Photoreceptor Testing: Fundamentals and Practice

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Photoreceptor Testing:
Part I - Fundamentals

What Tests to Run?

- Testing and characterization of photoreceptors (e.g., OPC) begin with an understanding of their basic functional requirements for applications in an electrophotographic printing system.
- The following is a brief summary of such requirements.

Photoreceptor Functional Requirements (1)

- **Electrical Properties**
  - Must charge & store charge adequately in the dark
  - Must discharge quickly and efficiently when exposed
  - No memory or quality problems in multi-page printing
- **Coating Quality**
  - Functional coatings (e.g., CGL & CTL) must be as uniform as possible
  - Uniformity is particularly critical for color printing
- **Resolution**
  - Must provide sufficient resolution
  - No blurring effect (due to lateral conduction, environmental sensitivity or contaminants)

Photoreceptor Functional Requirements (2)

- Print Quality & Print Defects
  - Uniform print density, particularly important for color printing
  - No print defects: black spots, background, banding or ghosting
  - Sharp fine structures, including lines and texts
  - No “Plywood” defect
- Environmental stability
  - Stable at HH & LL temperature and humidity range
  - High resistance to chemical degradation by corona discharge, UV and charge cycling
- Life
  - High wear and abrasion resistance to meet modern speed and print volume requirements
  - Continuing interest in recycling and reusability

Photoreceptor Testing Overview

- In response to the functional requirements, the following tests can be identified:
  - Charge Acceptance
    - Capacitance & Dielectric Thickness
    - Dark Decay
    - Charge roller charging
  - Photosensitivity
    - Photo-Induced Discharge Curve (PIDC)
    - Spectral sensitivity
    - Charge mobility
  - Cyclic Fatigue
    - Cycle down (charge acceptance) and cycle down (discharge sensitivity)
  - Coating Uniformity, Defects and Wear Mapping

Charge Acceptance

- **Charging and charge acceptance**
  - Uniformly charged by depositing ions on the surface
  - Devices: corotron, scorotron, charge roll, charge brush
  - Constant voltage or constant charge charging
  - Voltage determined by capacitance and dark decay

$$V = (L/\varepsilon\varepsilon_o) \cdot \sigma - \Delta V$$

Typical values:

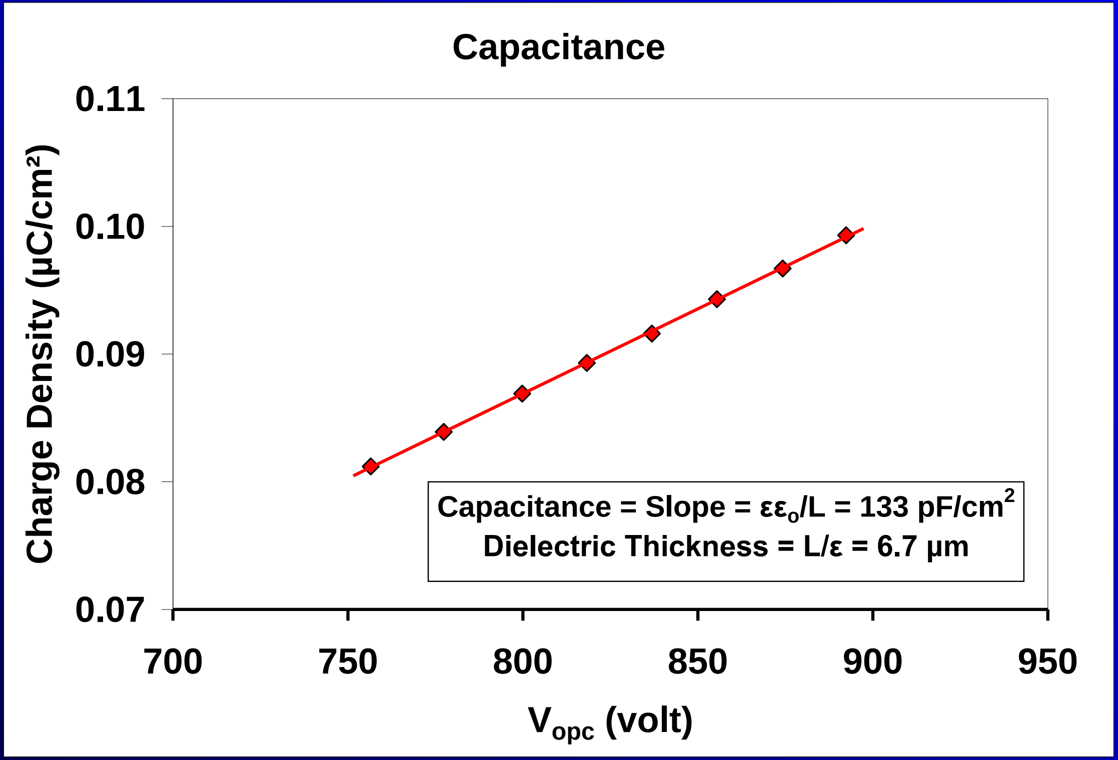
$L = 20\ \mu m$, $\varepsilon\varepsilon_o = 3 \times 8.85$ pF/m ~ 0.27 pF/cm

Capacitance = $\varepsilon\varepsilon_o /L = 135$ pF/cm^2

Dielectric thickness = $L/\varepsilon = 6.7\ \mu m$

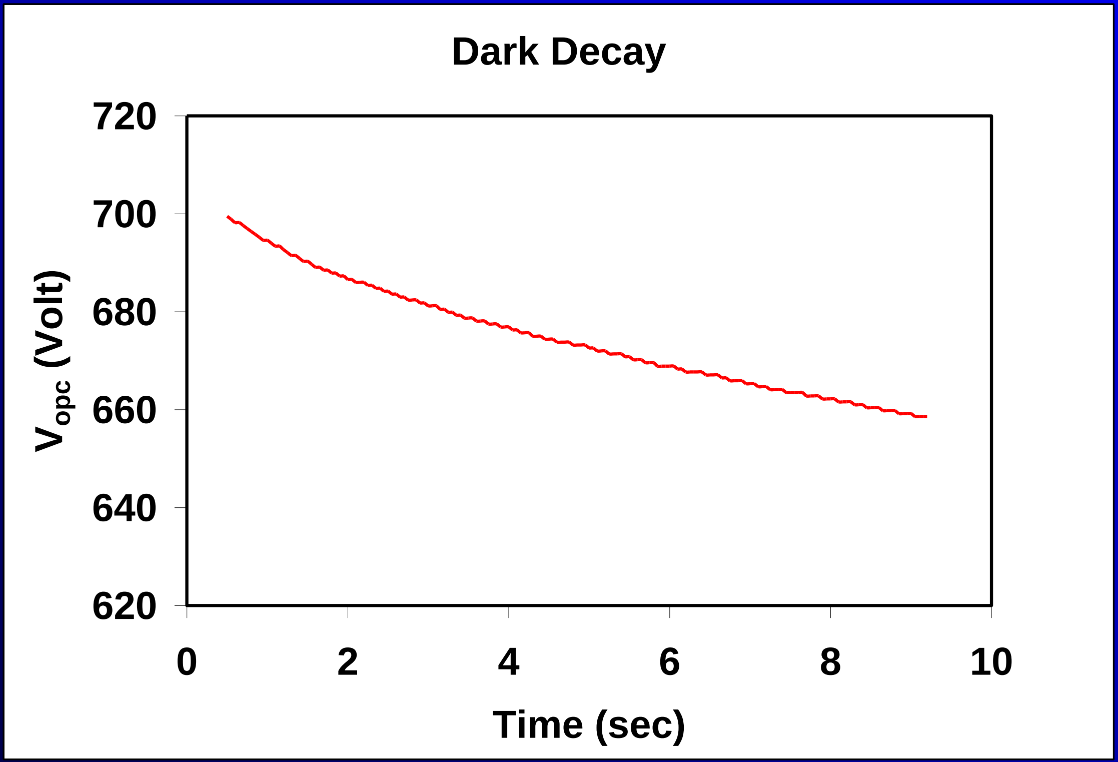
Capacitance & Dielectric Thickness

- Capacitance & dielectric thickness can be obtained from a Charge-V_{opc} curve.
- Primary variables are coating thickness & dielectric constant



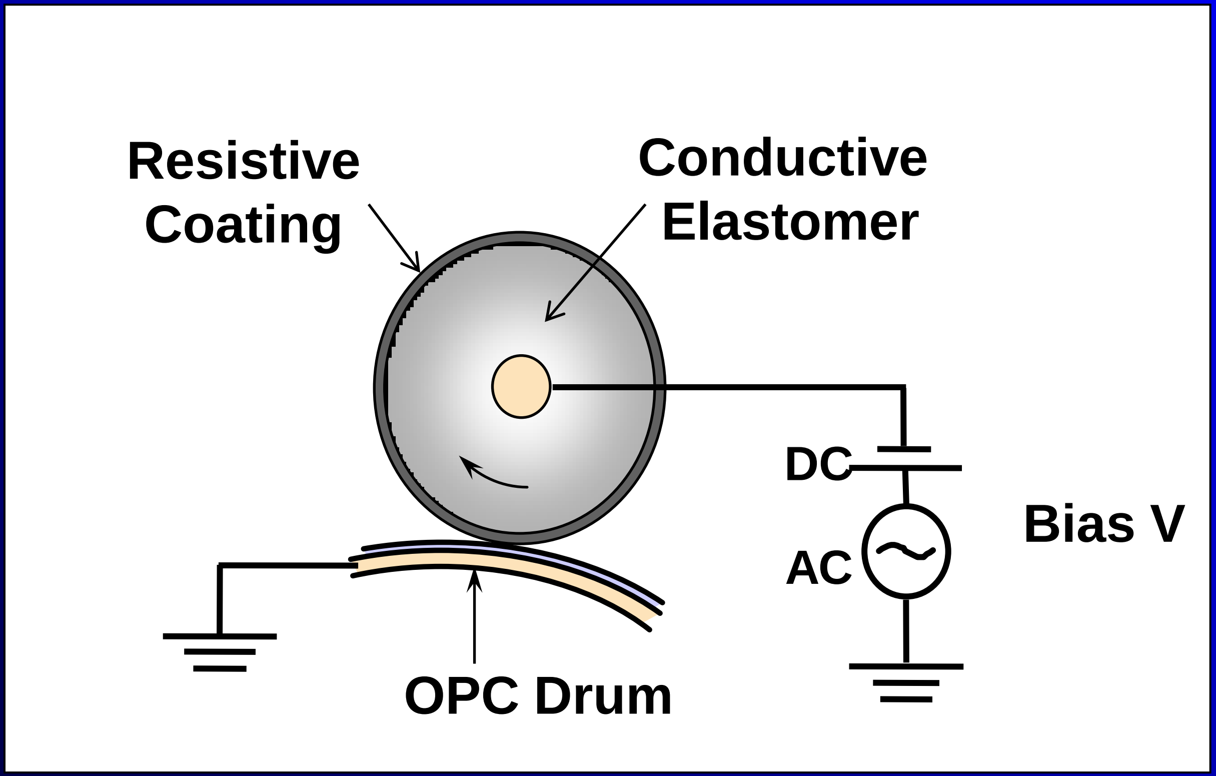
Dark Decay

- Dark decay is monitored by measuring V_{opc} vs time in the dark for a specified period of time.
- Sources of dark decay include: impurities, charge injection …



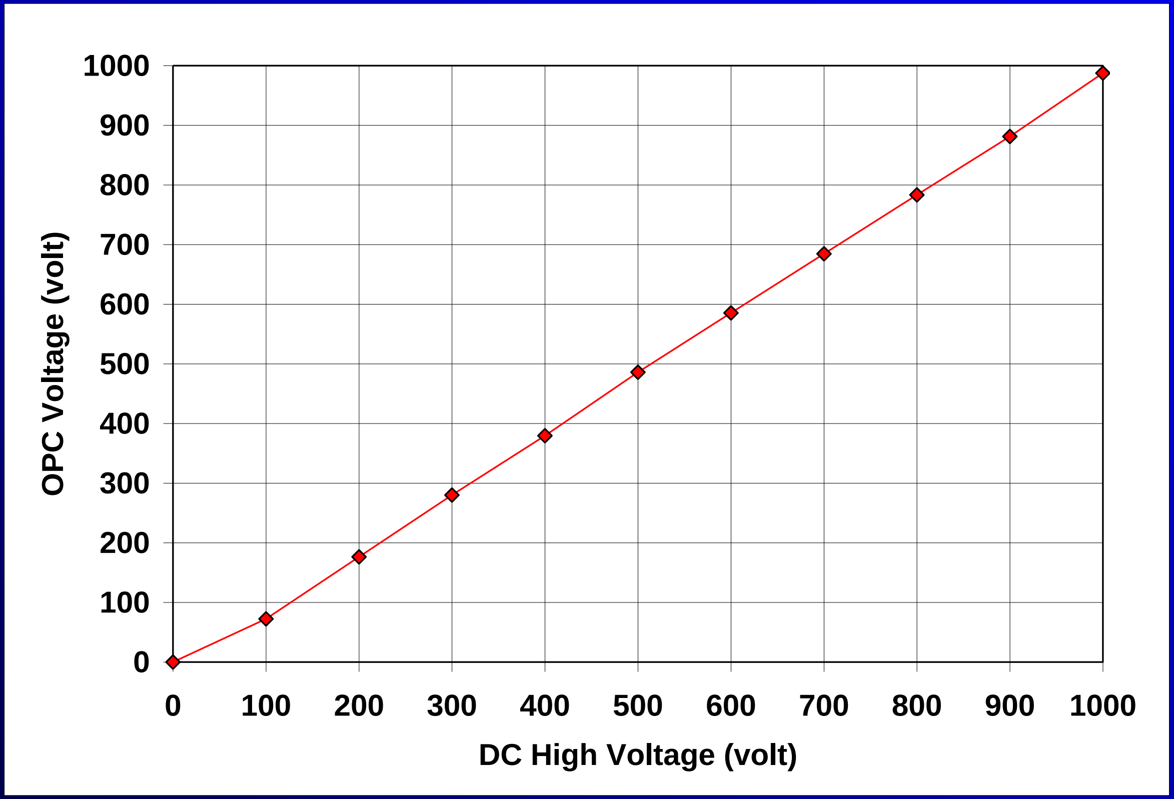
Charge Roller Charging

- Both AC+DC and DC-only configurations
- Essentially constant voltage charging
- How compatible is the OPC & the charge roller?



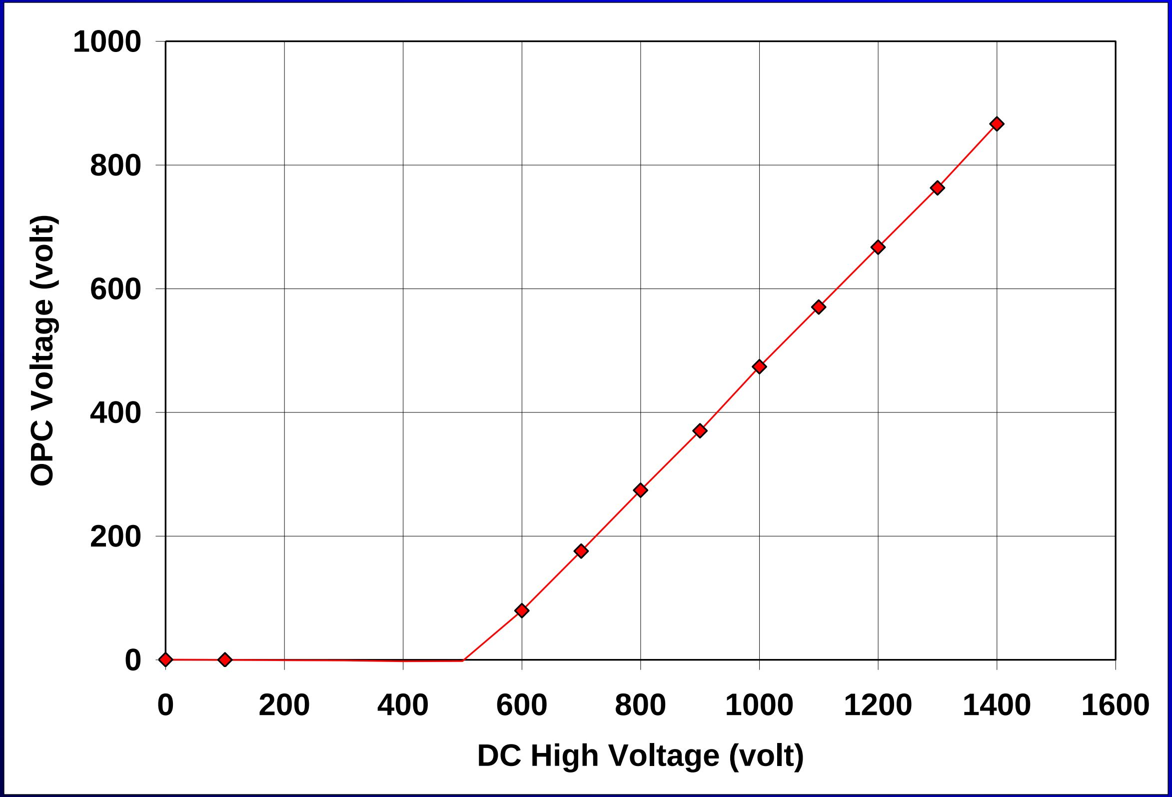
CR Charging Characteristics: DC+AC

- If AC amplitude is sufficiently high (e.g., ≥ 800V), $V_{opc} \sim V_{DC}$



CR Charging Characteristics: DC Only

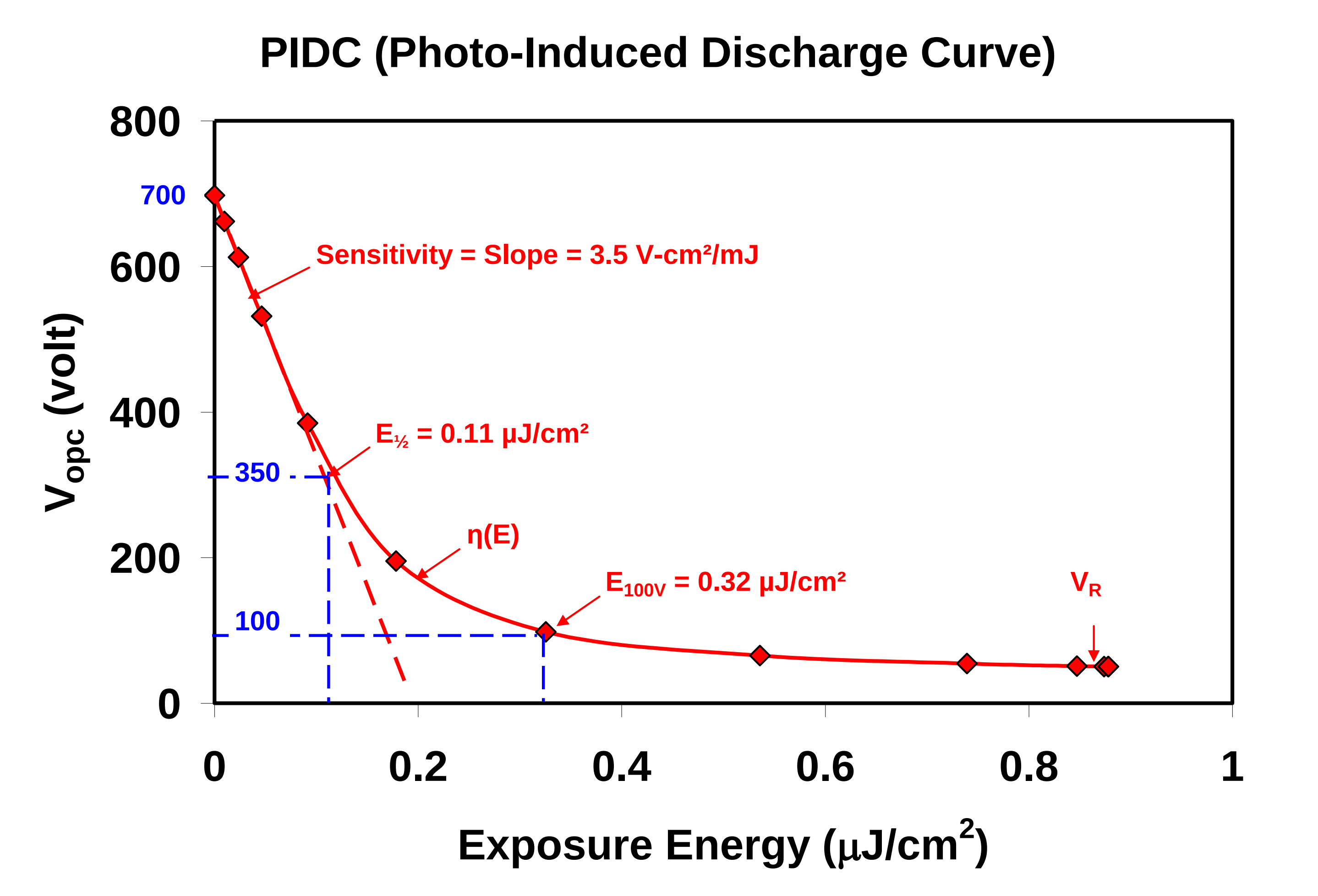
- If no AC is applied, $V_{opc} \cong V_{DC} - 500V$.



