

Separating physical and optical tone value increase in print images

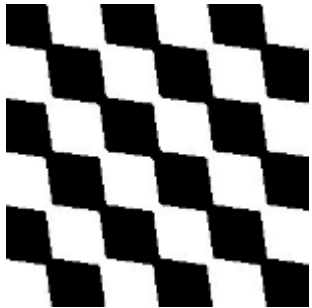
Martina Miletić



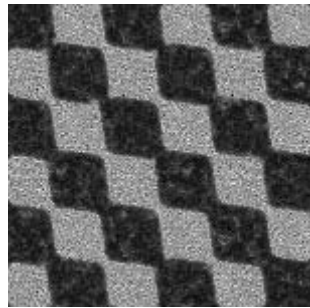
DRESDEN
concept
Exzellenz aus
Wissenschaft
und Kultur

Aim of the printing process: a true reproduction of a printing template!

Tone Values (Colours) $_{\text{Template}} \approx \text{Tone Values (Colours)}_{\text{Print}}$



Data template



Printing plate

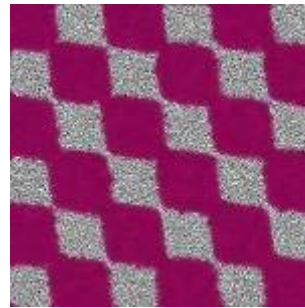
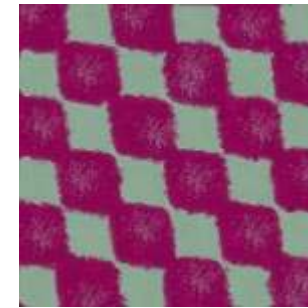


Plate + Ink



(Rubber blanket)



Paper

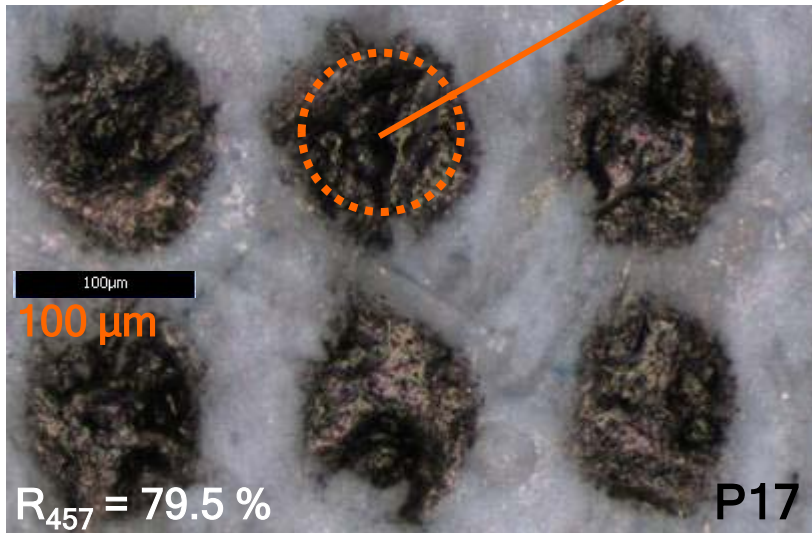
TVI = difference between TV_{Template} and TV_{Print}

Tone Value Increase Components:

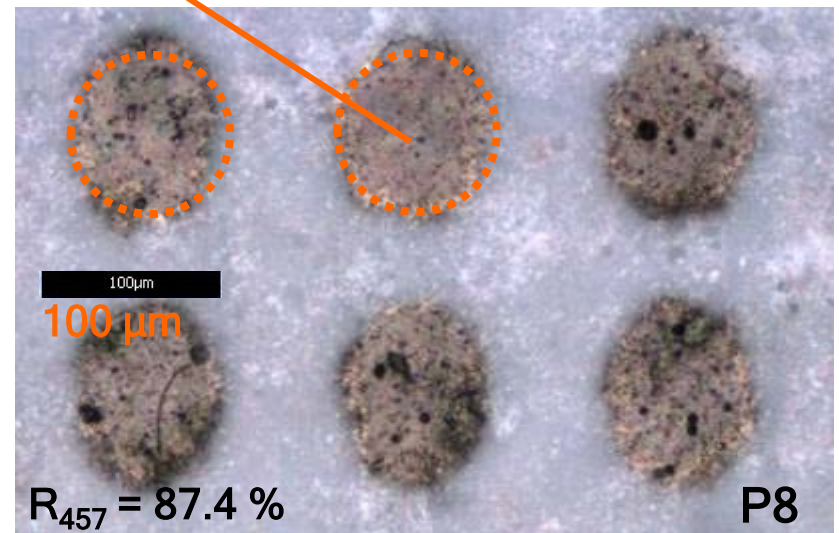
- Physical (increase in the size of the printing dots)
- Optical - light trap

