In-Line Optical Transmission Imaging of Decals for Quality Control – Task 3

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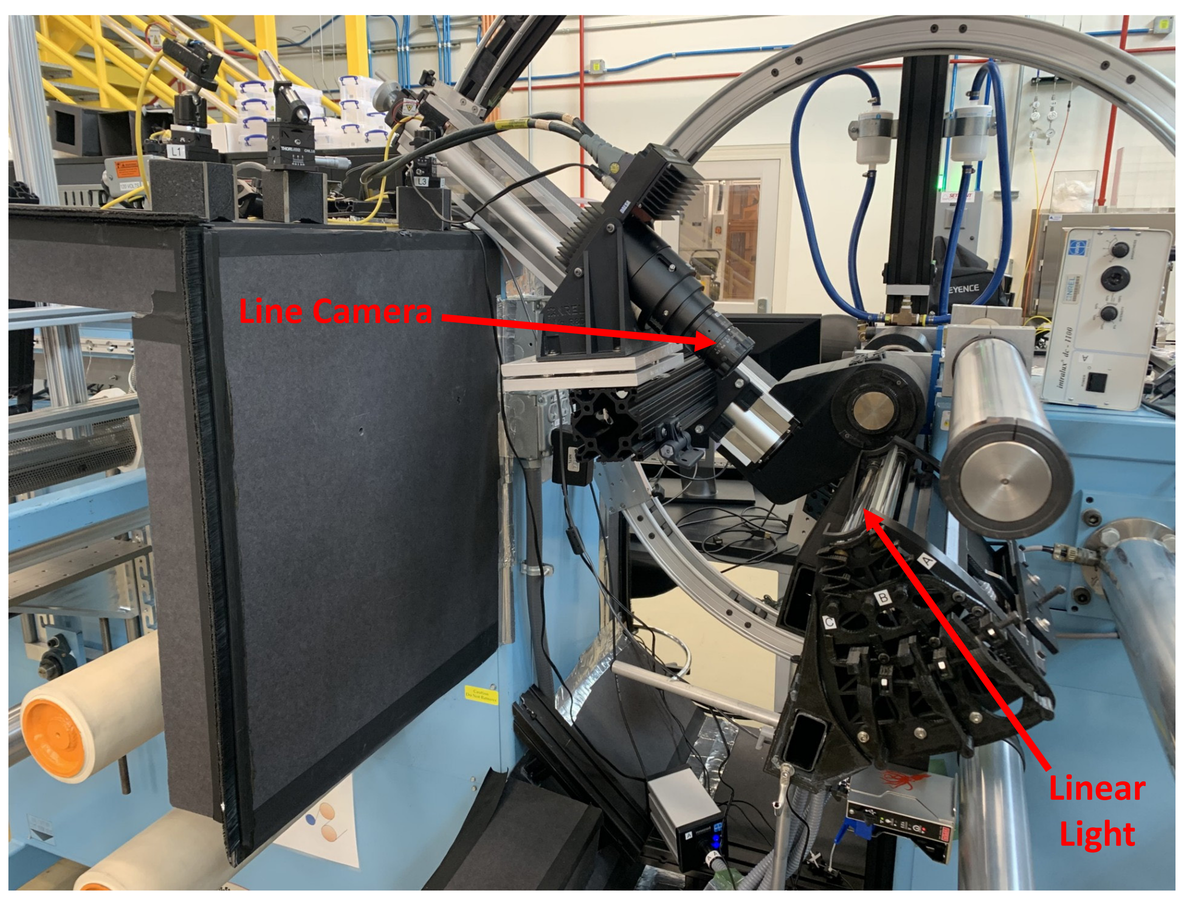
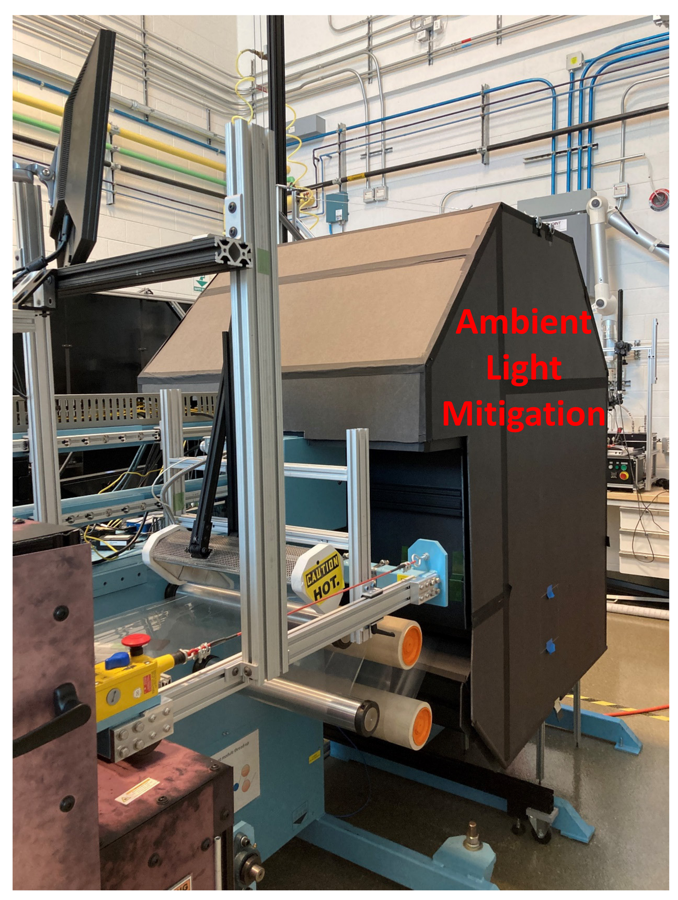
MOTIVATION