Photosensitivity

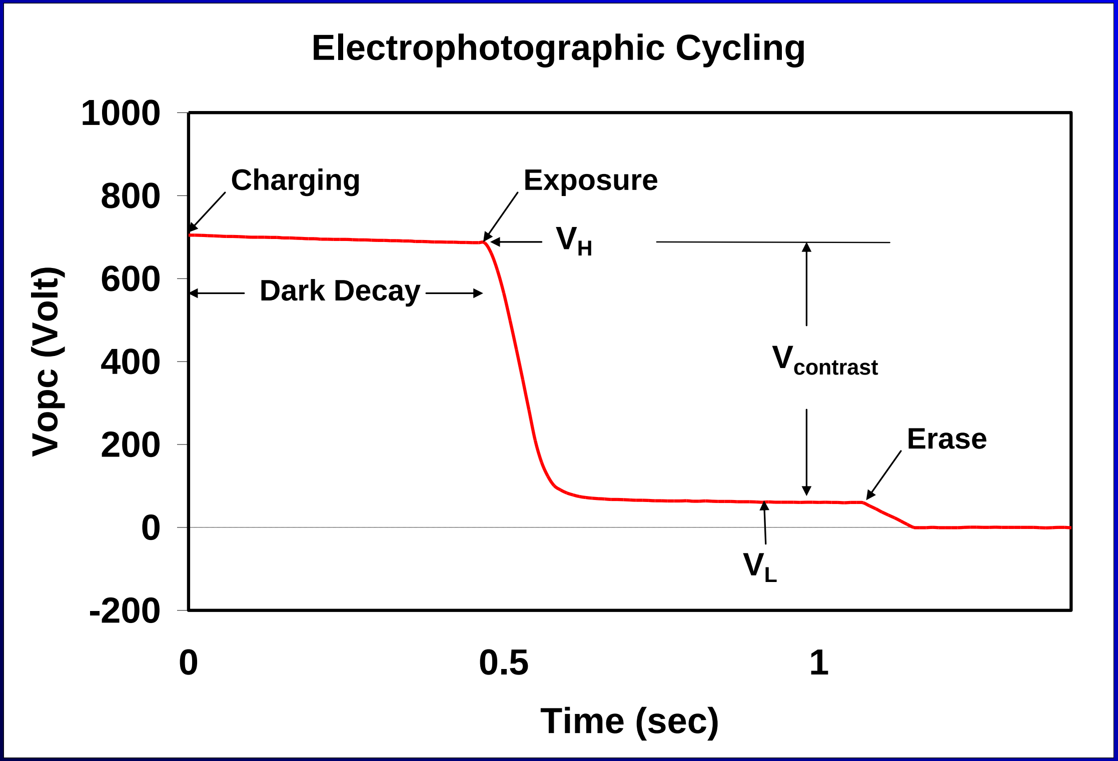
- Photosensitivity (PIDC)
  - Rate of photodischarge is determined by:
    - Photogeneration efficiency and field dependence, $\eta(E, \lambda)$
    - Spectral response in terms of absorption $A(\lambda)$
- Residual voltage (tail of the discharge)
  - transport limited
  - Trapped charge with effect on cycling & stability
- Sensitivity estimated from initial slope of the PIDC
- PIDC typically described by: $E_{½}$, E_{100V}, V_r …

Photosensitivity



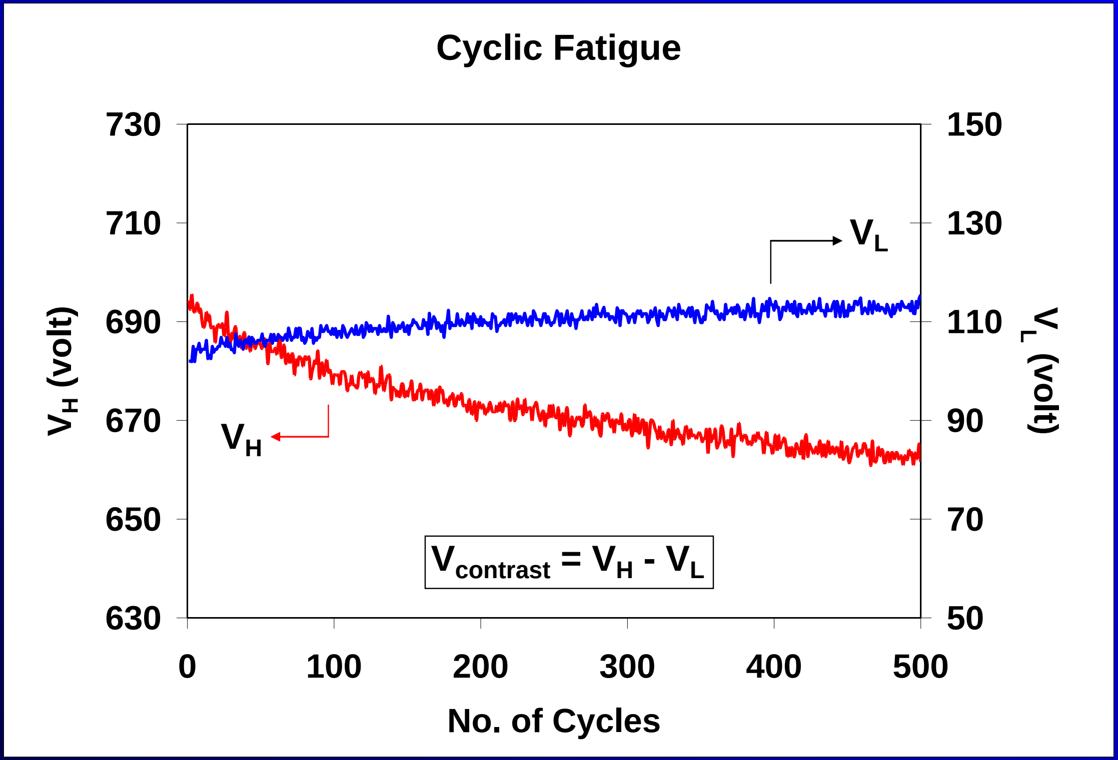
EP Cycle & Cyclic Fatigue

- Simulate the EP cycle (charge, expose and erase) and the drum run for multiple cycles to explore potential “cycle down” (charging) and “cycle up” (discharge) issues.



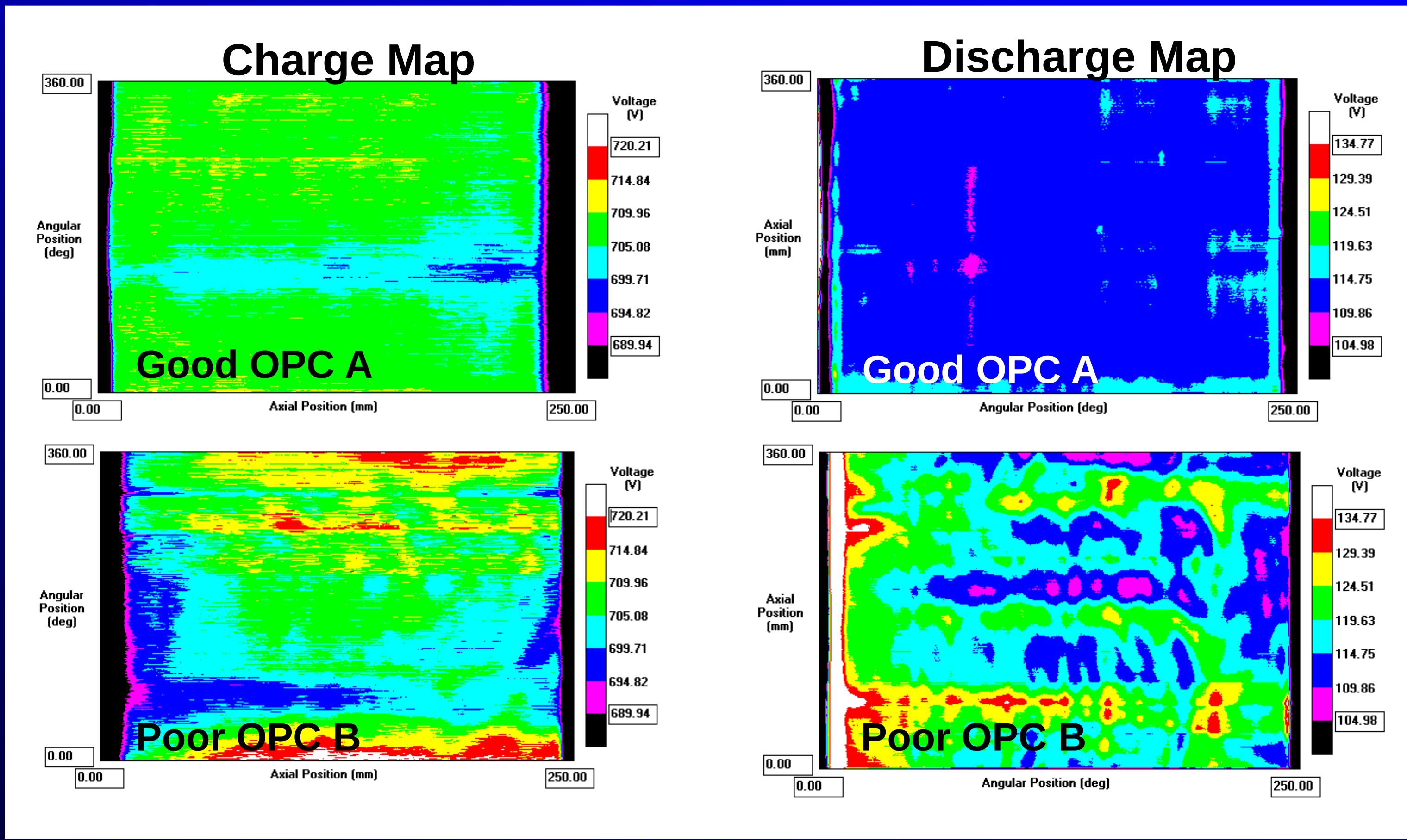
Cyclic Fatigue

- A common problem is decrease in V_H and increase in V_L as the no. of cycles increases, thereby decreasing the contrast potential, increasing toner background, and decreasing OD.



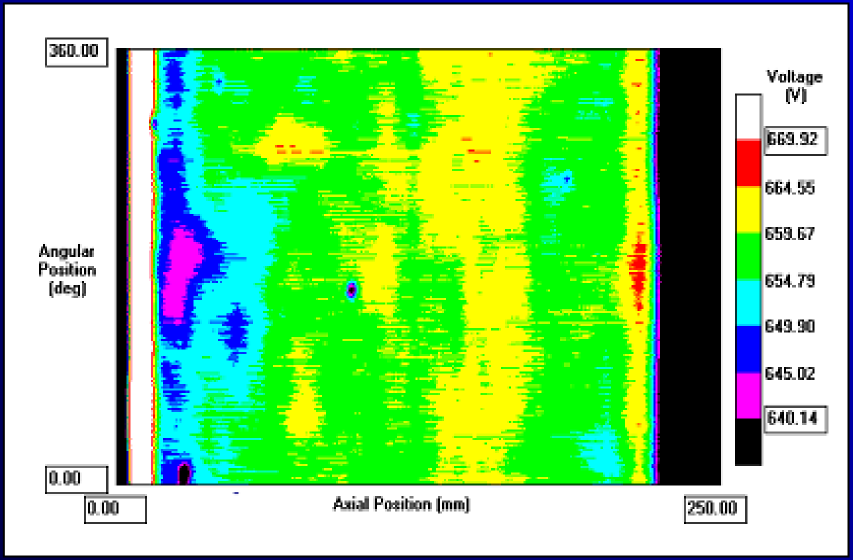
OPC Coating Uniformity

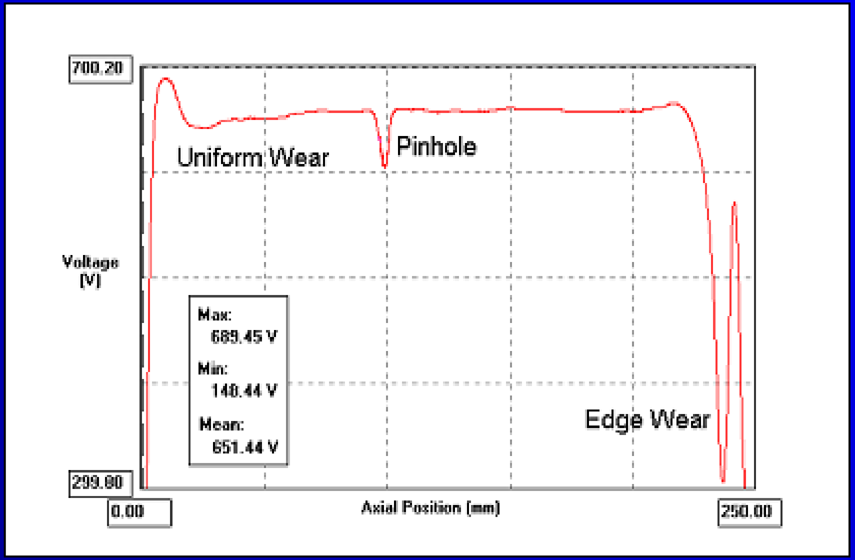
- Most critical to graphics print quality and color fidelity.



Mapping Defects & Drum Wear

- Most critical for drum durability monitoring
- Very useful for life and reusability assessment





More Advanced Test Functions

- Charge mobility measurements
- Lateral conductivity characterization
- Very high resolution scanning
- Environmental testing

Photoreceptor Testing:
Part II – A Case Study

A Case Study

- To demonstrate the range of photoreceptor test and characterization methods and tools, a case study is summarized in this report.
- The photoreceptors used in this study is a set of OPCs for the HP4000 Laserjet printer.
- The OPCs studied include both the OEM and a collection of aftermarket drums.
- The test methodology includes electrophotographic characterization using a drum test system and correlating with print quality by means of an image analysis system.

Tools (1)

- All electrophotographic characterization performed on the PDT-2000LA Advanced Photoconducting Drum Test System.
- Both corona and charge roller charging can be done in this system.

Tools (2)

- OPC coating thickness measured using the ECT-100 Coating Thickness Gage
- Thickness resolution is better than 0.5 μm

Tools (3)

- Print testing performed on a HP4050 printer in good condition. New OEM cartridges (toner, mag roller & charge roller used)
- Print quality analysis using the Personal IAS portable image analysis system.

Tools (4)

- A suite of test targets used (i.e. more than one).
- The targets are designed to:
  - Allow correlation between subjective assessment and objective measurements on the same page.
  - Stress different aspects in OPC characteristics.
  - Make it easier for interpreting the results.
- An HP4050 printer used. Different printer setting will be experimented to examine the print quality outcome.

In the following results, the set of HP4000 OPC will be identified as an OEM and aftermarket drums A through H

Charge Acceptance Tests

- Single track scans – charge and discharge
- Capacitance and dielectric thickness
- Dark decay
- Charge roller charging

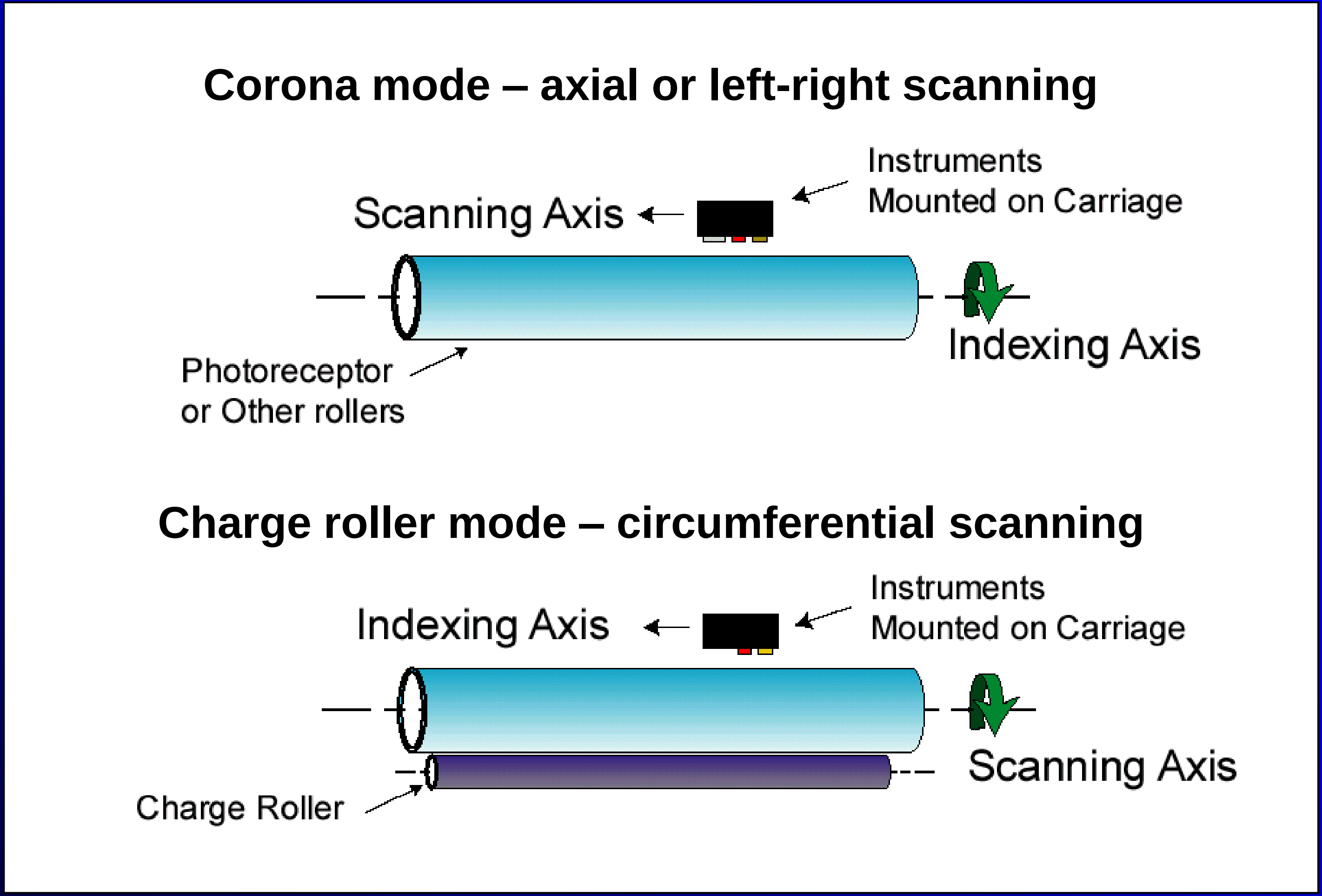
Charge Acceptance

- Corona charge and discharge scans first obtained.
- Charge acceptance determined by capacitance and dark decay:

$$V_{opc} = \underbrace{(L/\varepsilon\varepsilon_o) \bullet \sigma}_{\text{capacitance}^{-1}} - \underbrace{\Delta V}_{\text{dark decay}} \qquad (1)$$

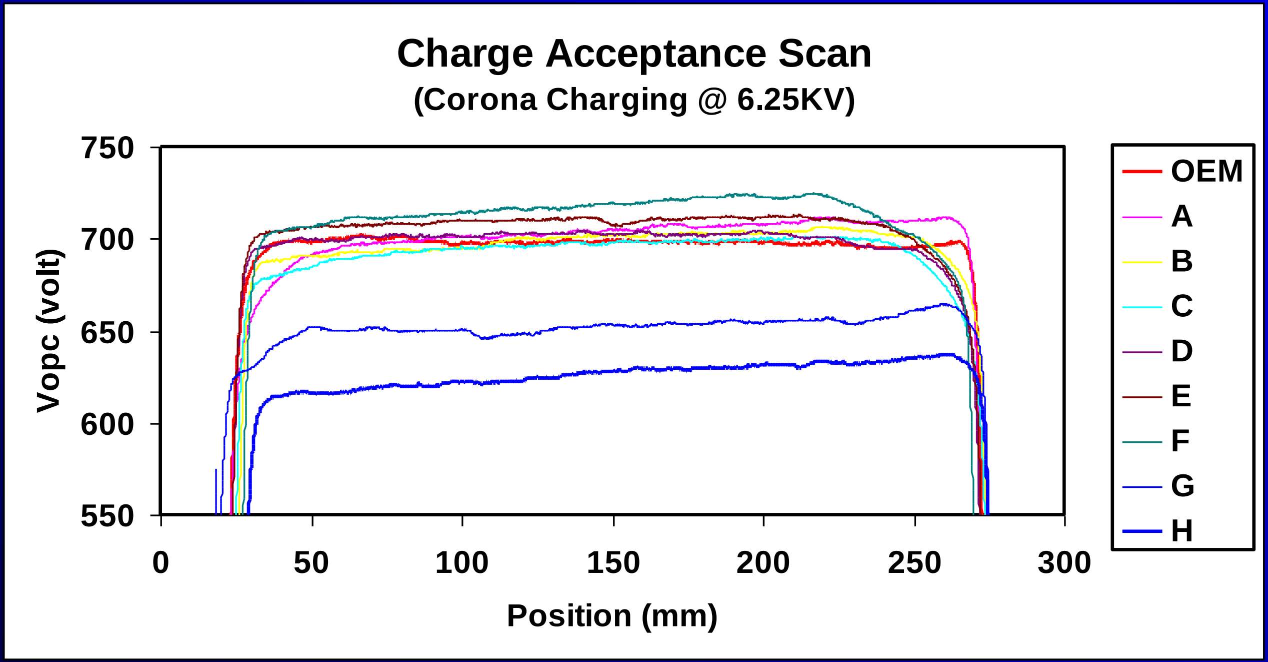
  – Capacitance, dielectric thickness & dark decay obtained next.
- Corona charging then examined in AC+DC mode (for the HP4000)

