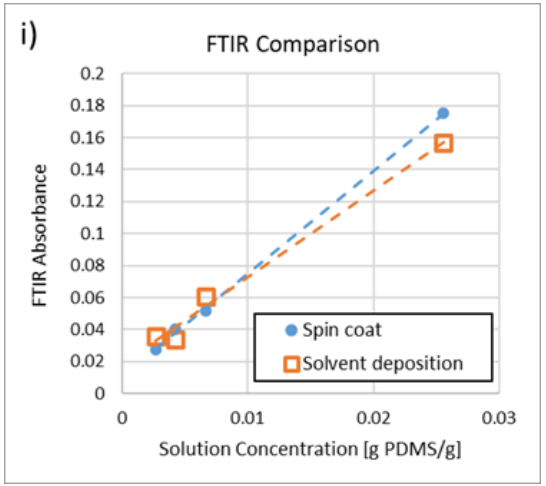
Method Comparison

- For the ionic contamination, the solvent deposition response is always slightly higher than that of the spin-coated sample
  - This is consistent with our understanding of how the film of contaminated solvent should form on the surface of the PWB
- Both methods produce linear results







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Conclusions

- When attempting to coat PWBs with a homogenous contamination layer for further analysis, it was clear that the choice of solvent was of high importance
  - The two key properties that the solvent must exhibit are a high solubility of the contamination and a low surface tension in order to completely wet the surface of the PWB
- When considering accuracy and repeatability, the spin-coated samples exhibited significantly better coverage homogeneity
- There are two methods for creating different surface concentrations for comparative purposes:
  1. Change the concentration of the contamination in the carrier solvent
  2. Change the rotational velocity of the sample in the spin coater

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Thank you!

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