- Evaluate the performance of the established optical inspection method to understand its correlation to catalyst uniformity. The secondary motivation was to correlate transmission signal to loading to monitor loading uniformity.
- **R2R Consortium Milestone**: perform optical imaging of three types of rolls, each a few meters long, at speeds comparable to the consortium figure of merit for electrolyzer production.
- **Goals:** Enhance understanding with how the material properties (loading, uniformity, catalyst microstructure, etc.) correlate with results of high-resolution in-line imaging. Having a more robust and higher throughput quality control system will allow for better monitoring of the processed materials and potentially improve yield as the materials become more uniform/defect free.

APPROACH

- High optical resolution was prioritized in these scanning runs to capture uniformity details on many length scales down to a micro level where a pixel corresponds to tens of micrometers.
- **Camera:** Low light line camera with a TDI of 96, the aperture fully closed, and a 76 mm field of view.
  - The resultant pixel size was 9.3 um which allowed us to visualize the microstructure.
- **Web-line parameters:** 5 ft/min at 1 pli (pounds per linear inch).
- **Light:** linear light guide. Ambient light mitigation to reduce noise.

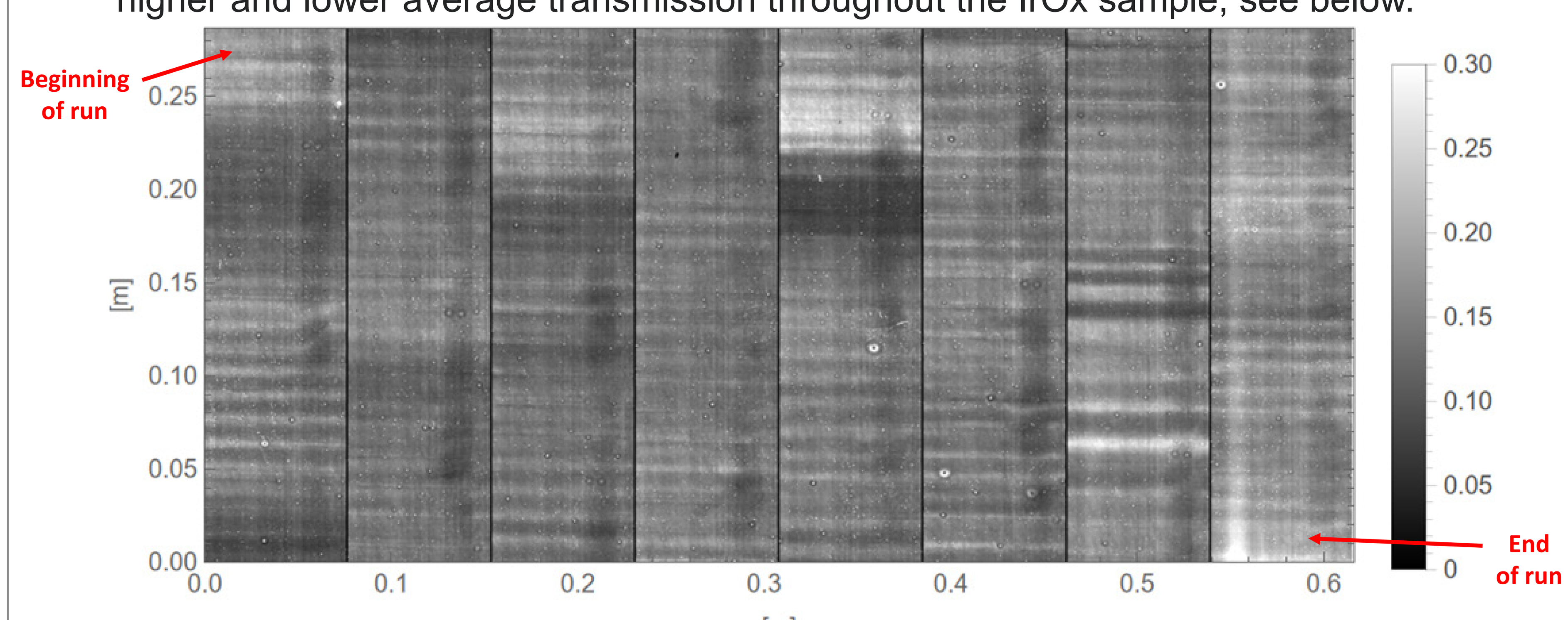




- Influences from reflection within the enclosure were found to be minimal which ensured high S/N.
- The lighting and camera settings were consistent throughout the runs to allow for more accurate optical comparisons.
- Following transmission scanning, sections would be cut for subsequent XRF measurements.

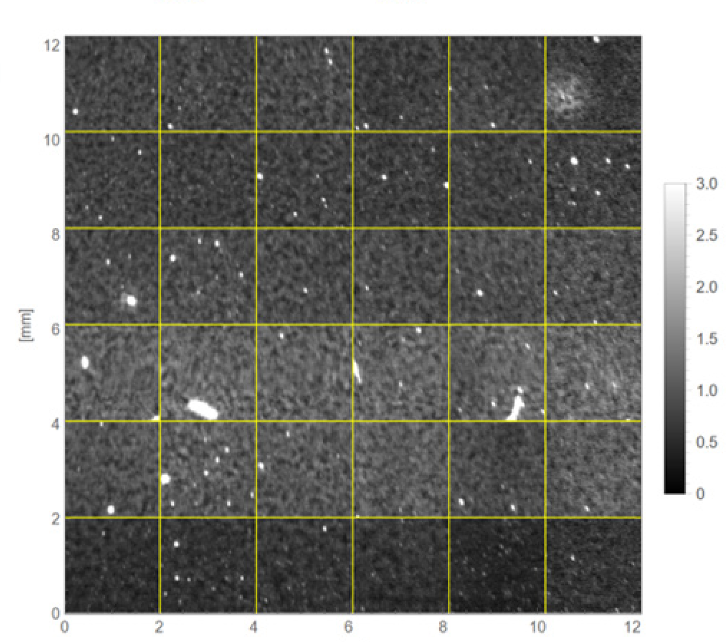
RESULTS

- On the macroscale of our high-resolution scans, we can see features such as periodic horizontal banding (most likely from coating process), dewetting spots, and areas of higher and lower average transmission throughout the IrOx sample, see below.



Transmission image of entire roll with boosted contrast to visualize transmission variations.

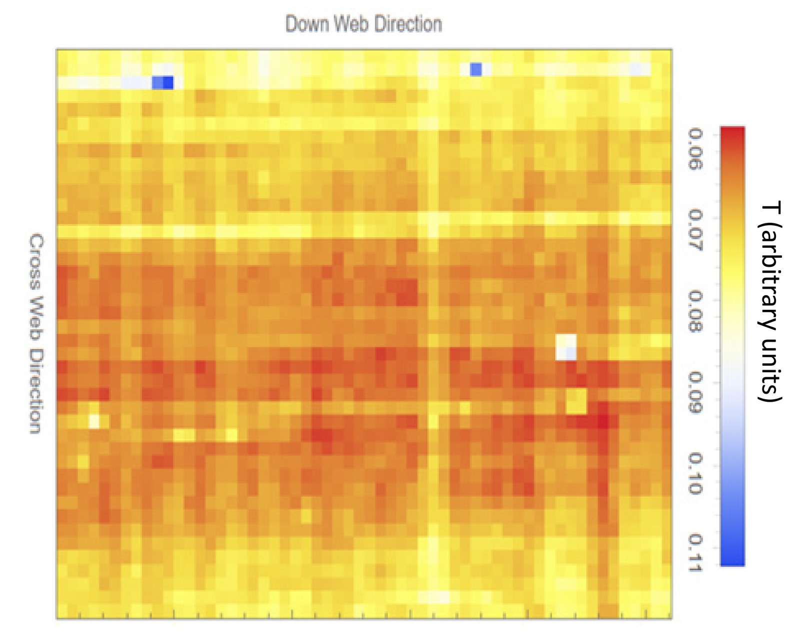
- On the microscale we can see features such as areas that lack coating, and the general microstructure with small-scale variations in transmission that most likely correspond to small changes in PGM loading, seen in the image to the right.