Drum Scanning – Corona Mode



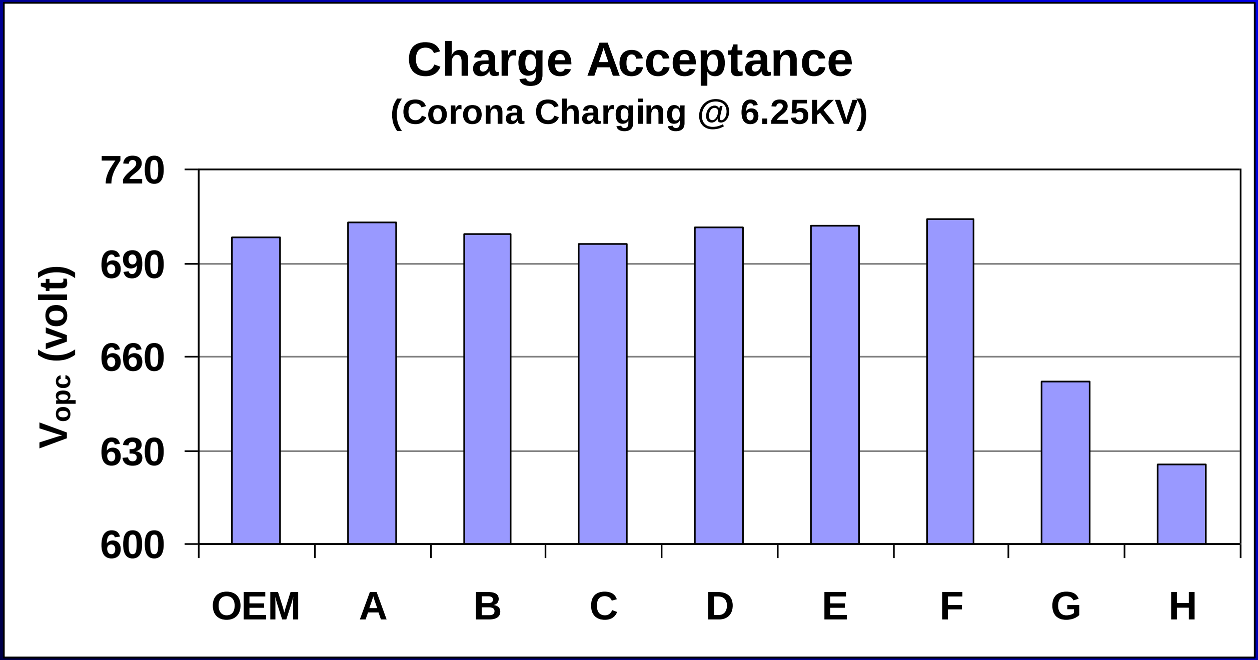
Charge Acceptance – Charge Scan (1)
(Corona charging)

- The OEM and most aftermarket OPC are fairly uniform and approx. the same charge acceptance.
- Two of the aftermarket OPC have significantly low charge acceptance, most likely due to dark decay problem (to be examined later)



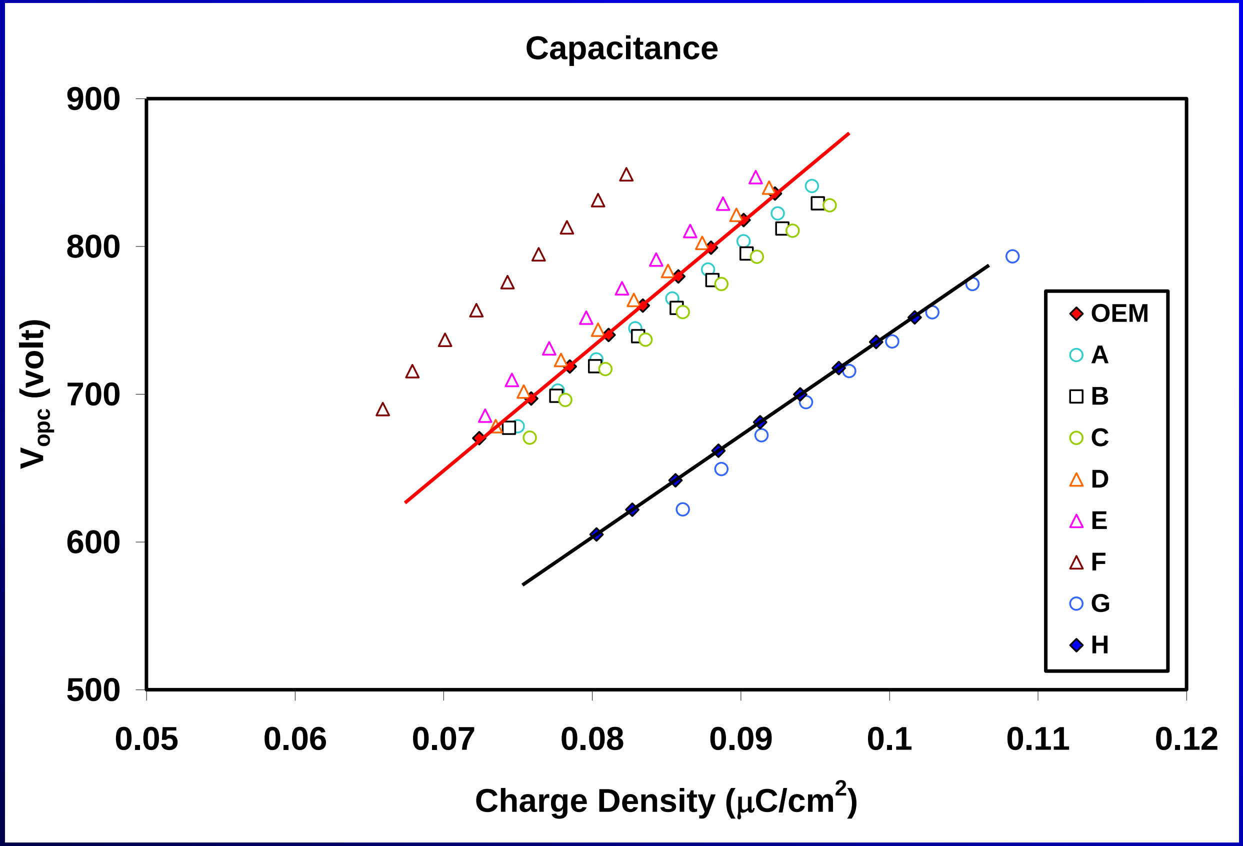
Charge Acceptance – Charge Scan (2)
(Corona charging)

- The V_{opc} reported is the average in an axial (left-right) scan.
- Most aftermarket OPC are quite similar to the OEM.
- The much lower charge acceptance for G & H is evident – consequence on print quality will be examined later.



Capacitance & Dielectric Thickness (1)

- The numerical results of capacitance and dielectric thickness are shown in the next slide



Capacitance & Dielectric Thickness (2)

- The higher the capacitance, the lower the charging efficiency.
- OPC H has the highest capacitance and lowest dielectric thickness.
- Most OPC have similar coating thickness, with the exception of F.

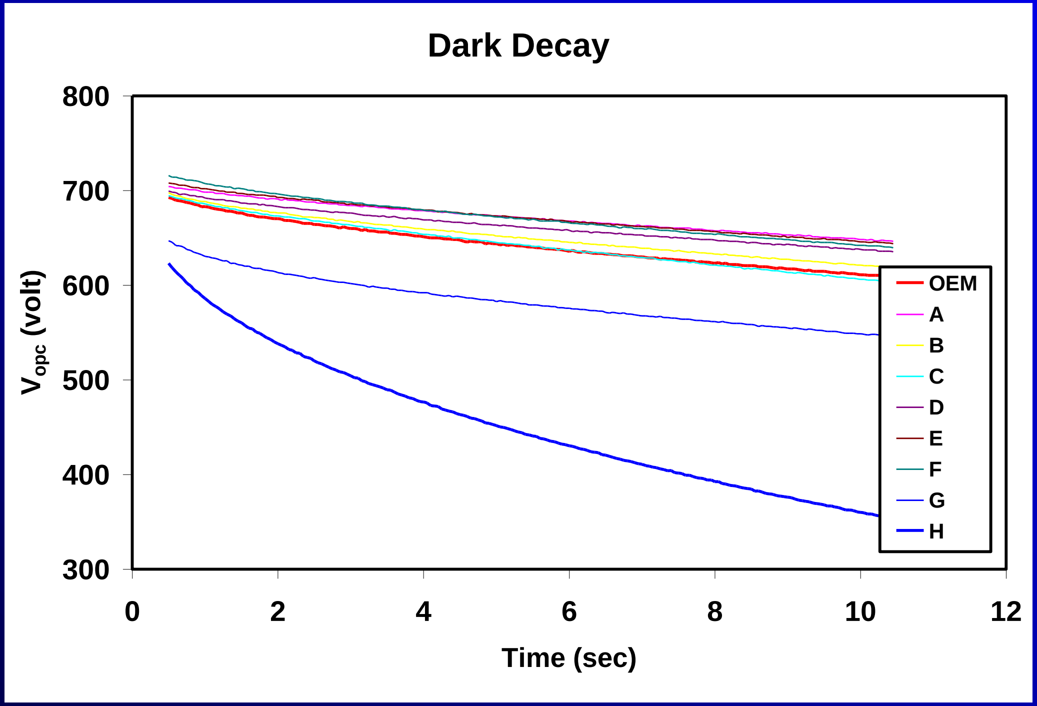
Capacitance & Dielectric Thickness

ID	Capacitance (pF/cm^2)	Dielectric Thickness (µm)	Thickness (µm) (see note)	Dielectric Constant
OEM	122.5	7.2	23.0	3.2
A	122.5	7.2	23.3	3.2
B	135.6	6.5	22.5	3.4
C	130.8	6.8	22.5	3.3
D	116.3	7.6	22.5	3.0
E	115.3	7.7	23.9	3.1
F	105.6	8.4	28.2	3.4
G	132.2	6.7	22.8	3.4
H	142.7	6.2	22.8	3.7

Note: OPC coating thickness was measured directly using QEA's ECT-100 Coating Thiickness Gage.

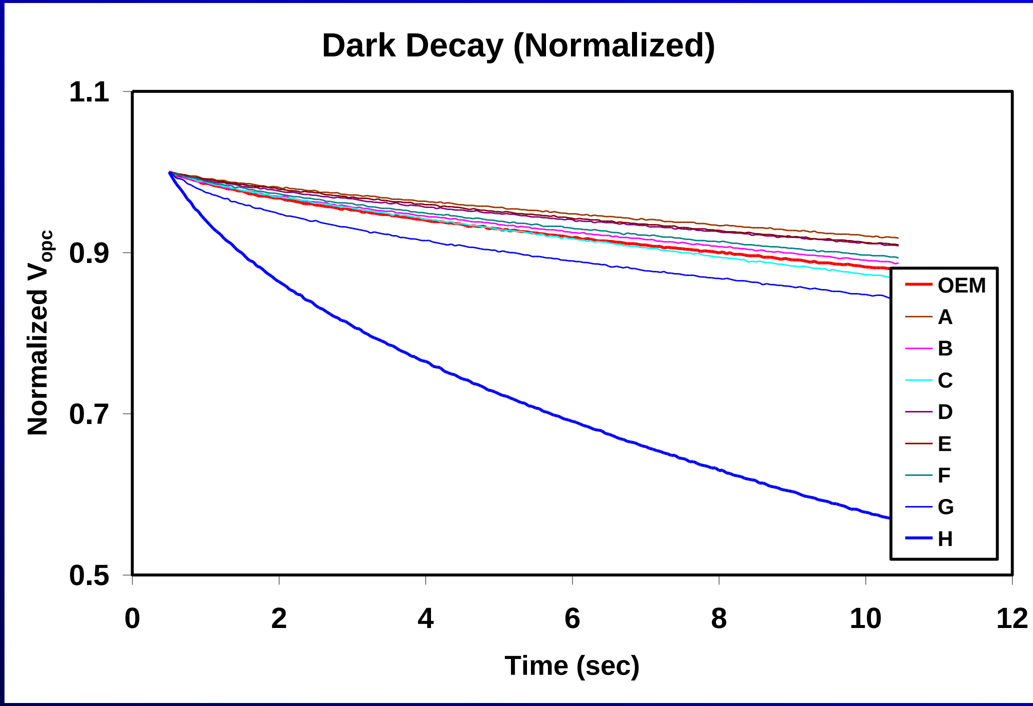
Dark Decay (1)

- Most OPC (OEM and aftermarket) have similar dark decay characteristics, with the exception of G & H.
- Dark decay in sample H in particular is exceptionally high.



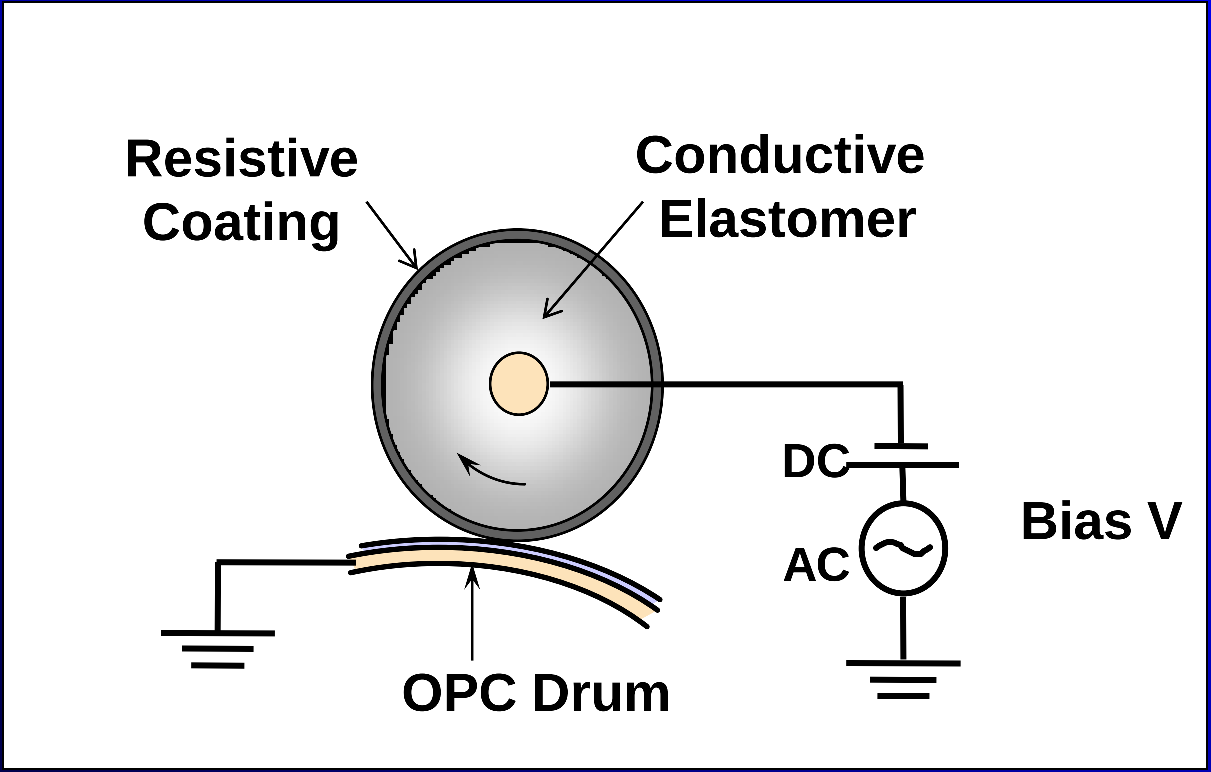
Dark Decay (2)

- For comparison purposes, it is sometimes easier to normalize the results as shown below.
- The consequence of high dark decay on print quality will be examined in more details later.



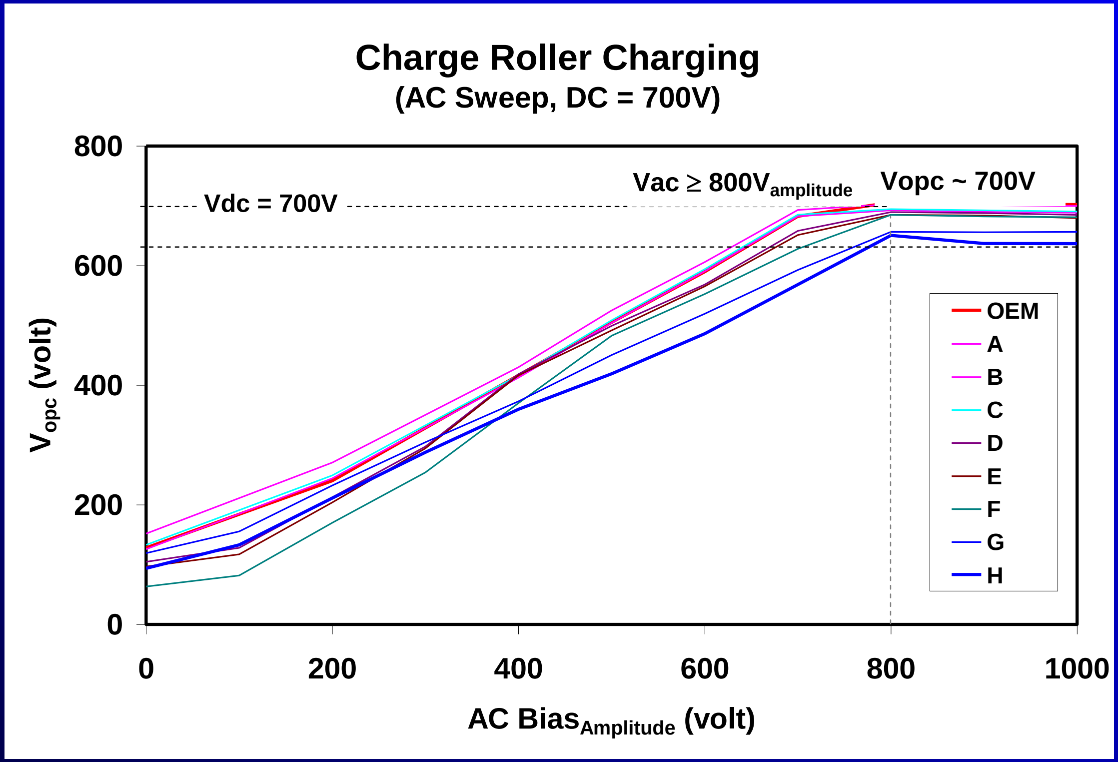
Charge Roller Charging (1)

- Only AC+DC examined for HP4000
- Essentially constant voltage if both OPC & PCR are “good”



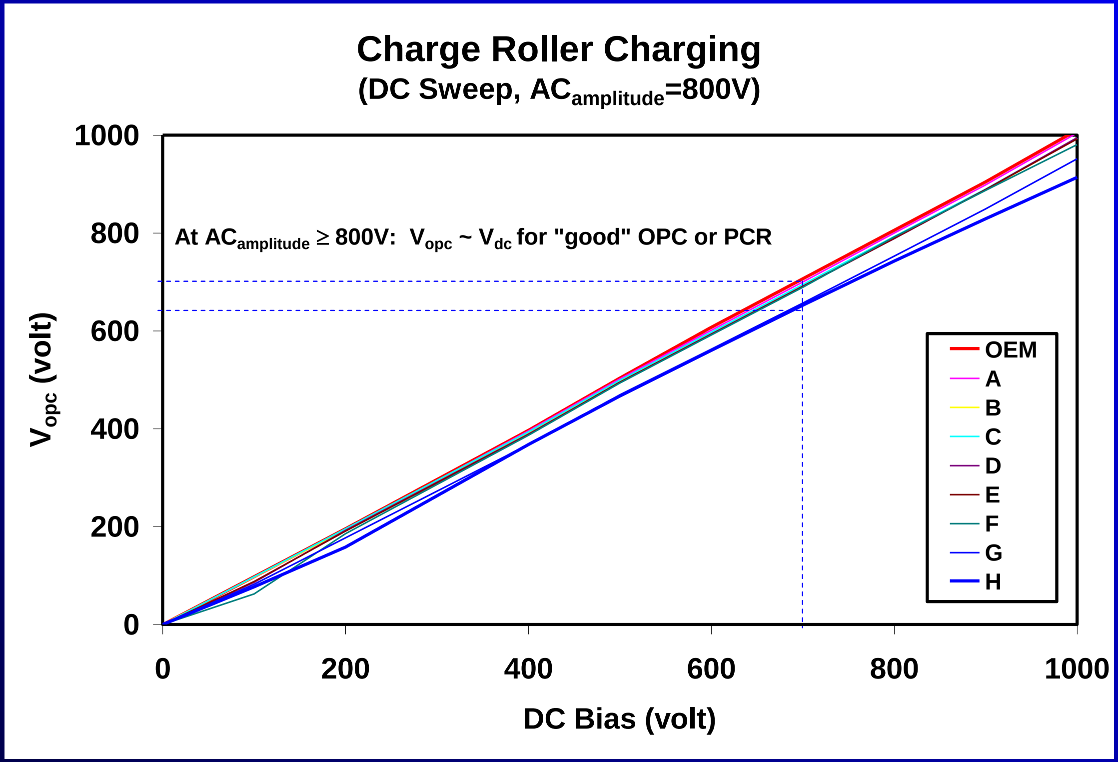
Charge Roller Charging (2)

- OPC, including OEM and A through F, have V_{opc} ~ 700V under the given AC+DC combination.
- Both G & H have significantly lower V_{opc} (~600V), probably the result of high dark decay as observed in corona charging.