Ink transfer from printing plate over rubber blanket onto paper → increase in the size of the dot through pressure („squeezing“)

Theoretical dot diameter (30% TV, 70 L/cm, linearly exposed plate) = 88 μm



70 g/m², matte, rc



focus variation images (IFM G3 10x)

70 g/m², glossy, wc

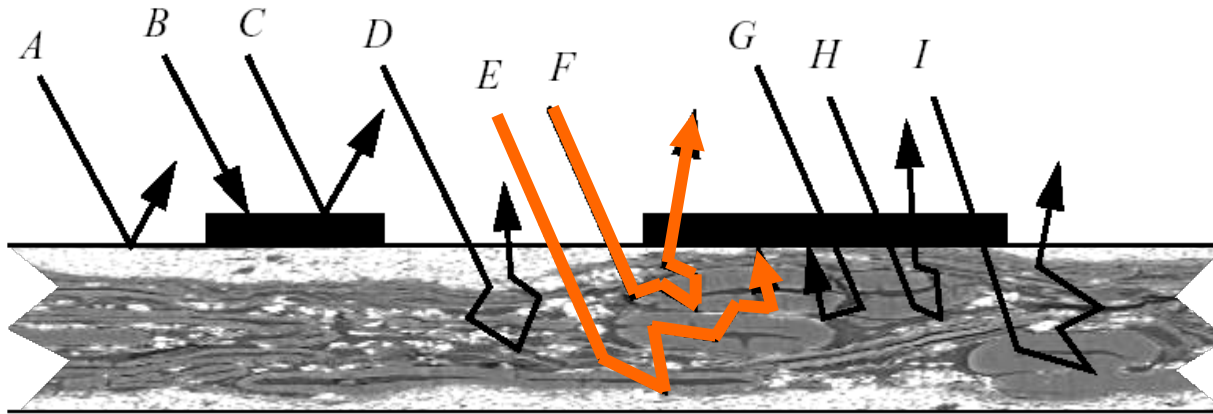
$TVI^* = 21 \%$

$TVI^* = 9 \%$

R_{457} (D65 - without UV-Filter)

**Spectrophotometrical measurement = cumulative reflection from the surface - cumulative TVI (D50, 2°; Paper; background black)*

Light scattering on the paper surface and in the paper body → light trap



Possible movement path of the photons in a single colour screen print

Printed surface appears darker (optically bigger) than it is physically/geometrically.

- A - reflection from the surface
- B - photons absorbed by the ink layer before approaching the paper
- C - light reflected from the ink layer
- D - inner reflection
- E - light is scattered in the paper body, back reflected and absorbed from the ink layer → LIGHT TRAP**
- F** } movement paths
- G** } possible in case of
- H** } small absorption
- I** } coefficients of the ink layer

Optical microscope: LEICA M3Z, 25x

Camera: Go Q Imaging

Acquired Resolution: 5120 x 4096

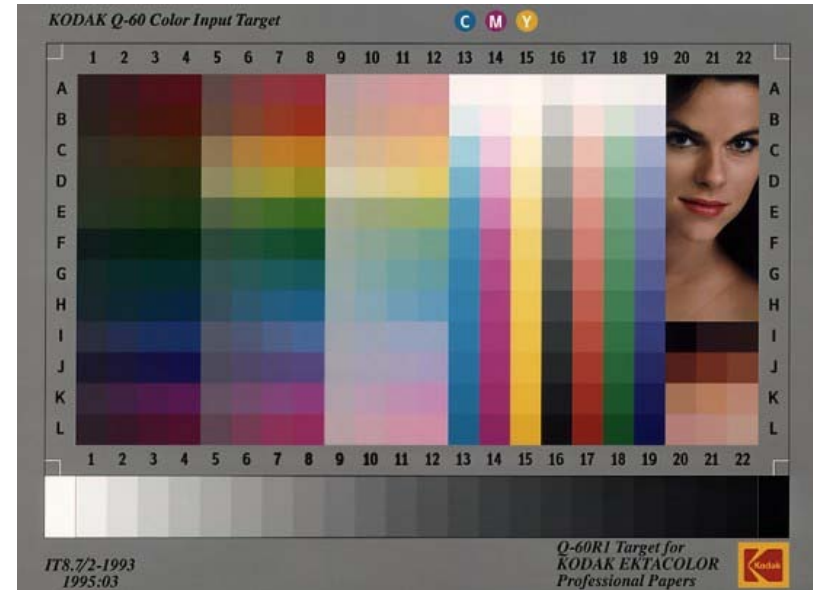
Pixel Size: 0.51 μm ;