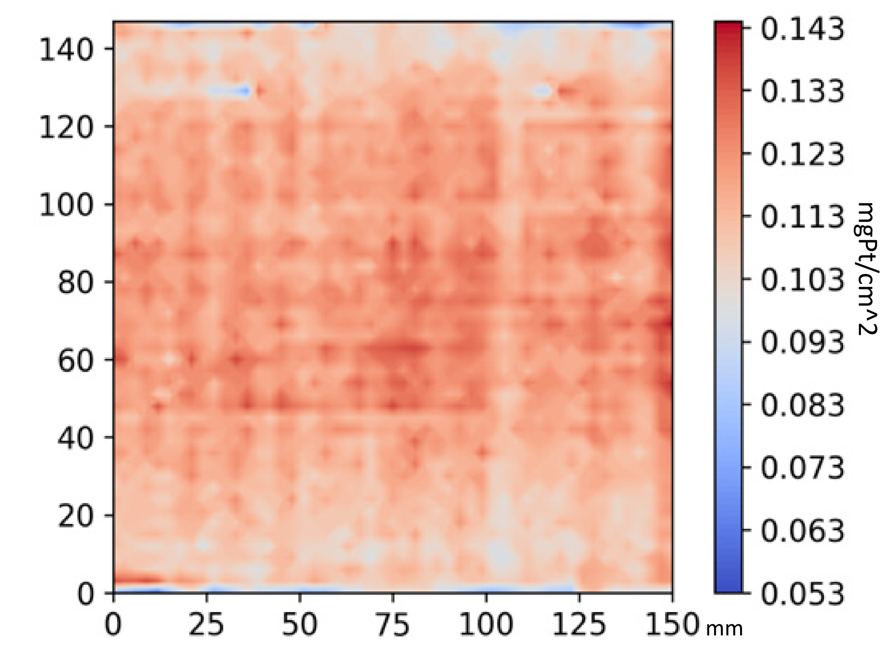
2mm length scale images of IrOx

RESULTS - CONTINUED

- Converting the optical transmission images to transmission heat maps, a qualitative comparison can be made to XRF heat maps, seen below.
  - These two Pt/C heat maps exhibit similar features which signifies that a more quantitative comparison can be made between transmission signal and catalyst loading.