Charge Roller Charging (3)

- The similarity between the OEM and A through F is evident in the following DC operating curve (i.e., DC sweep)
- As shown, with sufficient AC, $V_{opc} \sim V_{dc}$.
- OPC G & H are definitely much lower in charge acceptance.



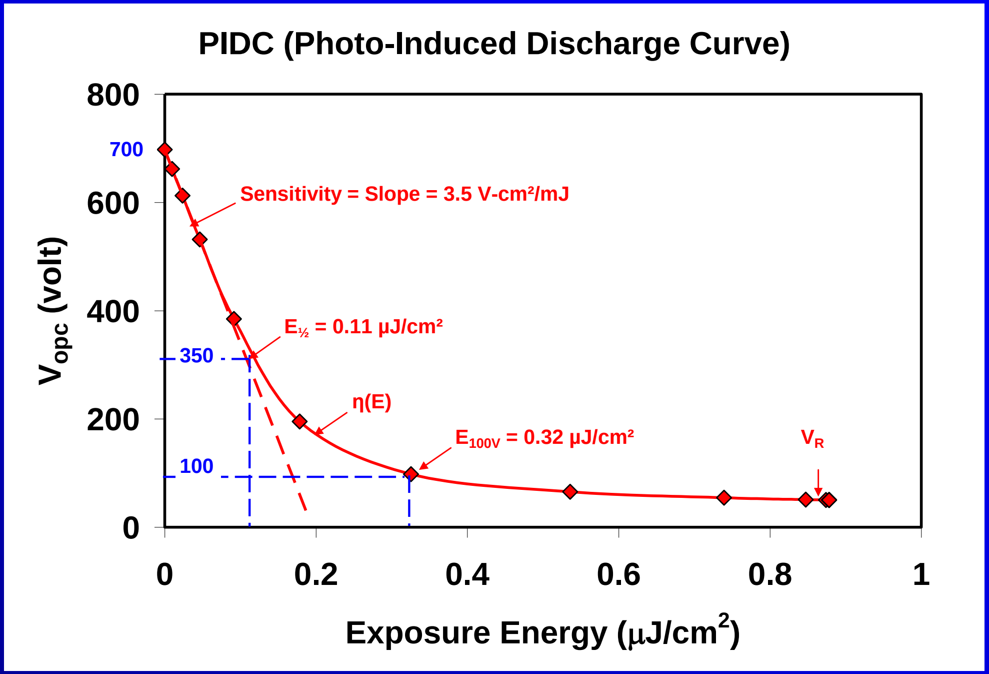
Charge Roller Charging (4)

- The numerical results are summarized in the following table.
- The much lower V_{opc} for G & H is evident.

Charge Acceptance: Charge Roller Charging	
ID	V_{opc} (DC=700V, AC=1600V_{pp})
OEM	706.6
A	700.1
B	692.6
C	694.9
D	691.0
E	690.5
F	689.2
G	656.9
H	652.5

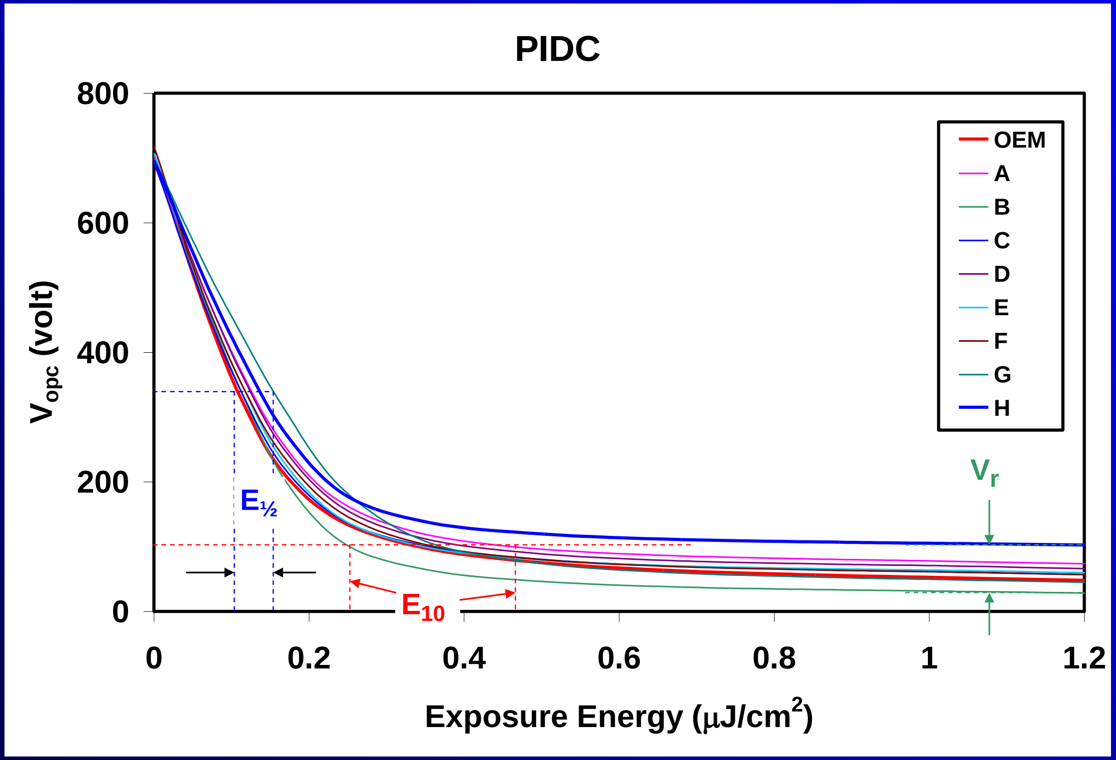
Photosensitivity (1)

- Photosensitivity is characterized by the PIDC or photo-induced discharge curve
- Sensitivity is estimated from initial slope of the PIDC
- Residual voltage is the tail of the discharge
- PIDC typically described by: $E_{½}$, E_{100V}, V_r …



Photosensitivity (2)

- OPC sensitivity is indicated by the initial slope in the PIDC.
- The OEM has the highest sensitivity ($E_{1/2}$~0.11) and G has the lowest ($E_{1/2}$~0.15)
- V_r is highest for H (~100V) and lowest for B (~30V).



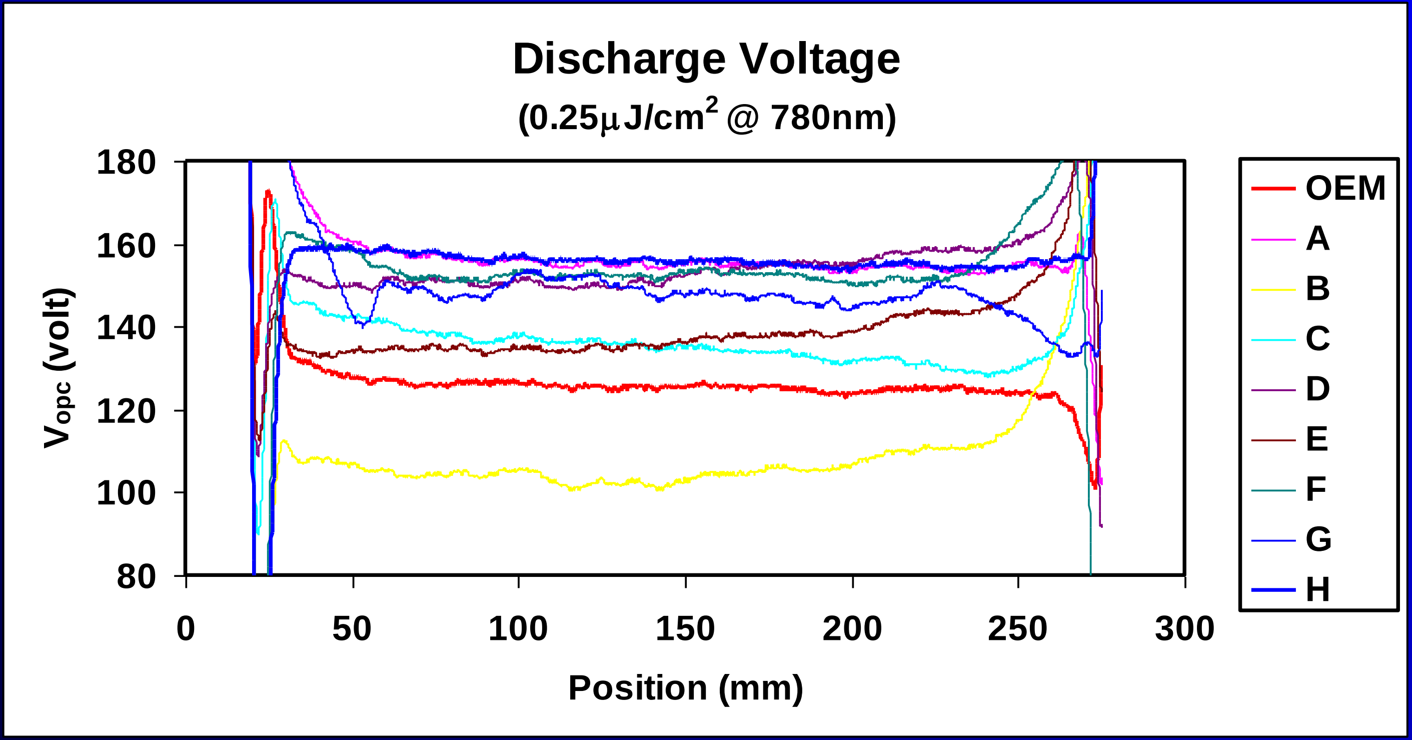
Photosensitivity (3)

- OPC sensitivity is indicated by the initial slope in the PIDC.
- The sensitivity is highest for the OEM (3.35 V-cm^2/mJ) and lowest for G (2.32 V-cm^2/mJ).
- As will be shown later, this range in sensitivity is responsible for a range of visual quality in print also.

	Exposure Energy (μJ/cm^2)		Sensitivity (V-cm2/mJ)	V_{opc} (V)			
ID	$E_{1/2}$	E_{100V}	(= 350/$E_{1/2}$)	0	0.25 μJ/cm^2	0.5 μJ/cm^2	1.2 μJ/cm^2
OEM	0.105	0.342	3.35	702.2	136.3	75.5	47.7
A	0.123	0.466	2.85	698.8	166.5	97.0	73.2
B	0.110	0.259	3.18	694.1	103.3	46.5	28.2
C	0.110	0.303	3.18	692.3	139.3	80.6	56.6
D	0.120	0.358	2.93	704.5	158.1	89.3	65.6
E	0.112	0.427	3.13	707.6	140.0	79.8	59.4
F	0.110	0.372	3.18	718.2	148.6	80.3	56.6
G	0.151	0.388	2.32	696.3	185.3	74.6	44.5
H	0.135	-	2.60	696.3	178.9	119.7	102.3

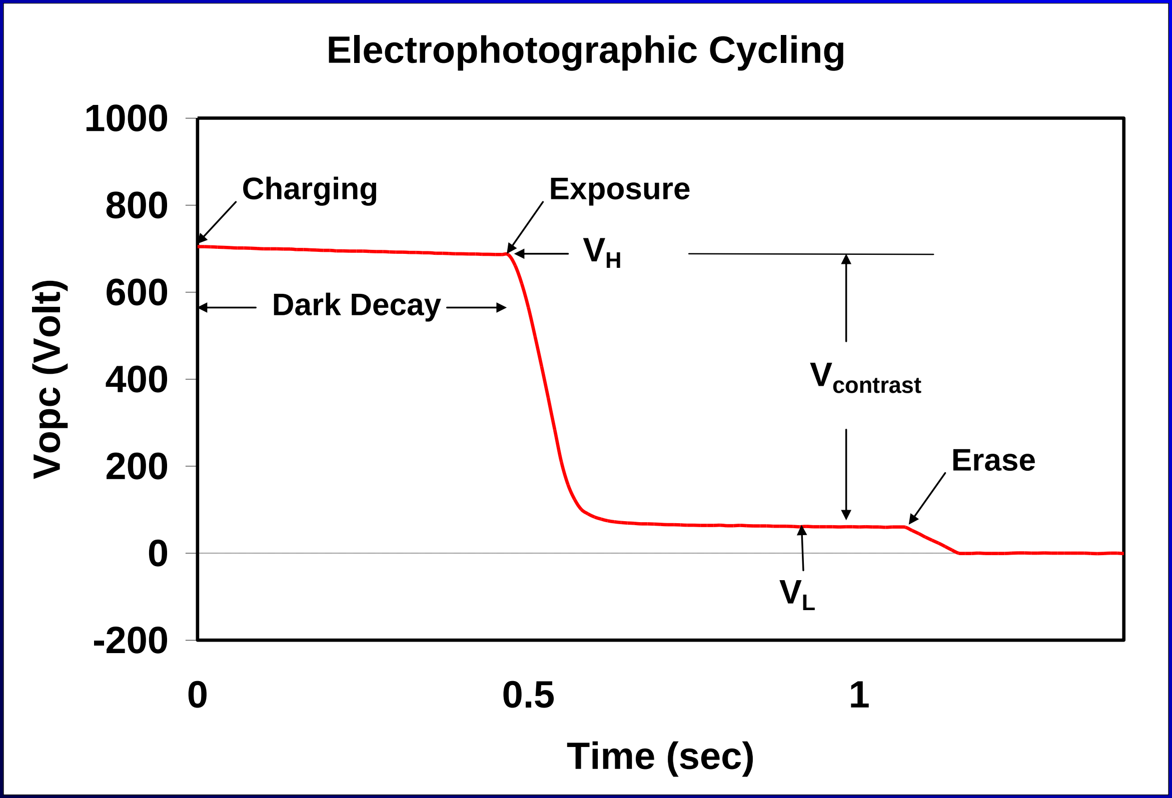
Photosensitivity (4)

- The following are the results for an axial corona charging scan on the set of OPC.
- The results demonstrate the range of $V_{discharge}$ and the non-uniformity for some of the OPC.



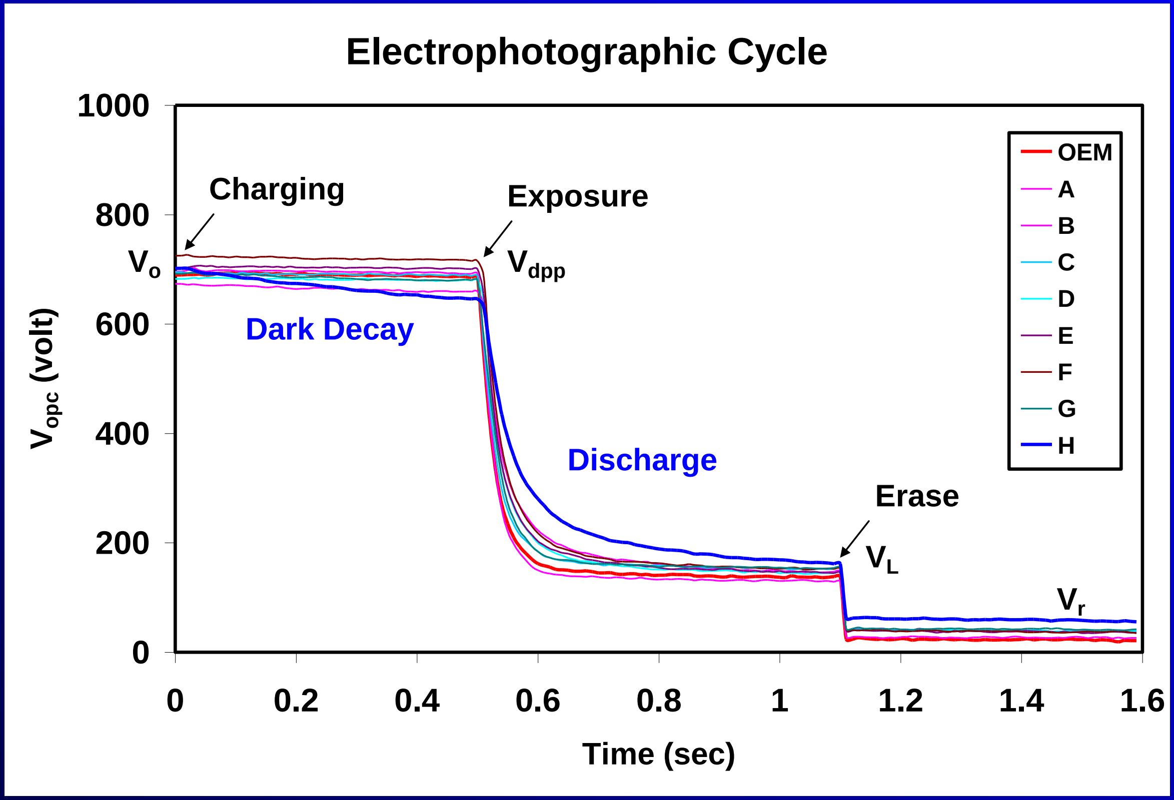
EP Cycle & Cyclic Fatigue (1)

- This test simulates the EP cycle (charge, expose and erase) and is run for 100 cycles to explore cycle down (charging) and cycle up (discharge) issues.



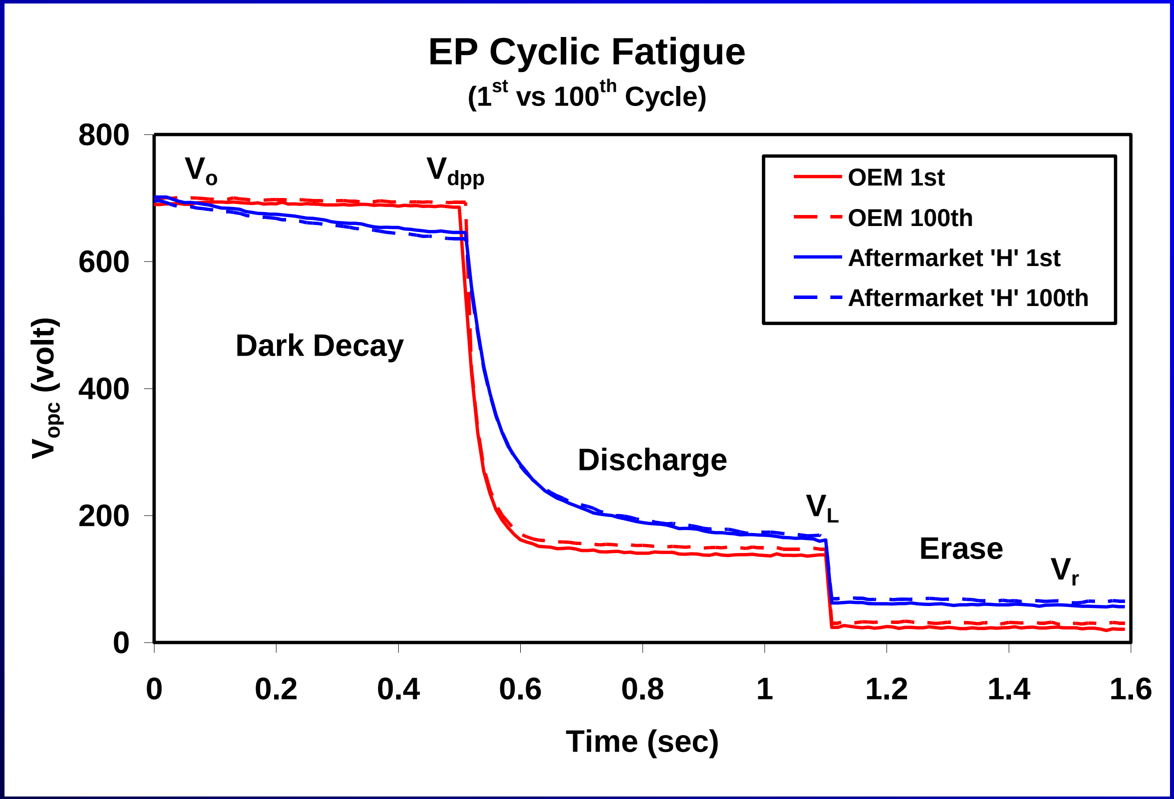
EP Cycle & Cyclic Fatigue (2)

- The results shown here are consistent with the last sets of data on charge acceptance, dark decay and photosensitivity.
- This test cycle is repeated to look for cyclic behaviors.