Pixel Aspect Ratio: 1

Image Field: 2.61 mm x 2.08 mm

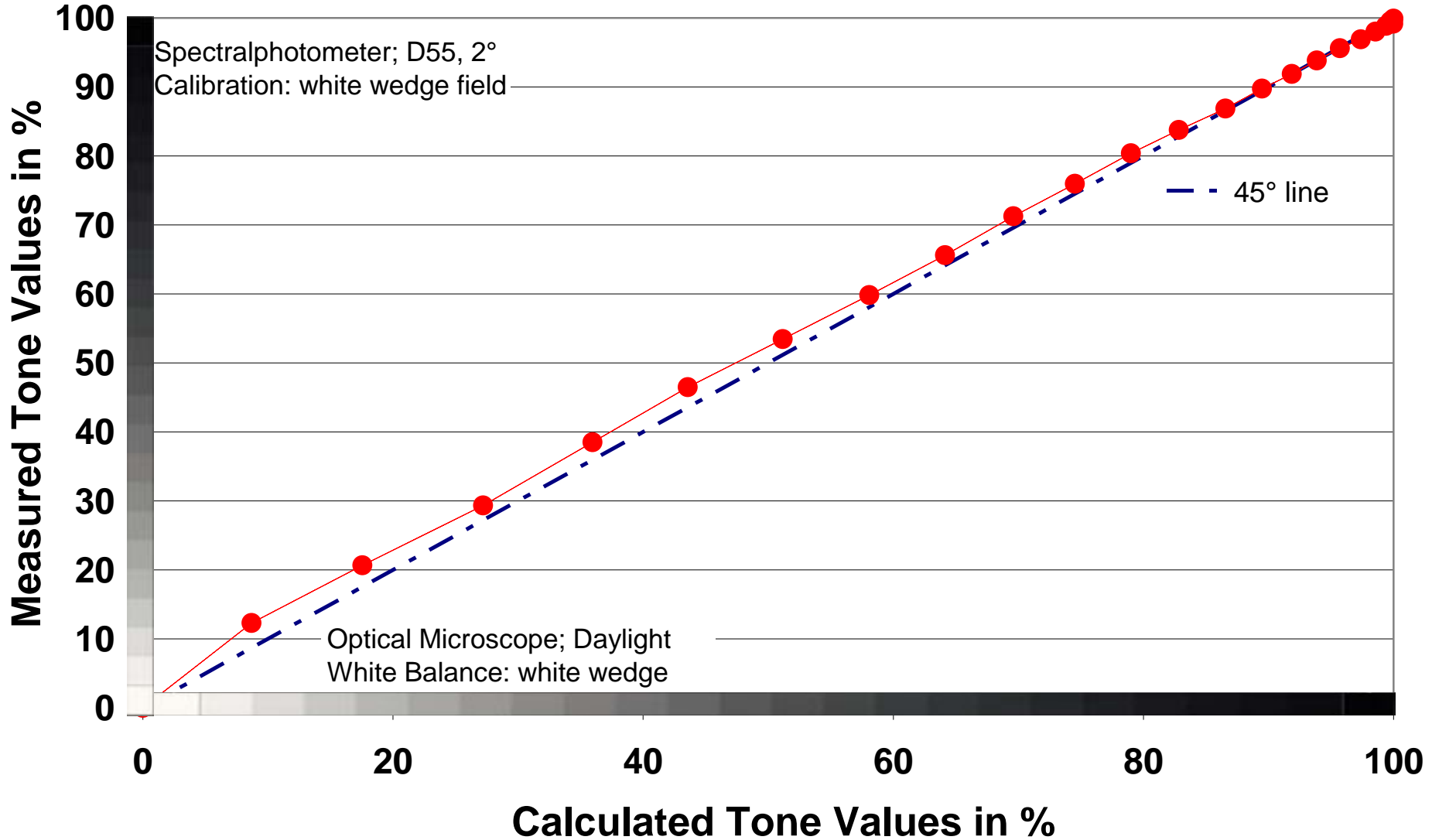
Light Source: Daylight

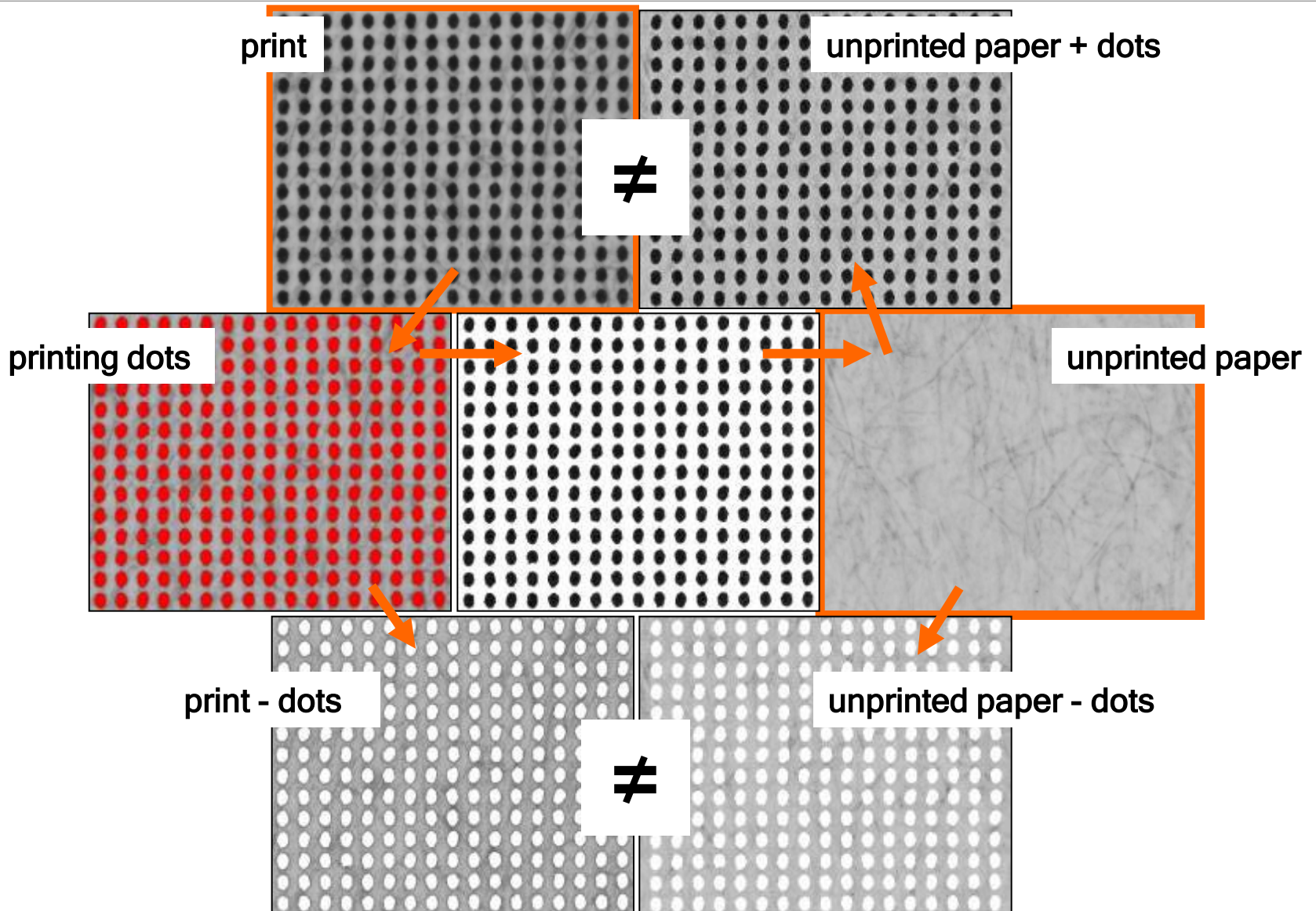
White Balance: R: 1.190; G: 1; B: 2.470



Microscope calibration: over a colour and grey scale step wedge

Correction of uneven background intensities and compensation for irregularities due to uneven lighting, non-uniform camera response or minor optic imperfections and to remove evidence of dust on the lens was conducted.