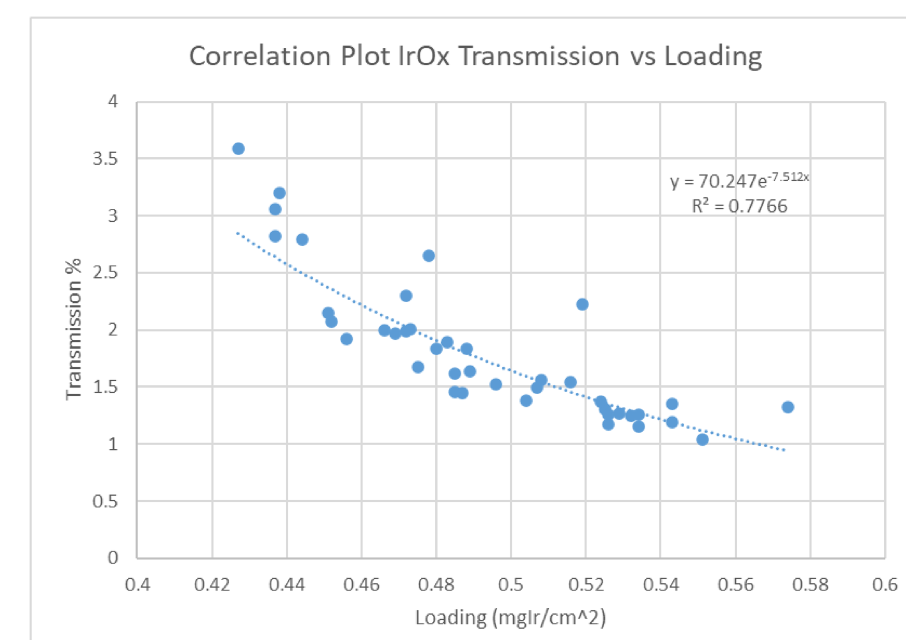


Transmission image converted to heat map

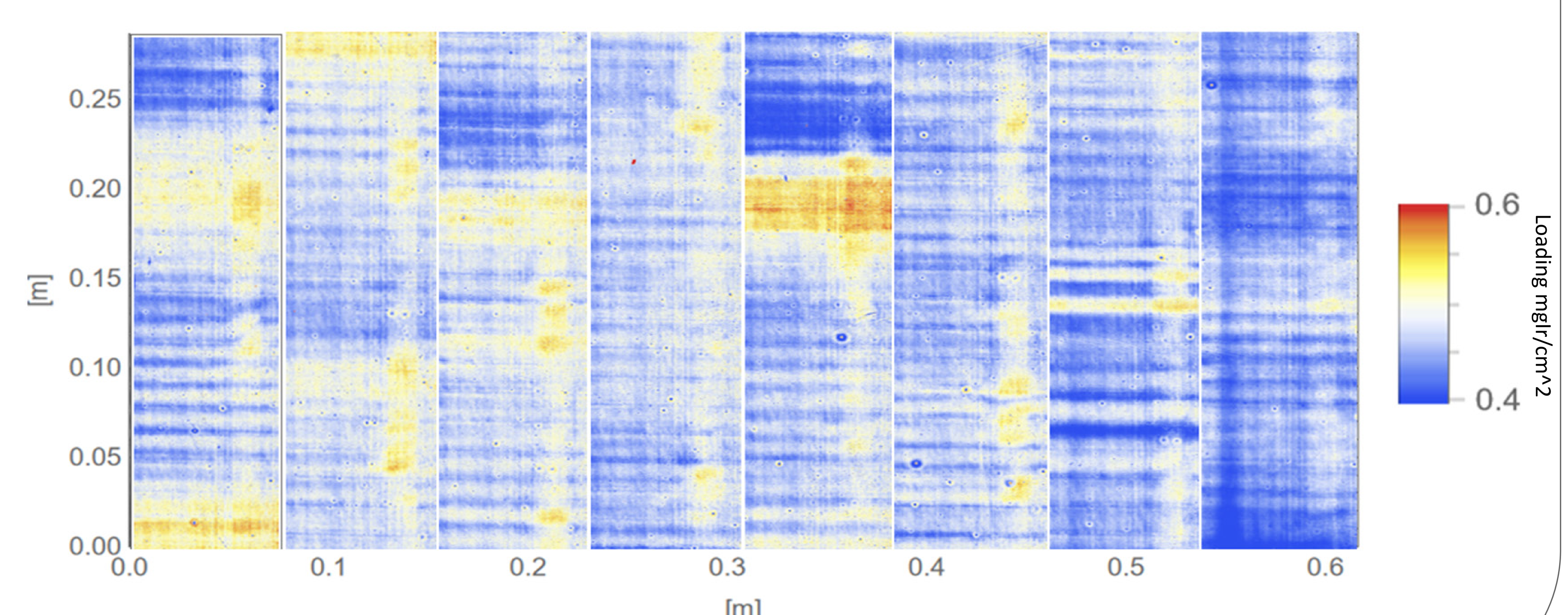


XRF heat map of same area

- Using features seen in optical scans, we were able to align an optical region with an XRF array measurement of the same region.
  - From this we could build a calibration curve to correlate transmission signal to IrOx loading that follows the expected beer-lambert law, see right.
  - Improper alignment is our current hypothesis for why we aren't able to build a strong calibration curve for Pt/C yet.
  - With the calibration curve, we get a high-resolution IrOx loading map of the entire run, see below.



Correlation between transmission response and XRF loading



Optical transmission map converted to loading map for the entire run

COLLABORATIONS

- This activity falls mostly under Task 3 (QC) .
- Yuepeng Zhang (ANL), Andrew Lee (ANL). Maps were sent to ANL for development of ML processing methods (Task 5).
- This work is done in tandem with process development (Task 2) and guides how different processing parameters and inks alter the defect formation and uniformity of the electrode loadings.

MAJOR ACCOMPLISHMENTS/FUTURE WORK

Accomplishments:
- Successfully scanned rolls and mapped out their transmission response.
- Observed variations in transmission response to visualize uniformity at the micro and macro scale.
- Successfully correlated transmission response to IrOx loading variations.

Current:
- Scanning various Pt/C samples to visualize the change in uniformity as a function of different processing parameters.
- Scanning mock inks to show their similarity to IrOx coated materials.

Future Work:
- Test scanning speeds commensurate to fuel cell production rates (>50 ft/min).
- Experiment with other materials (membranes, GDEs, GDLs, mock inks) to gather their optical response and try to correlate to physical properties.
- Enhance understanding the lack of correlation currently seen with Pt/C optical transmission to loading.

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U.S. DEPARTMENT OF ENERGY
Hydrogen and Fuel Cell Technologies Office

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