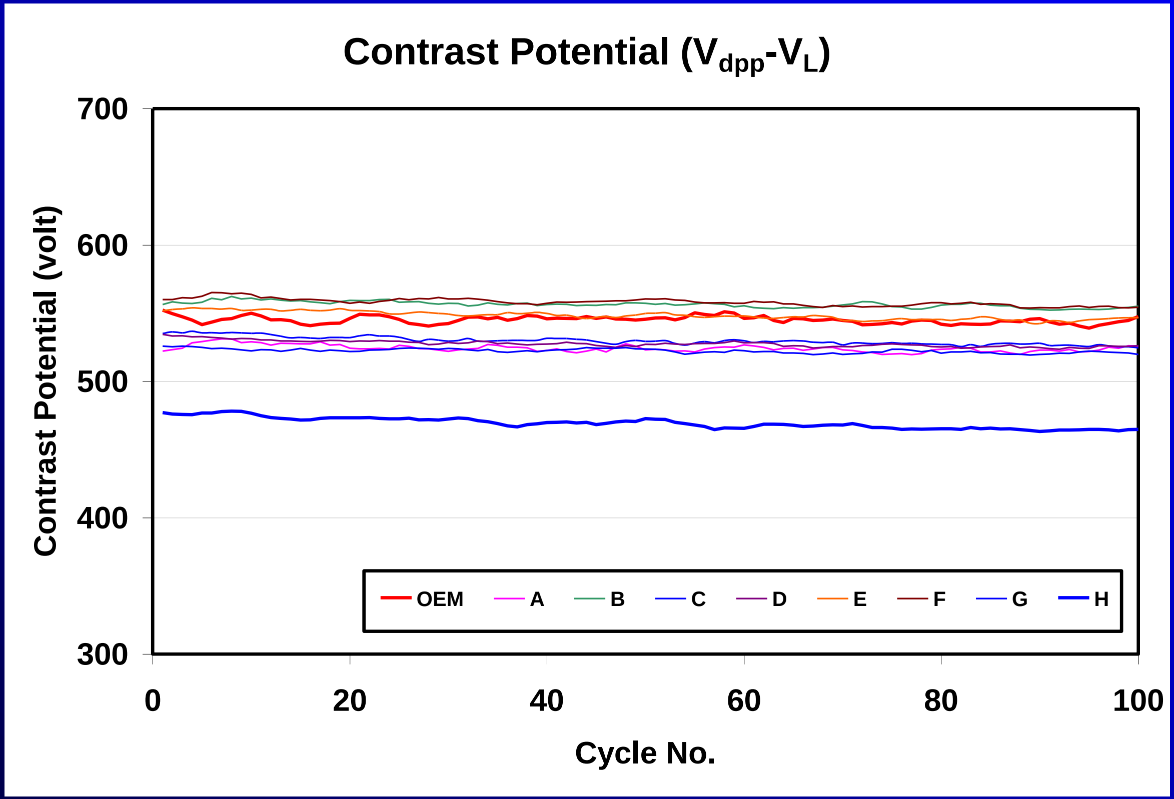
EP Cycle & Cyclic Fatigue (3)

- For clarity, only the test results on OEM & H are shown.
- While H is higher in dark decay, lower in sensitivity, and higher in residual, both the OEM and H are quite stable over 100 cycles.



EP Cycle & Cyclic Fatigue (4)

- The contrast potential is the difference between the V_H ($\sim V_{dpp}$) and V_L.
- For the set of OPC studied, the contrast potential is quite stable over 100 cycles; although the value is quite low for sample H.



EP Cycle & Cyclic Fatigue (5)

- The following table shows the numerical results of the contrast potential for the set of OPC.
- All OPC are quite stable; H has the lowest contrast potential.

Contrast Potential $\Delta V_{opc} = V_{dpp} - V_L$ (volt)		
ID	1^{st} Cycle	100^{th} Cycle
OEM	552.2	547.5
A	522.2	525.8
B	556.3	555.2
C	535.0	524.7
D	534.5	526.1
E	551.8	546.8
F	559.9	554.3
G	528.8	519.7
H	477.1	464.8

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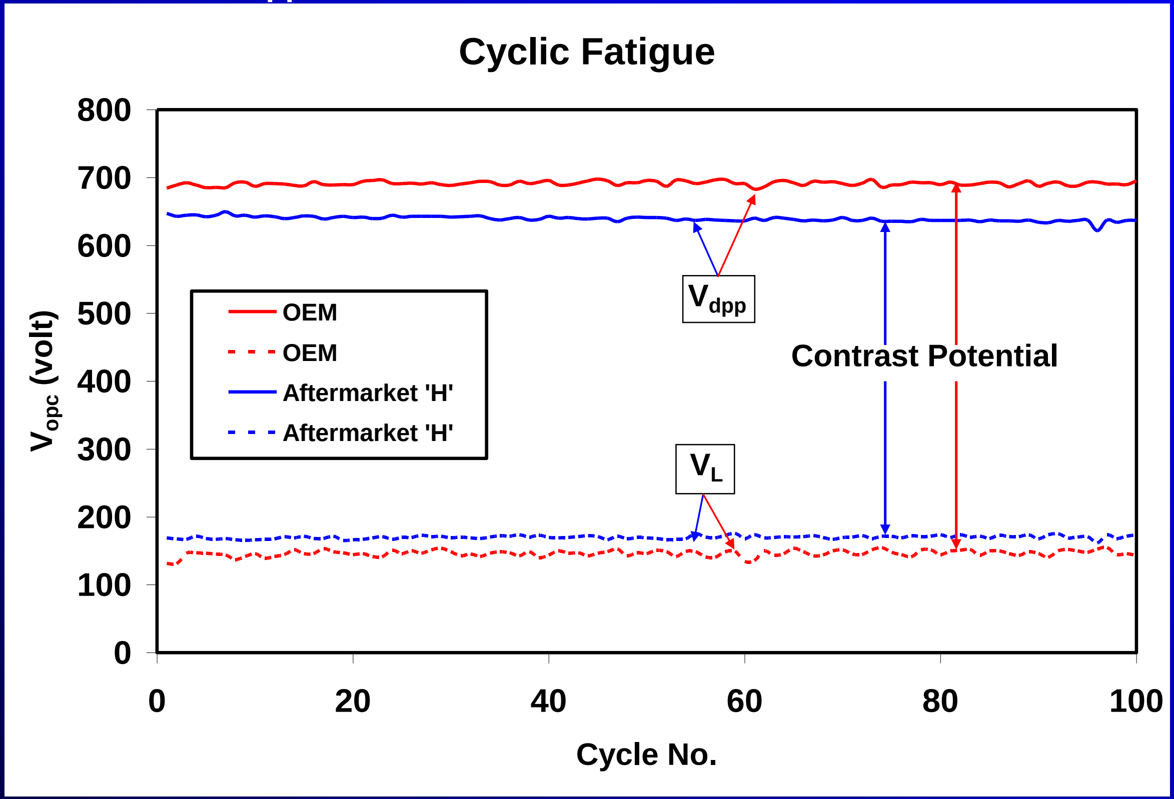
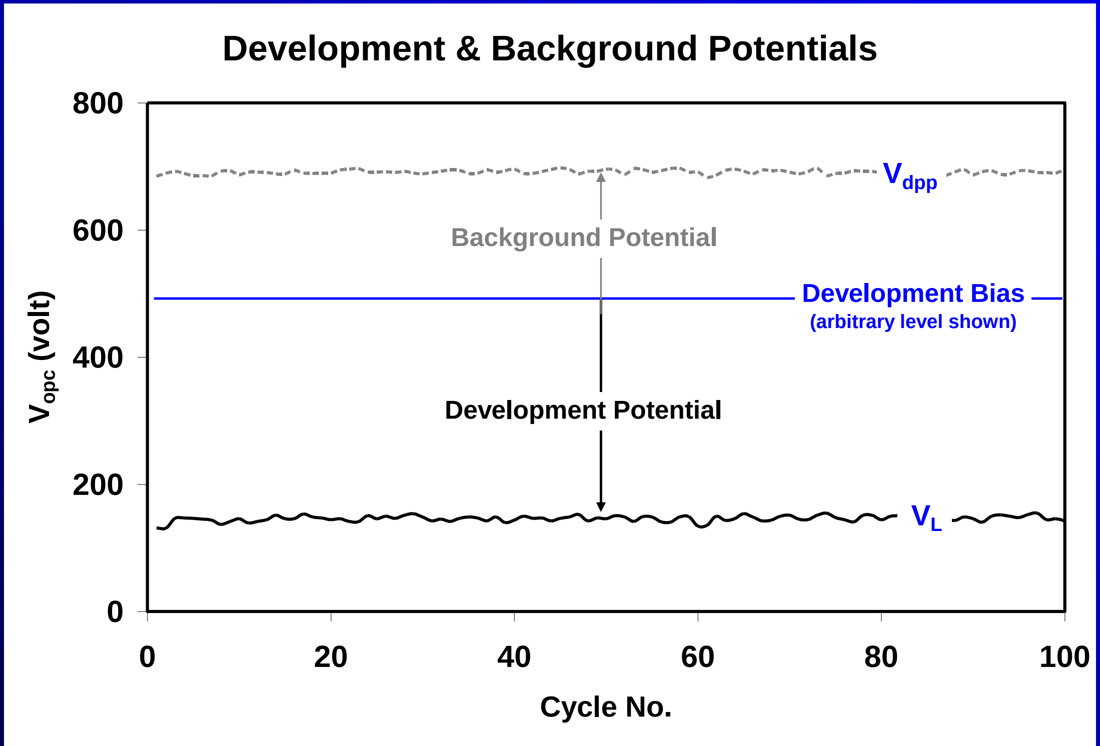
EP Cycle & Cyclic Fatigue (6)

- V_H (~V_{dpp}) and V_L for OEM and H are shown in this graph.
- V_H , V_L and contrast potential are both quite stable in the 100 cycles.
- The importance of V_{dpp} and V_L on print quality is shown in the next slide.



EP Cycle & Cyclic Fatigue (7)

- In the HP4000 development bias (AC+DC) is applied to the mag roller.
- $V_{dpp} - V_{bias}$ gives the background potential (the larger, the less background).
- $V_{bias} - V_L$ gives the development potential (the larger, the darker the image).

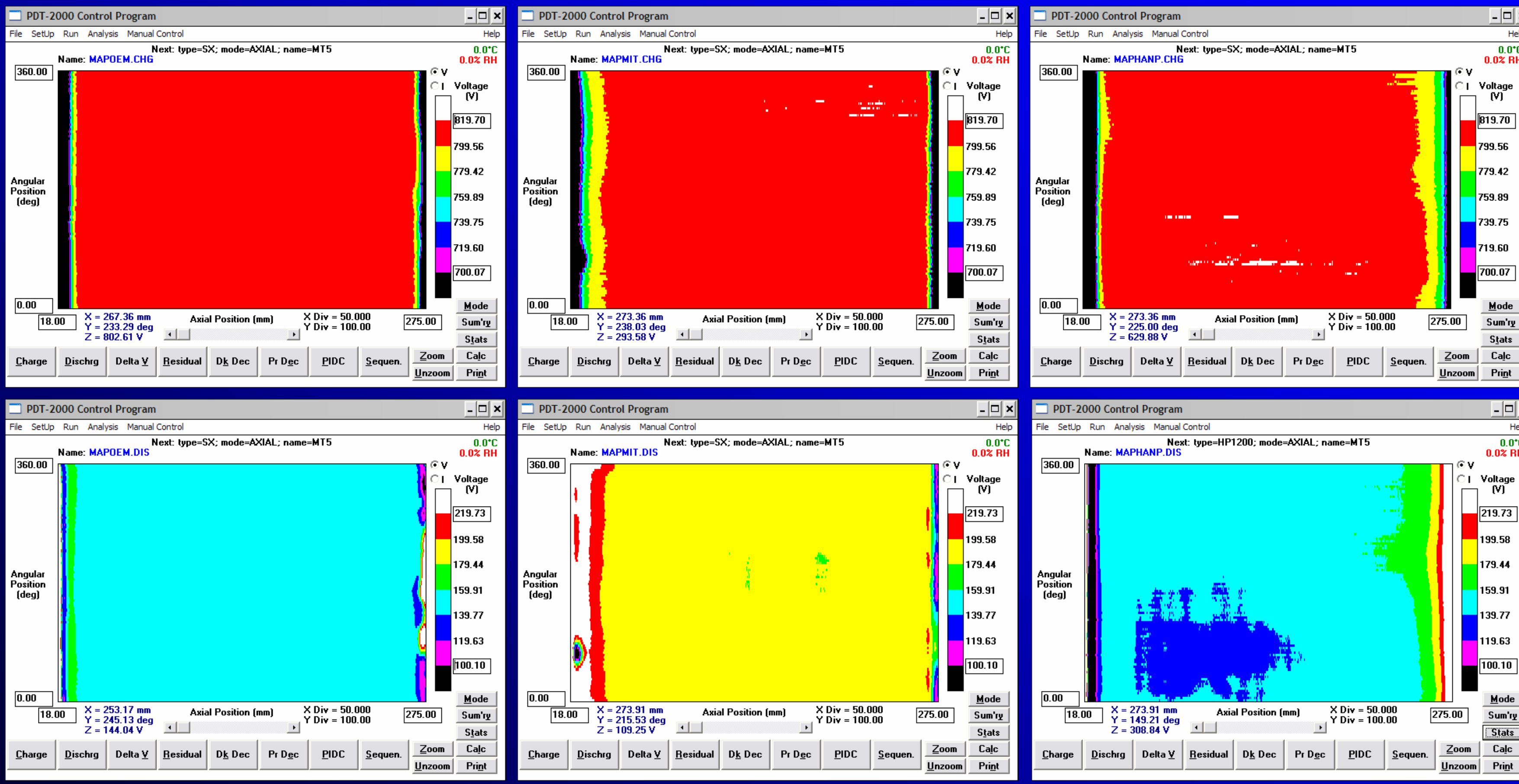


Charge & Discharge Maps (1)

- In the following, the charge and discharge uniformity (or, non-uniformity) maps will be shown.
- As shown, most OPC are quite uniform in both charge and discharge maps.
- The typical problems for the aftermarket drums are at the two ends, where the charge voltage tends to drop off and the discharge voltage tend to increase.
- G & H are the least uniform OPCs.
- All OPC are new, therefore, no wear maps are available.
- In the following slides, the top row is the charge map, and the bottom row is the corresponding discharge map for the same OPC.

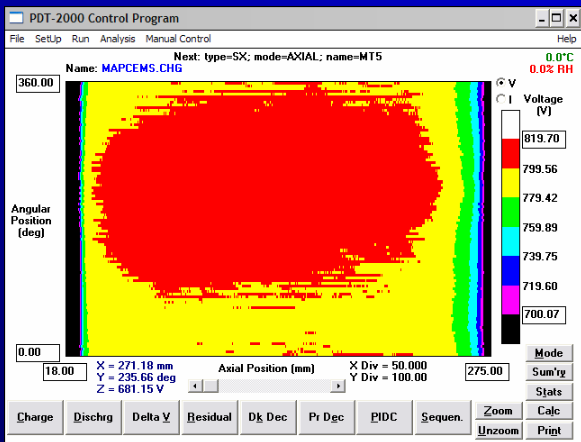
Charge and Discharge Maps (2)

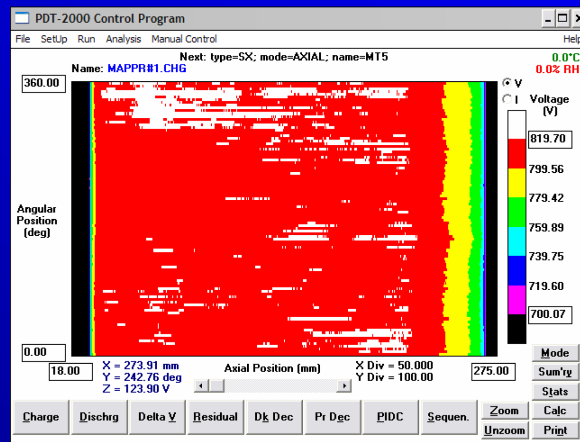
OEM **A** **B**

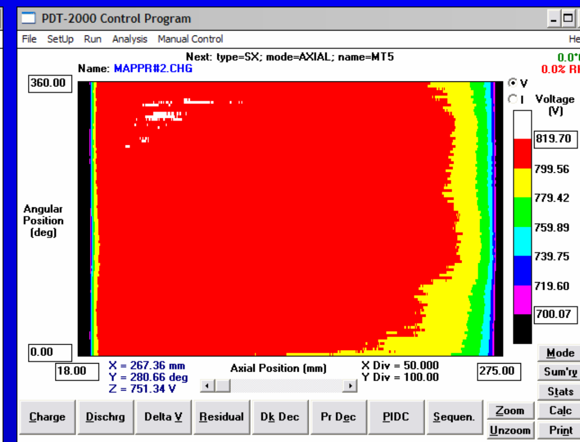


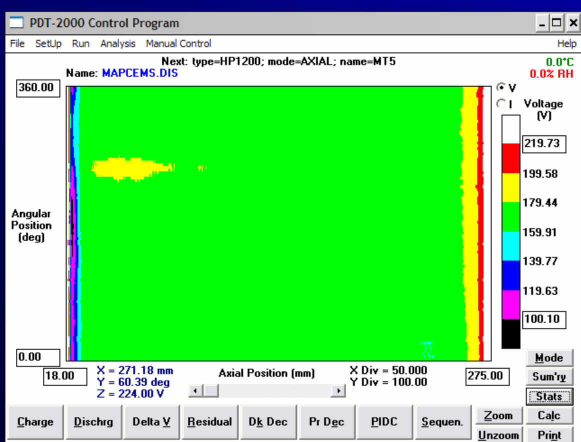
Charge and Discharge Maps (3)

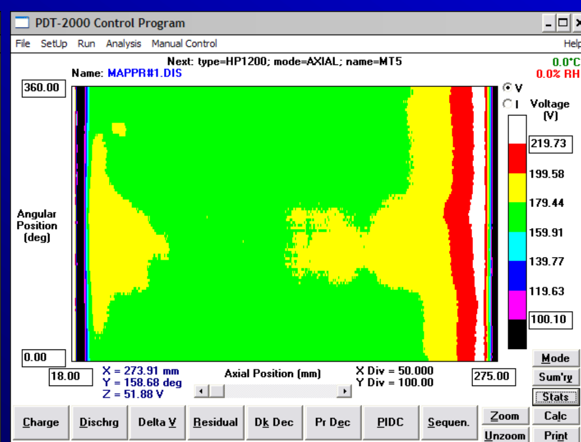
C D E

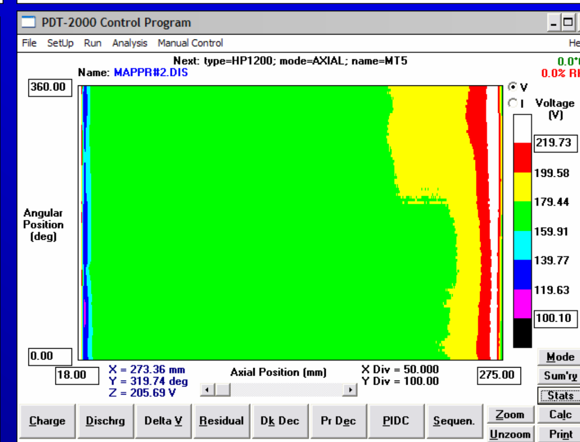






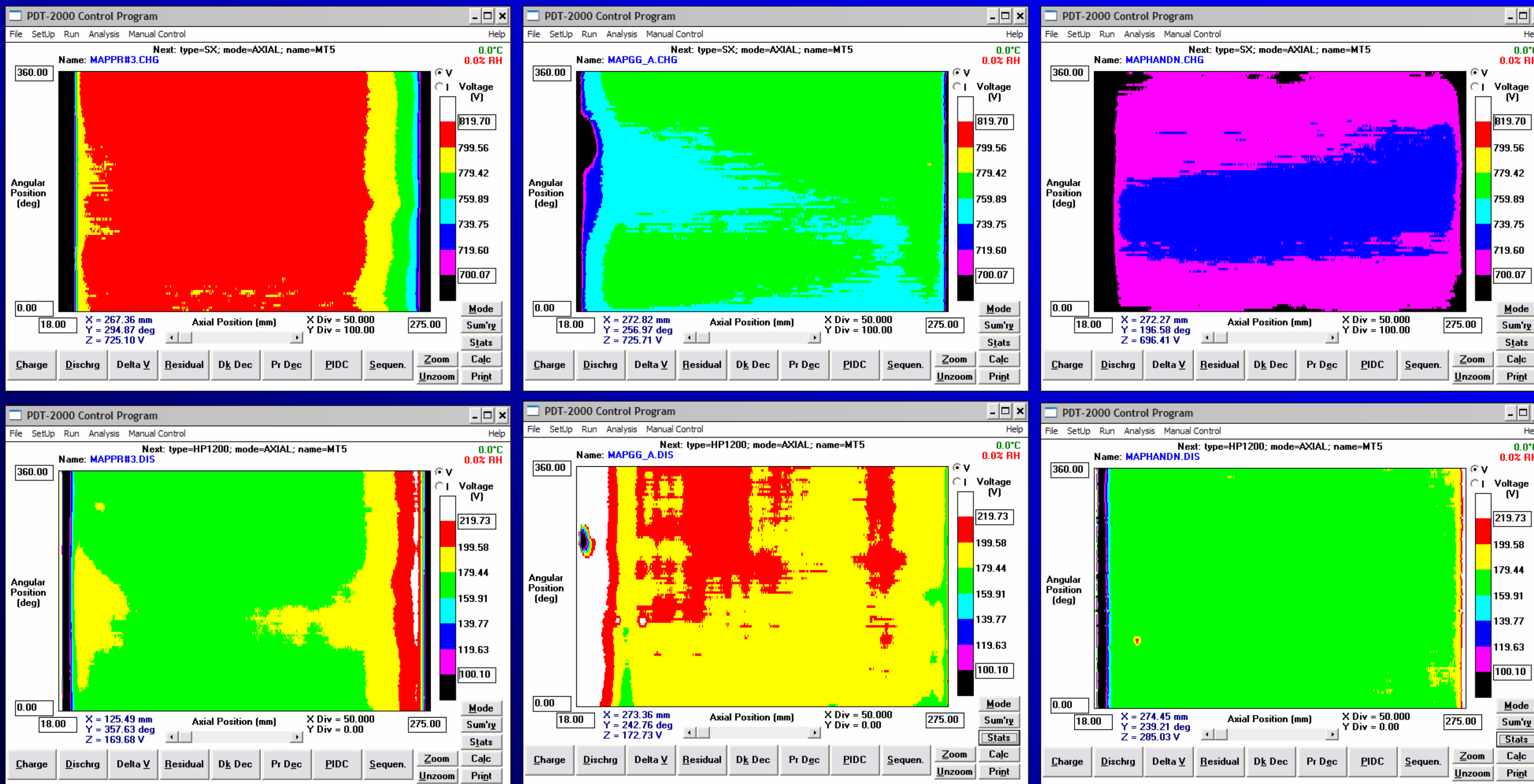






Charge and Discharge Maps (4)

F G H



Charge and Discharge Maps (5)

- The following table shows the average V_{opc} (both charge and discharge) for the maps.
- The charge acceptance is similar for OEM and A through F; G & H are exceptions, similar to earlier observations. The discharge voltages are more variable among the set of OPC.

	Average V_{opc} (volt)	
ID	Corona Charging (6.25KV)	Exposure Energy (0.25μJ/cm^2)
OEM	698.3	125.7
A	703.2	155.9
B	699.5	105.6
C	696.1	135.6
D	701.6	153.1
E	701.8	137.2
F	704.0	152.9
G	652.3	148.5
H	625.3	156.0

Photoreceptor Testing:
Part III – Print Quality

Objective

- In Part III of this report, we will analyze several key print quality attributes and will also examine the correlation between the OPC characteristics and these attributes.
- The print quality attributes to be examined include optical density, tone reproduction, background, ghosting and line quality.
- The objective here is to develop a good understanding on how print quality should be evaluated and how it is affected by OPC's electrophotographic characteristics in order to gain insight into the significance and interpretation of OPC testing.

Dispelling A Myth

- In the laser printing industry, good print quality is often equated to an optical density of 1.4.
- This concept is perhaps a carry-over from the earlier application of laser printing to mostly text based printing and is, unfortunately, quite outdated and quite misleading in terms of how we evaluate print quality.
- Today, with the increase in graphics and color printing, we must recognize how the entire gray scale (tone reproduction) makes a visual impact on an observer.
- It is therefore critical for us to understand this point and to develop a new appreciation of the critical variables in print and component quality.

Maximum Density

- The following data is obtained in this case study.
- The printer setting in the HP4050 was set at two levels, 1 and 5.
- Despite the range of OPC properties and printer settings, the maximum optical density is rather constant - at just about 1.4!

	Maximum Optical Density	
ID	PD* = 1	PD* = 5
OEM	1.40	1.42
A	1.44	1.40
B	1.40	1.44
C	1.42	1.40
D	1.41	1.41
E	1.41	1.43
F	1.41	1.41
G	1.39	1.39
H	1.39	1.44

* PD = print density setting = printer setting

Visual Quality (1)

(printer setting = 1)

- Despite having similar OD at 100%, the overall appearance of the two images are clearly very different.

OEM

G

Visual Quality (2)
(printer setting = 5)

- Same conclusion can be drawn at a higher printer setting.
- What's going on? What makes the difference?

OEM

G

Tone Reproduction Curves (1)

(printer setting = 1)

- This is a good example to illustrate the point that the same maximum OD doesn’t guarantee the same visual appearance.
- Note the visual difference in gray level darkness below 100%, that’s the reason for the significant difference in appearance.

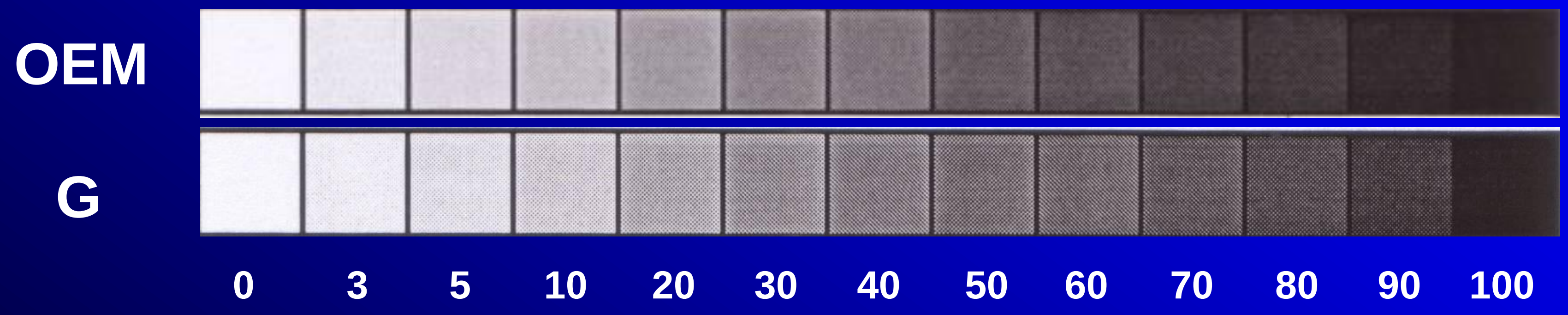
OEM

G

0 3 5 10 20 30 40 50 60 70 80 90 100

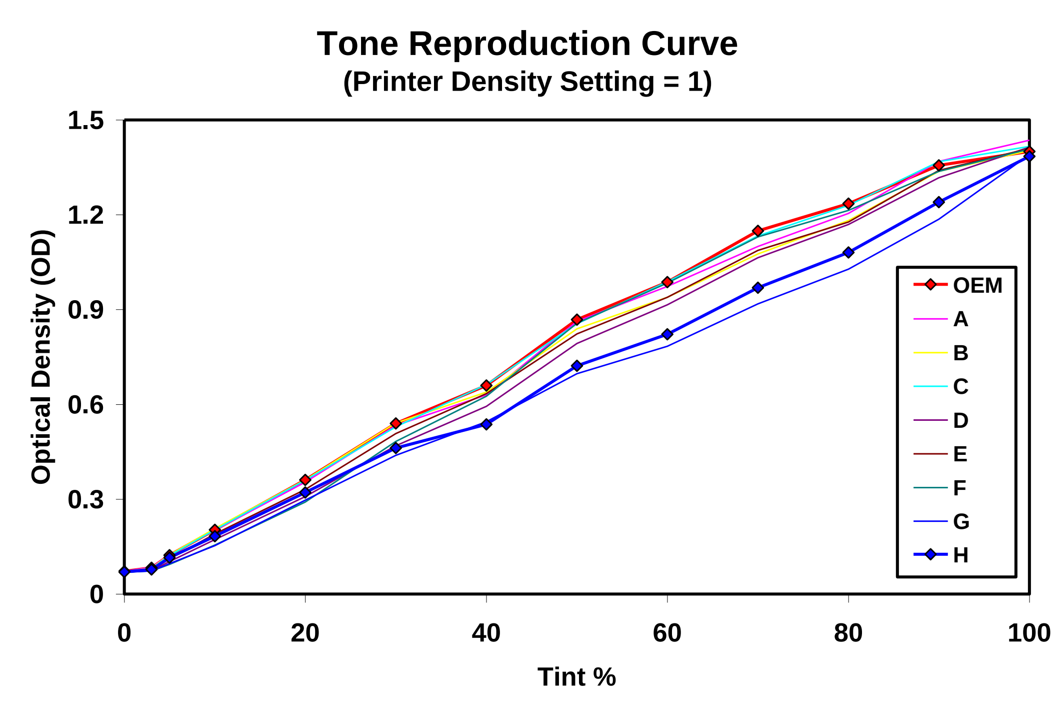
Tone Reproduction Curves (2)
(printer setting = 5)

- The difference can be seen in the tone scale at a printer setting of 5 also (although less dramatic compared to a printer setting of 1).
- Let's examine this in more details to see if we can understand the microstructural difference in the image and how the OPC determines such difference.



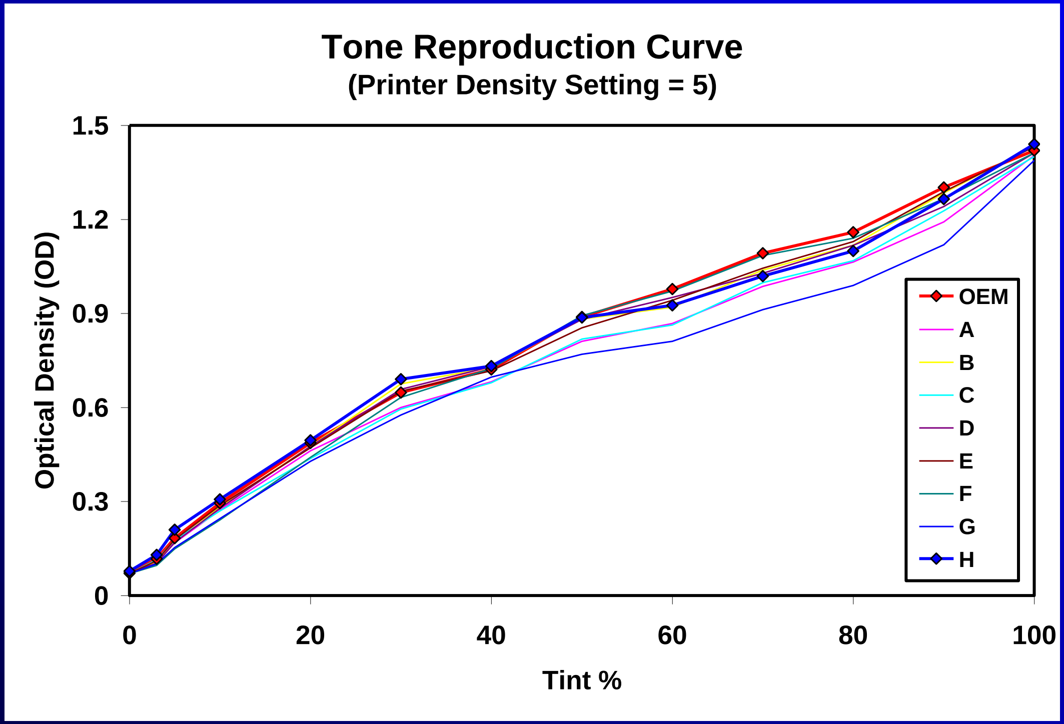
Tone Reproduction Curves (3)
(printer setting = 1)

- The following tone reproduction curves (TRC) quantify the differences among the set of OPC samples.
- As shown in the previous slides, the difference in TRC leads to very clear differences in appearance.



Tone Reproduction Curves (4)
(printer setting = 5)

- The TRC at a printer setting of 5 are less linear than those at printer setting of 1.
- Although the difference is still very clear, it seems to be less between the set of OPC than in the case of printer setting of 1.

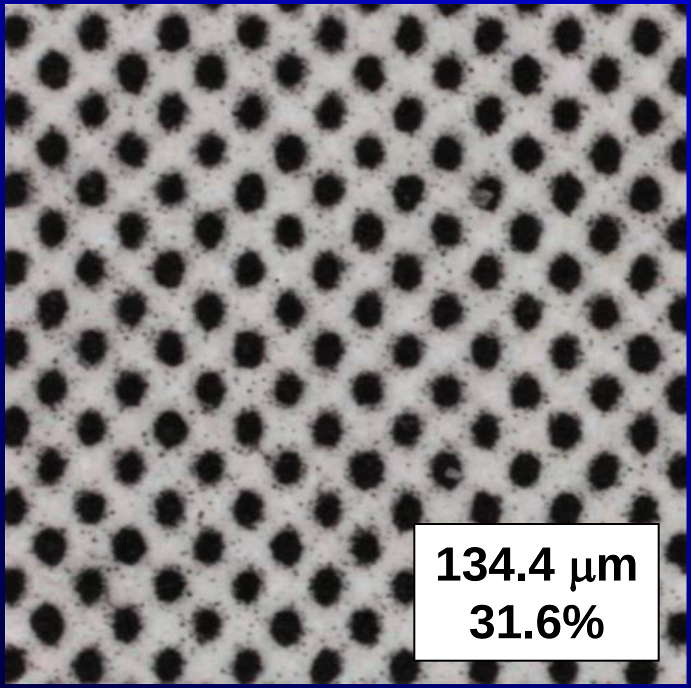


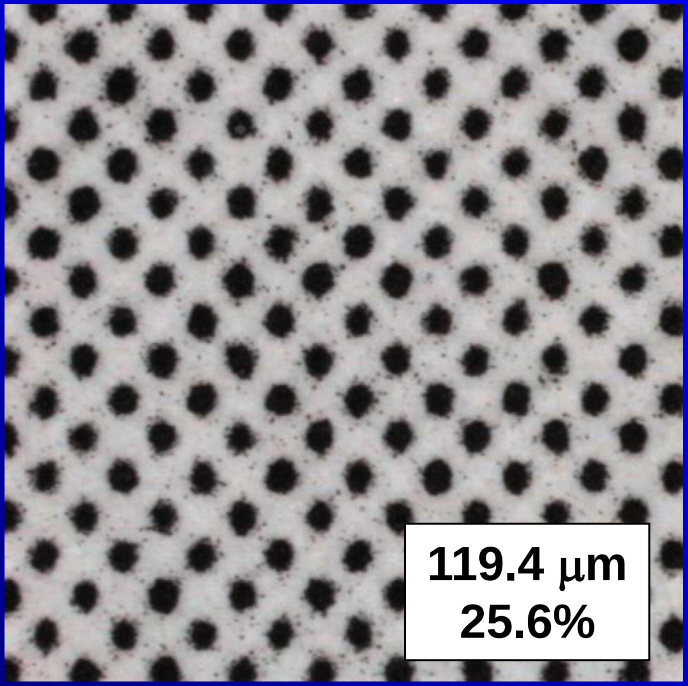
TRC and Dot Gain (1)

(At 20% Tint, Printer Setting = 1)

- **The darker appearance and the corresponding higher optical density in the TRC can be explained by the higher dot gain (i.e., larger dot diameter) as shown in the following micrographs obtained and analyzed using the Personal IAS.**

OEM





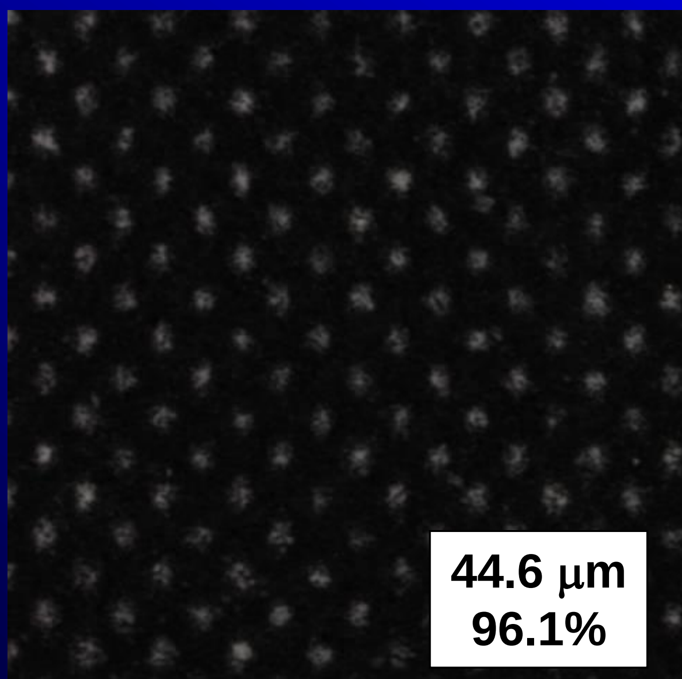
G

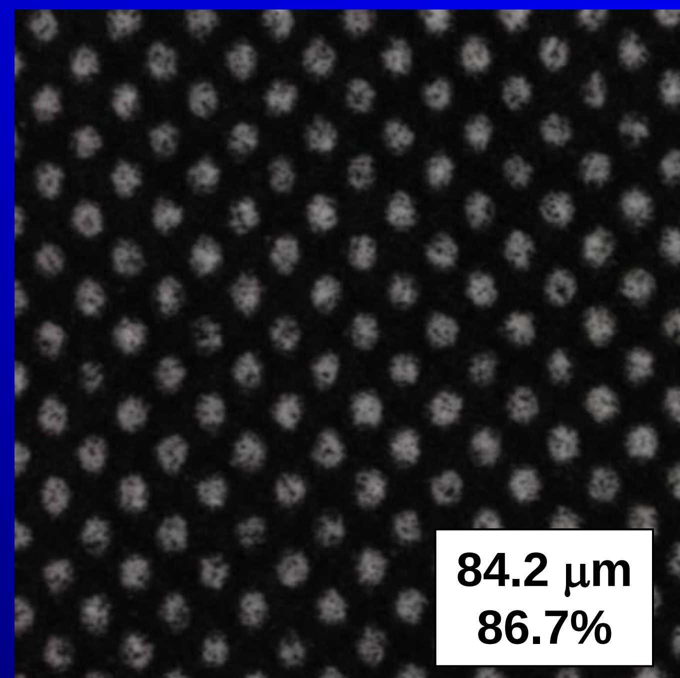
TRC and Dot Gain (2)

(At 80% Tint, Printer Setting = 1)

- The same observations (i.e., higher dot gain in the OEM sample can be seen at 80% tint also.
- Clearly, there is a difference between the OPC samples, what is it that underlies the difference in dot gain?

OEM



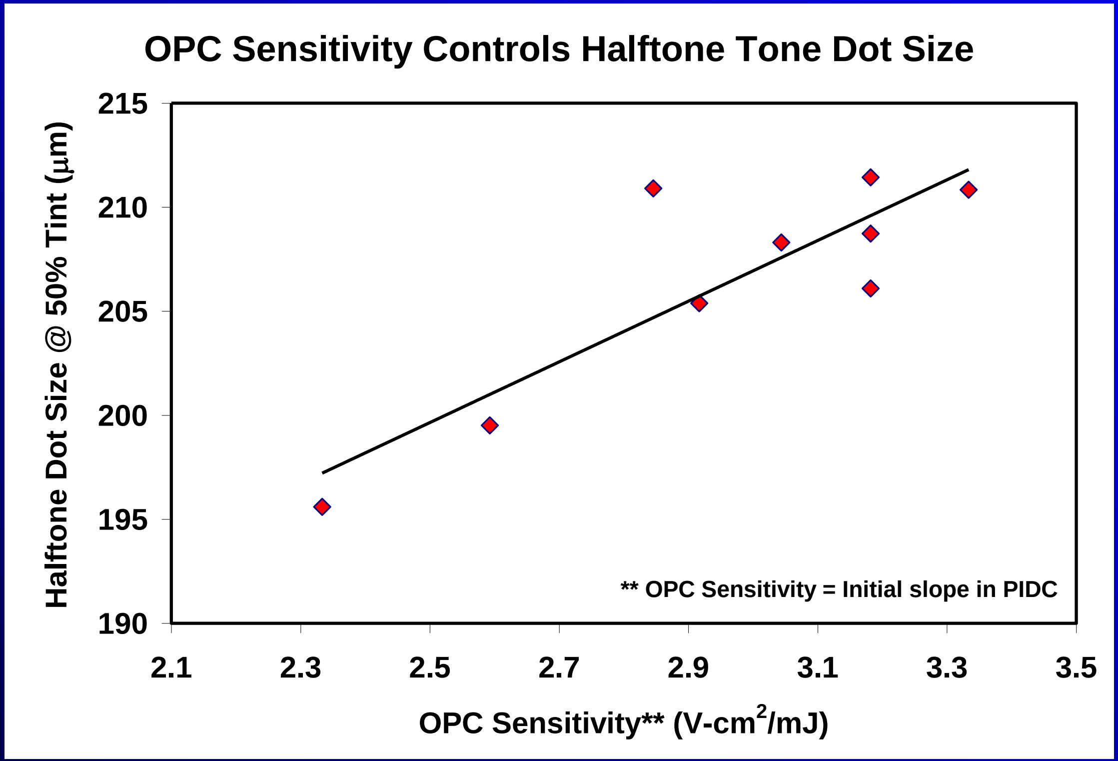


G

Correlation with OPC Sensitivity (1)

(Printer Setting = 1)

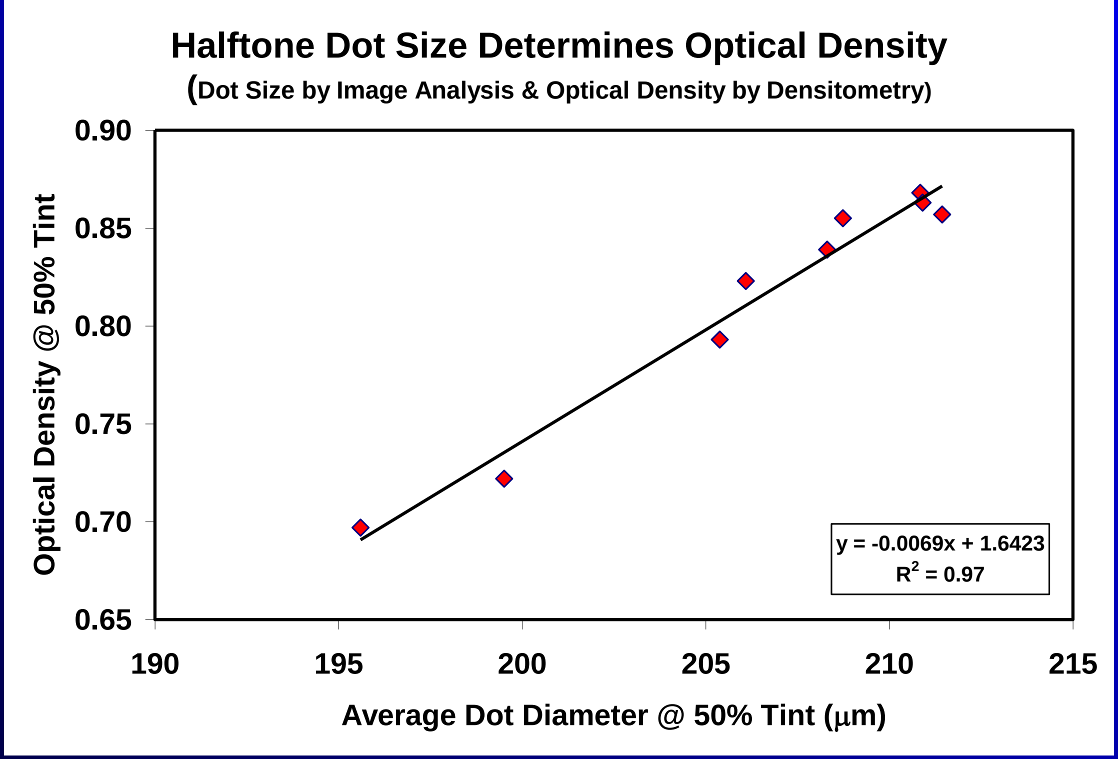
- The graph below shows that apparently, OPC sensitivity controls the halftone dot size, which in turns, determines the optical density as shown in the next slide.



Correlation with OPC Sensitivity (2)

(Printer Setting = 1)

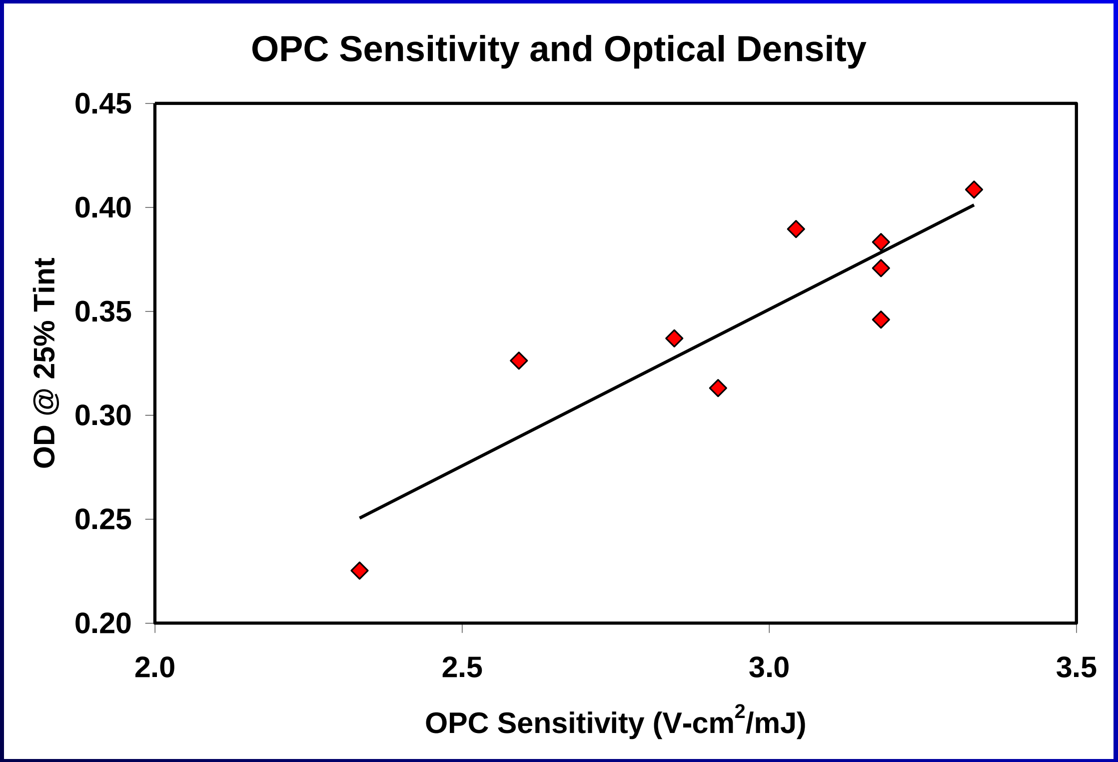
- The halftone dot size and dot gain has a direct impact on optical density. Hence, we can conclude that since OPC sensitivity controls halftone dot size, it also has a strong influence on OD and appearance.



Correlation with OPC Sensitivity (3)

(Printer Setting = 1)

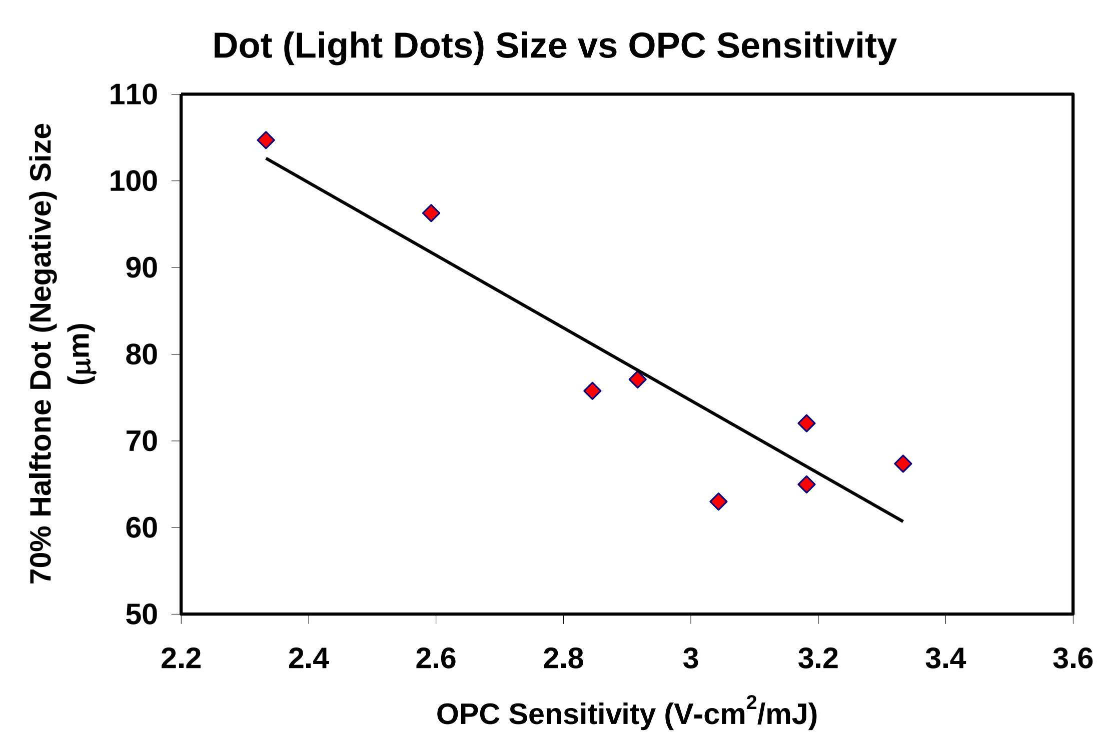
- This and the next graph further confirms the OPC sensitivity-dot size-OD causal relationship.
- This graph is for 25% tint.



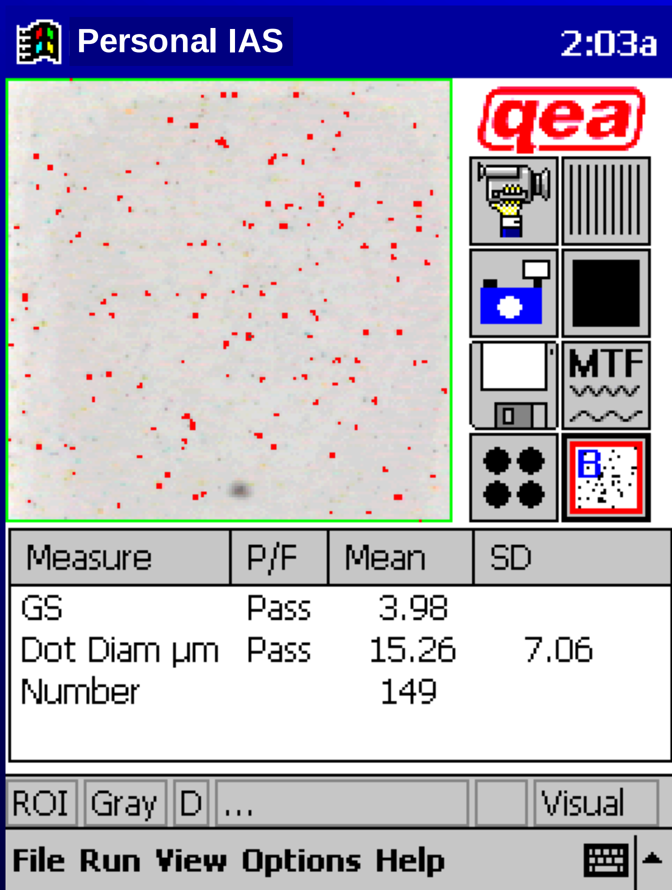
Correlation with OPC Sensitivity (4)

(Printer Setting = 1)

- This graph is the dot gain at 70%.
- The result further confirms the importance of OPC sensitivity in determining optical density and appearance.



Toner Background (1)



- **Toner background can be evaluated by the GS method, which depends on size (d_i) and the number of particles (N)**

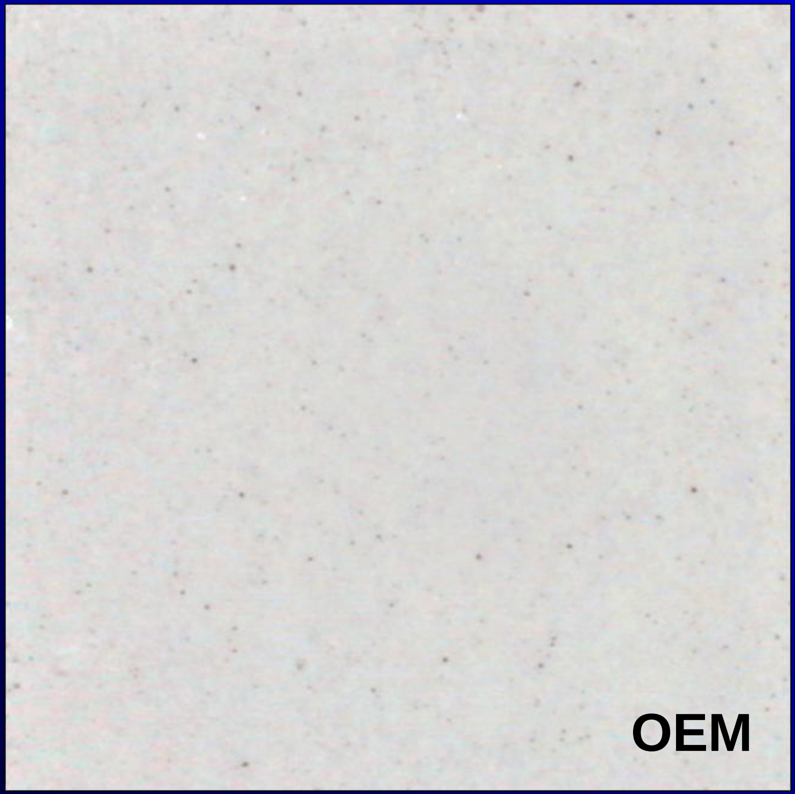
$$GS = \sqrt{\frac{4.74 \times 10^{-6} \sum_i (d_i)^4}{a}}$$

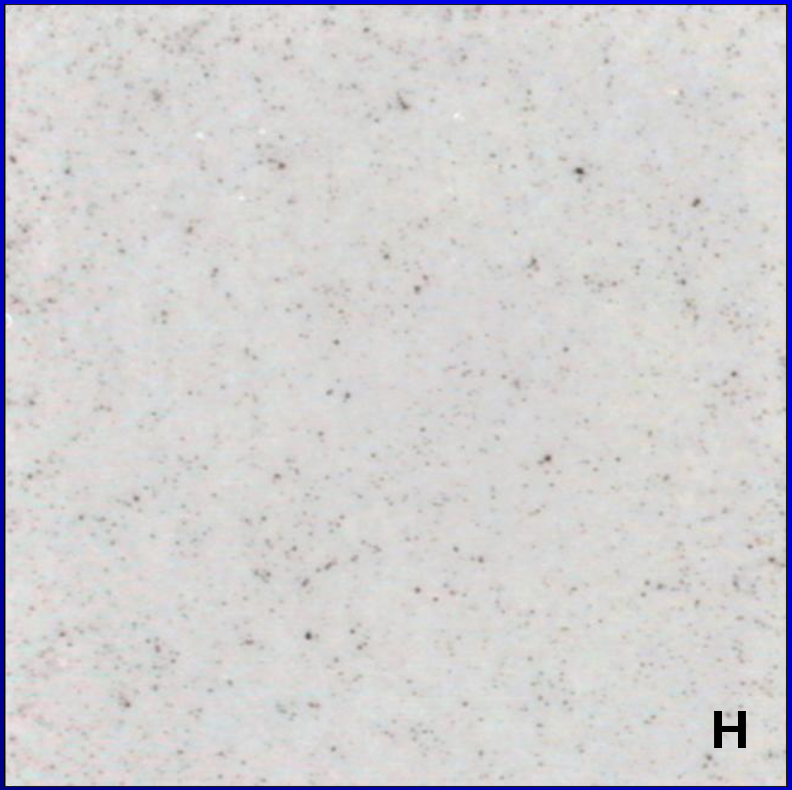
where i = 1 to N

and a is the area of the region of interest

Toner Background (2)

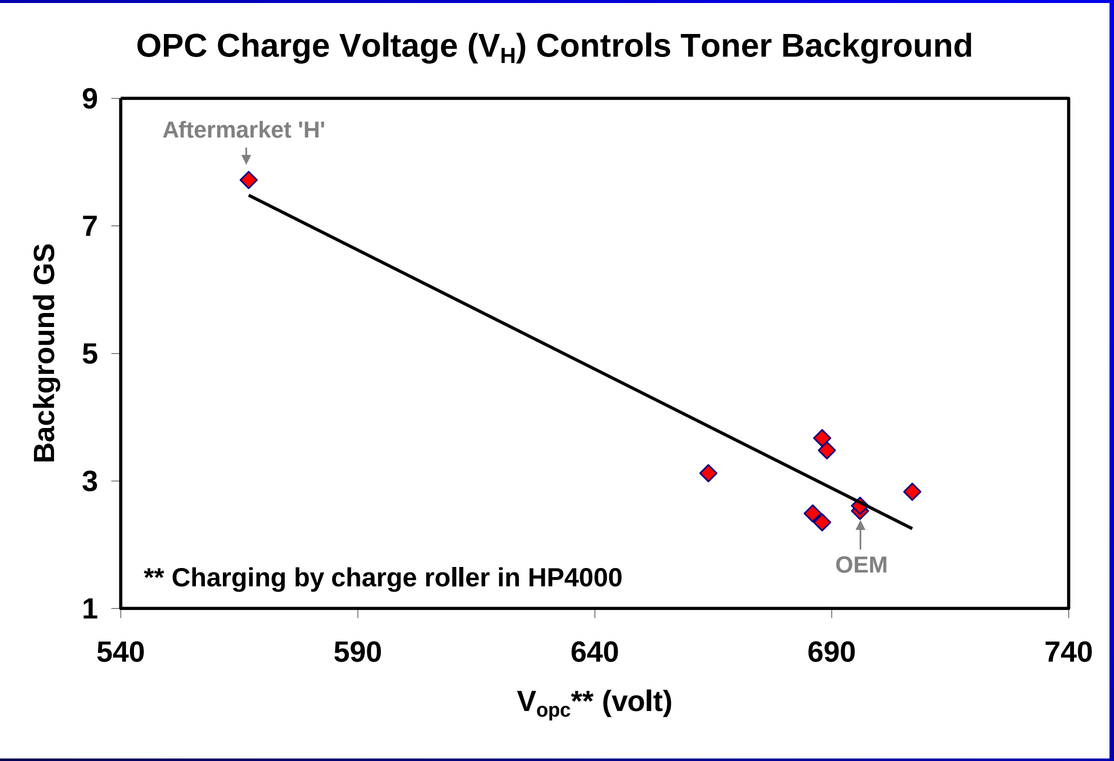
- Sample H has the highest toner background GS value.
- All other samples have fairly similar GS.





Toner Background (3)

- Although the data do not span the V_{opc} range evenly, the general correlation between background and OPC charge voltage is clear.



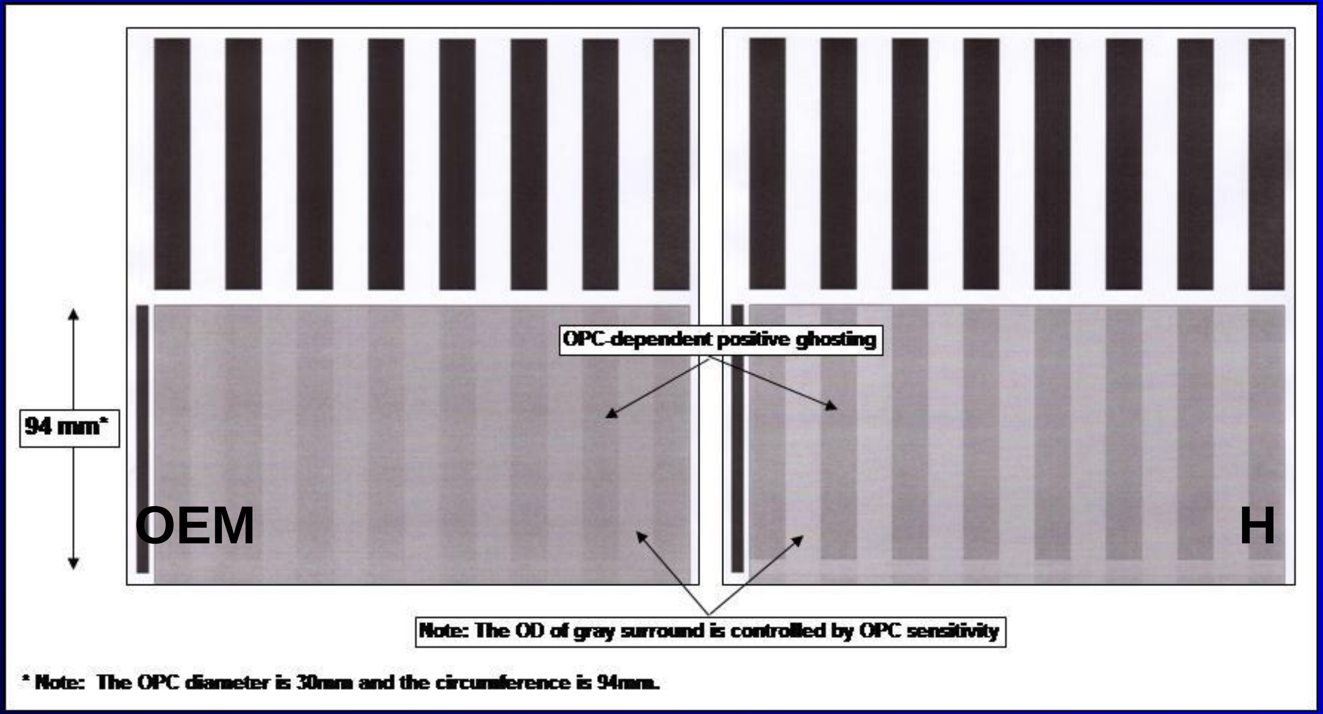
Toner Background (4)

- The following is a summary of V_{opc} vs background GS.

ID	V_{opc} (volt)	Background GS
OEM	696	2.5
A	688	2.6
B	688	2.4
C	686	2.5
D	696	2.6
E	707	2.8
F	689	2.5
G	664	3.1
H	567	7.7

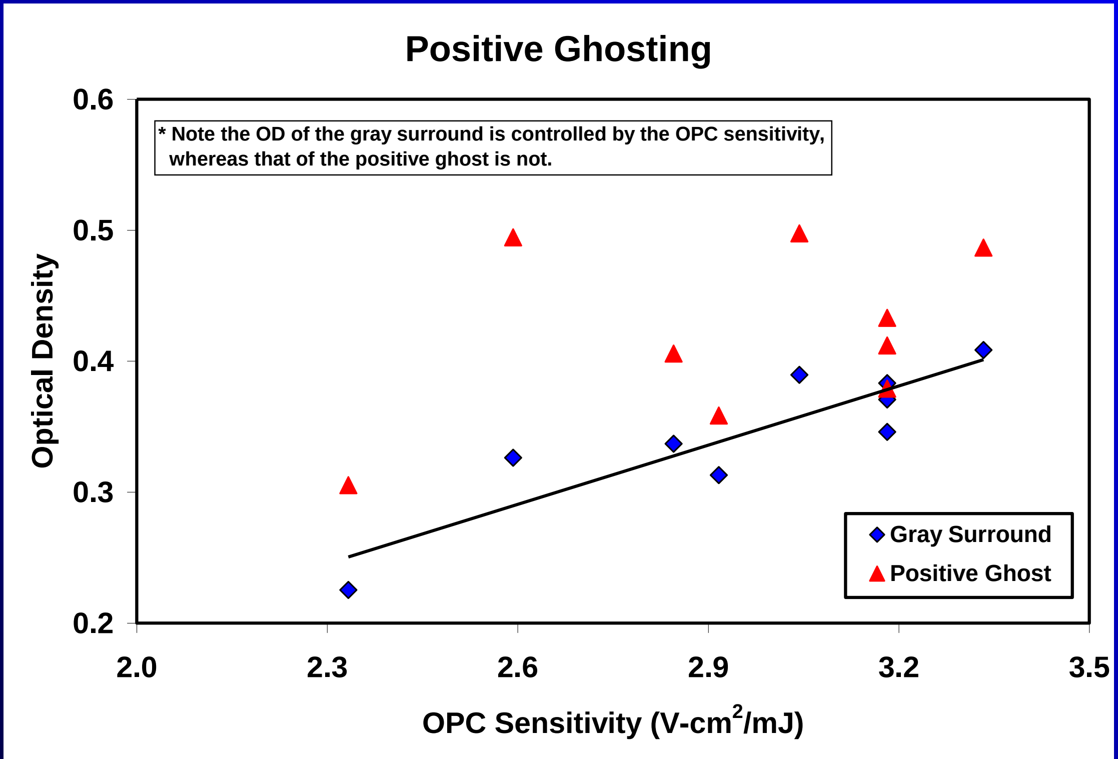
Ghosting (1)

- Positive ghosting observed in a special target print for all OPC samples.
- The ghosting is most severe with sample H.
- No other form (such as negative ghost) observed.



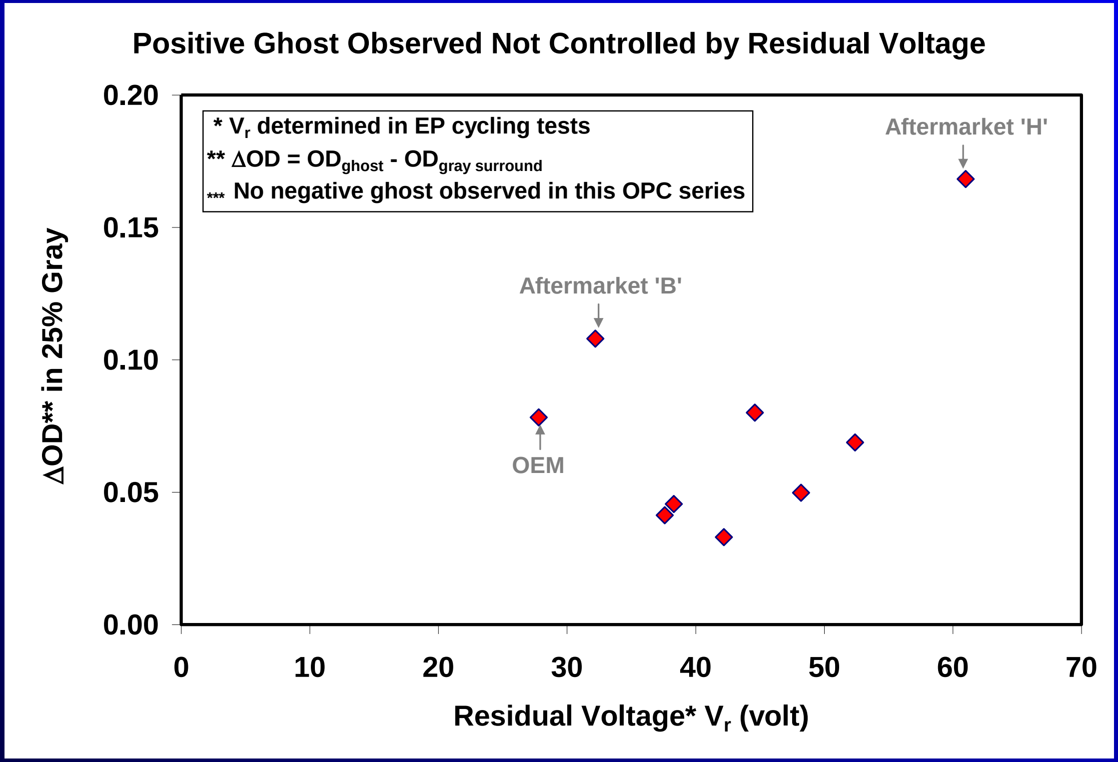
Ghosting (2)

- The optical density of the gray surround is determined by the OPC sensitivity as shown below.
- The ghost density, however, is not dependent on OPC sensitivity.



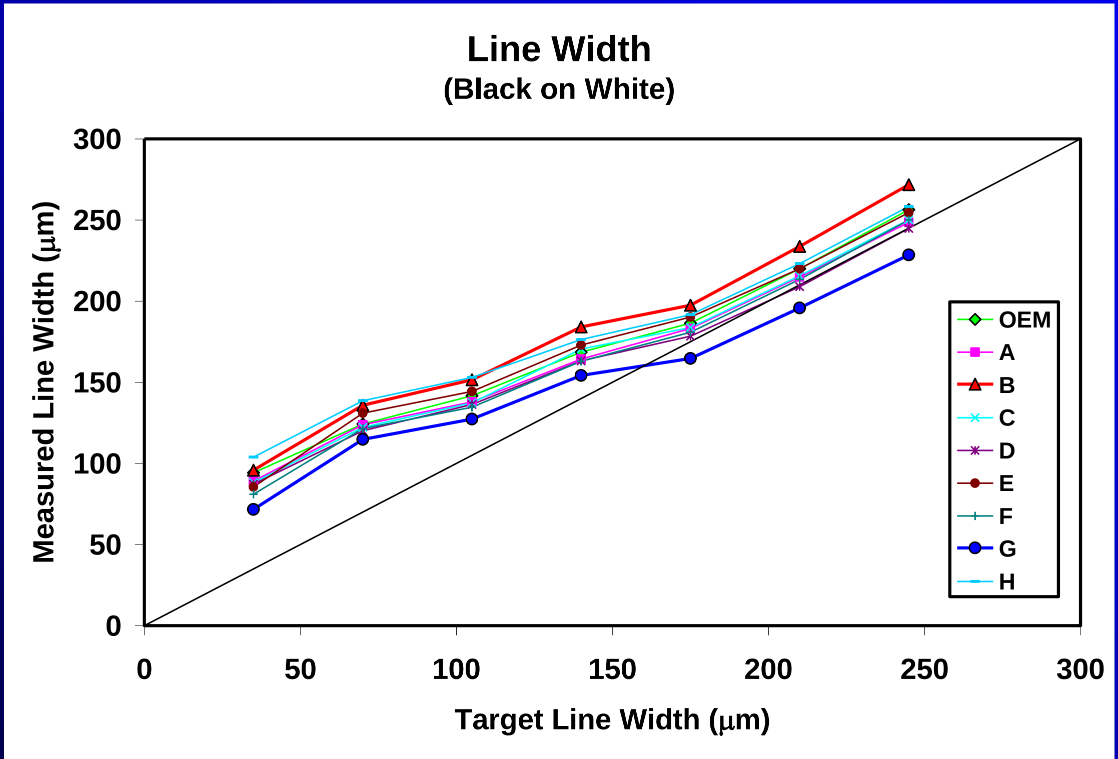
Ghosting (3)

- Often ghosting is associated with residual voltage. In this case, however, there is no correlation between the positive ghost observed and Vr. No clear causal relation found between this specific form of ghosting and OPC characteristics.



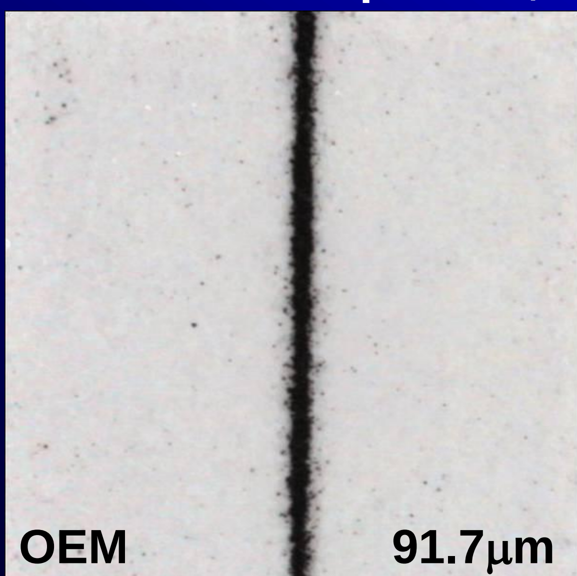
Line Quality (1)

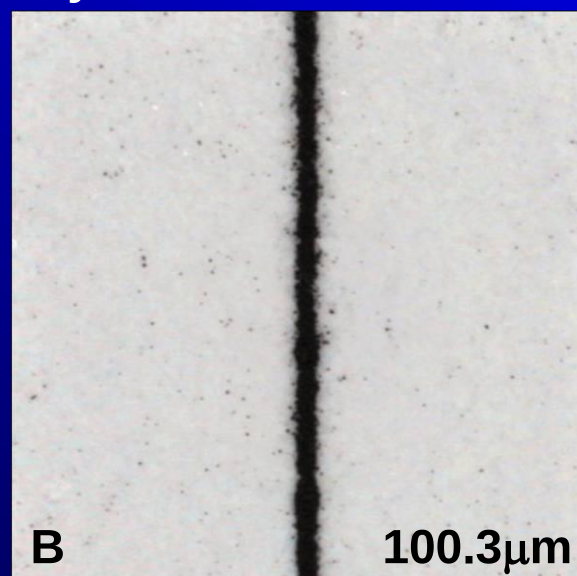
- The graph below for a range of target line seems to suggest a systematic difference among the set of OPC studied.
- Is this systematic difference attributable to any OPC characterisitcs?

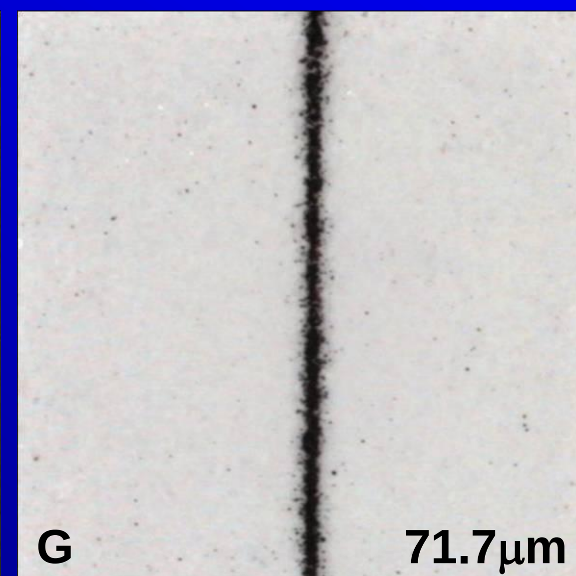


Line Quality (2)
(Target Line Width is 35µm)

- As shown in the following Personal IAS images & analysis results, there seems to be a relationship between line width and OPC sensitivity (e.g. OEM > G). However, the reversal between OEM & B counters this assertion.
- It appears that the relationship between line quality and OPC properties is not a simple one, if any.

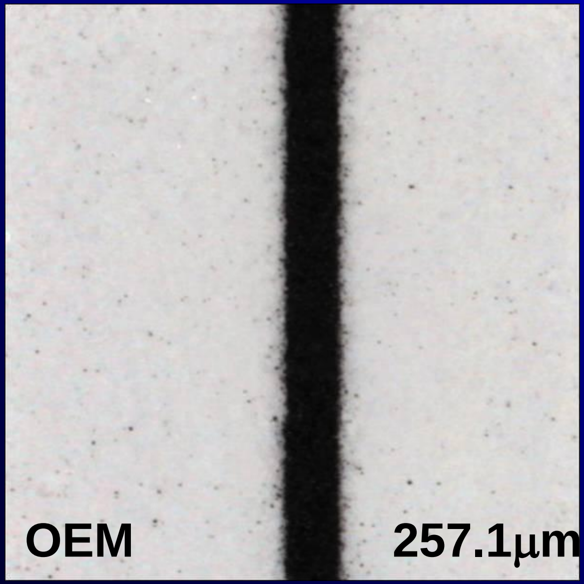


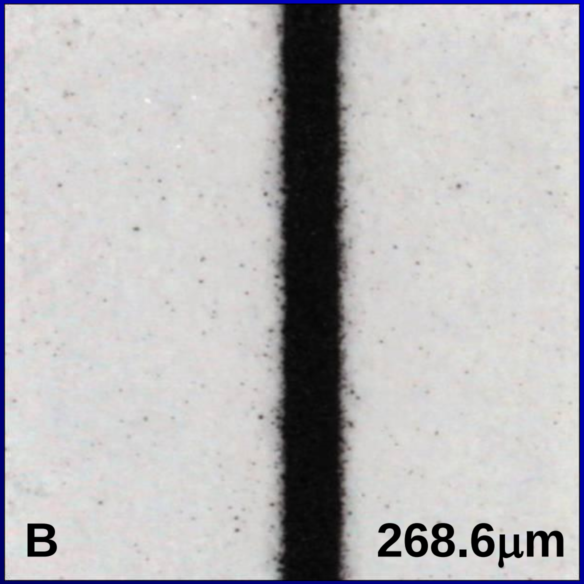


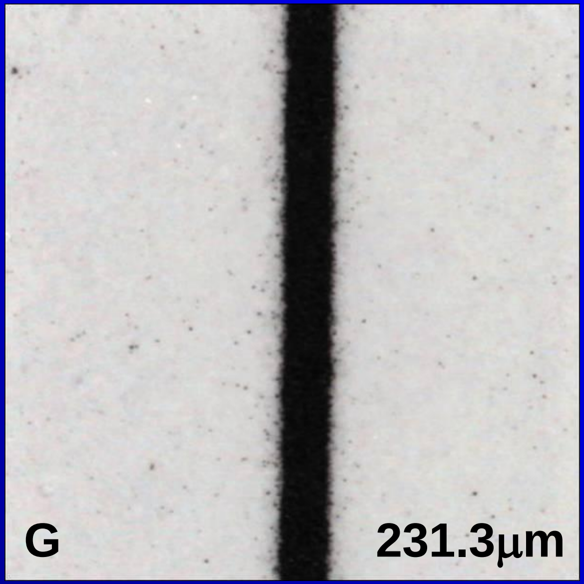


Line Quality (3)
(Target Line Width is 245μm)

- Similar to the observation drawn in the previous slide, there is no apparent simple relationship between line quality and OPC characteristics.
- For line width at 245μm, B > OEM > G, but for OPC sensitivity, OEM > B > G.

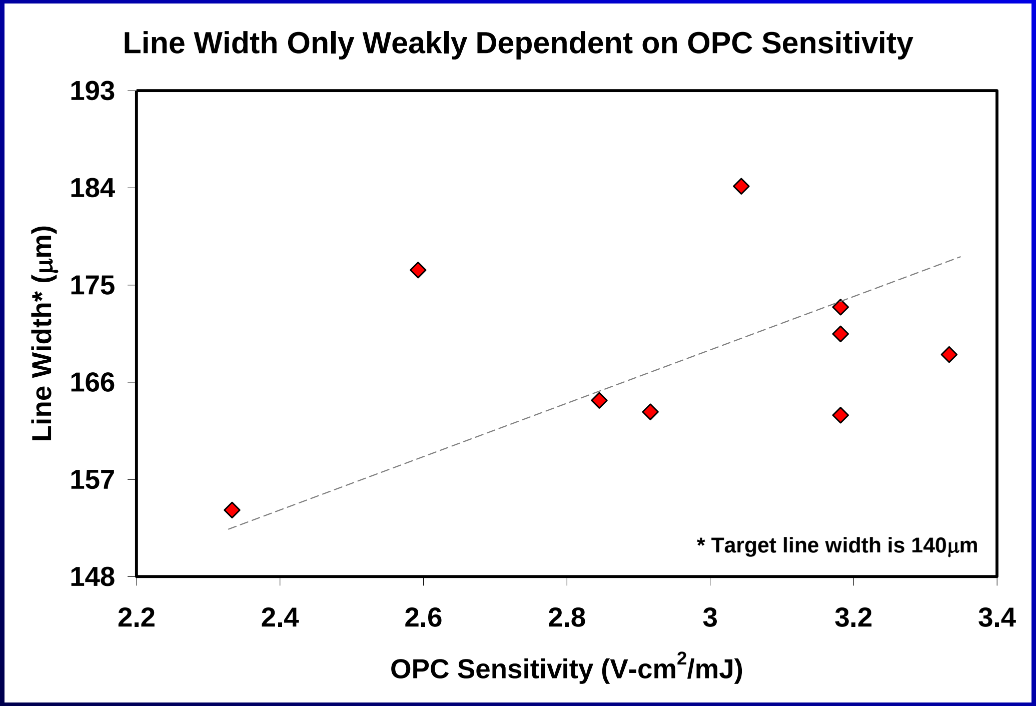






Line Quality (4)

- The graph suggests that line width is only weakly dependent on OPC sensitivity.
- It is more likely that line width is affected more strongly by the variables in development than OPC properties alone.



Summary

Photoreceptor Functional Requirements

- Photoreceptor functional requirements cover a broad range:
  - Electrical properties
  - Coating quality
  - Resolution
  - Print quality & print defects
  - Environmental stability
  - Life
- To meet these requirements, OPC qualification requires testing with instrumental methods in addition to the common practice of print testing

Photoreceptor Testing & Characterization

- Relative to the functional requirements, the most important OPC tests include:
  - Charge Acceptance
    - Capacitance & Dielectric Thickness
    - Dark Decay
    - Charge roller charging
  - Photosensitivity
    - Photo-Induced Discharge Curve (PIDC)
    - Spectral sensitivity
    - Charge mobility
  - Cyclic Fatigue
    - Cycle down in charge acceptance and cycle down in discharge sensitivity
  - Coating Uniformity, Defects and Wear Mapping

Measurement Tools

- QEA provides a range of tools for OPC test and qualification. These include:
  - PDT-2000LA Advanced Drum Test System for complete EP characterization
  - ECT-100 for OPC coating thickness measurement
  - Personal IAS for quantitative print quality evaluation
- This set of tools is essential for any serious developers, manufacturers, and users of OPC.

Case Study – EP Results

- A set of 9 HP4000 OPC was tested, including an OEM and 8 aftermarket samples.
- The results suggest that most aftermarket OPC are quite similar in EP properties to the OEM. However, there are a few "outliers" with significantly different sensitivity and dark decay.
- The cyclic stability appears to be quite acceptable for all samples.
- No environmental or wear test has been performed in this study, although the test can be done in controlled environmental conditions and to support a OPC durability study.
- The OEM remains a benchmark product.

Case Study – Print Quality (1)

- This study clearly highlight the inadequacy of using OD=1.4 alone as the criterion for judging print quality.
- In today's graphical and color printing environment, the full tone reproduction curve must be considered.
- The TRC is controlled by dot gain, which in turn is significantly determined by OPC sensitivity.
- Toner background is primarily affected by charge acceptance – low charge voltage leads to high background.

Case Study – Print Quality (2)

- Ghosting is a complex phenomenon and as such, the mechanism is not necessarily unique.
- Positive ghosting was observed in this study. However, no apparent correlation between the observed ghosting and OPC EP properties was found.
- While line width is weakly dependent on OPC sensitivity, other variables (such as in development) in an EP print system must affect line quality also.