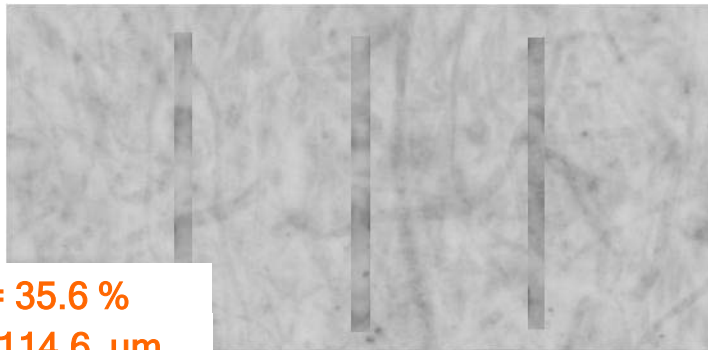


Components that contribute to the reflection (tone value) of a screen image:

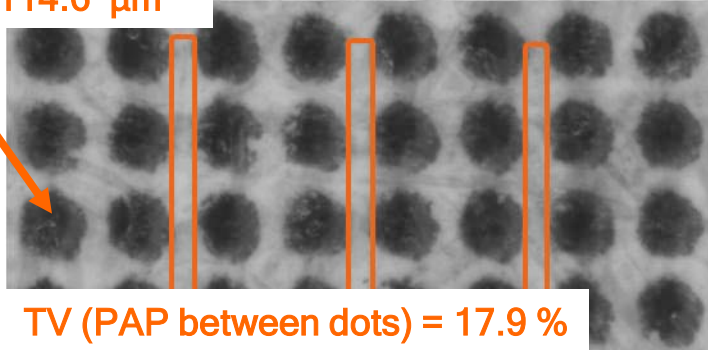
- Dot size
- Light transmittance of the dot (ink layer thickness, ink properties)
- Optical darkening of surrounding paper → optical properties of paper

TV (unprinted paper) = 5.7 %

P9



TV (PD) = 35.6 %
Ø (PD) = 114.6 µm

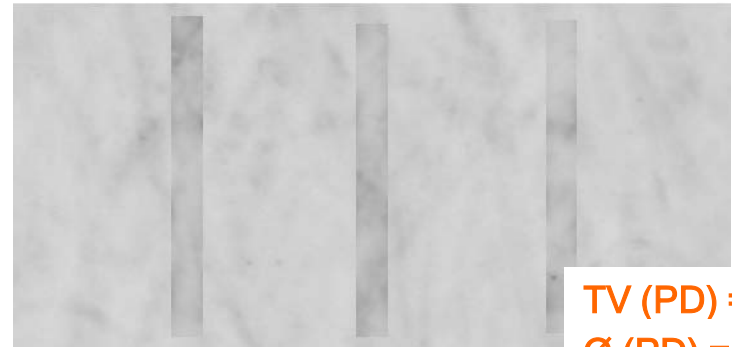


TV (PAP between dots) = 17.9 %

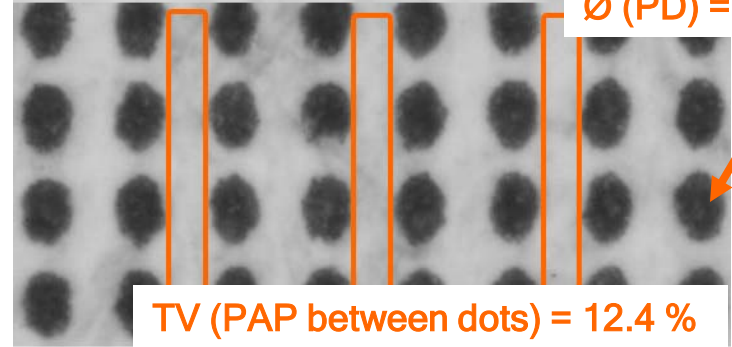
TV (print) = 51 % → TVI of 21 %

TV (unprinted paper) = 1.1 %

P8

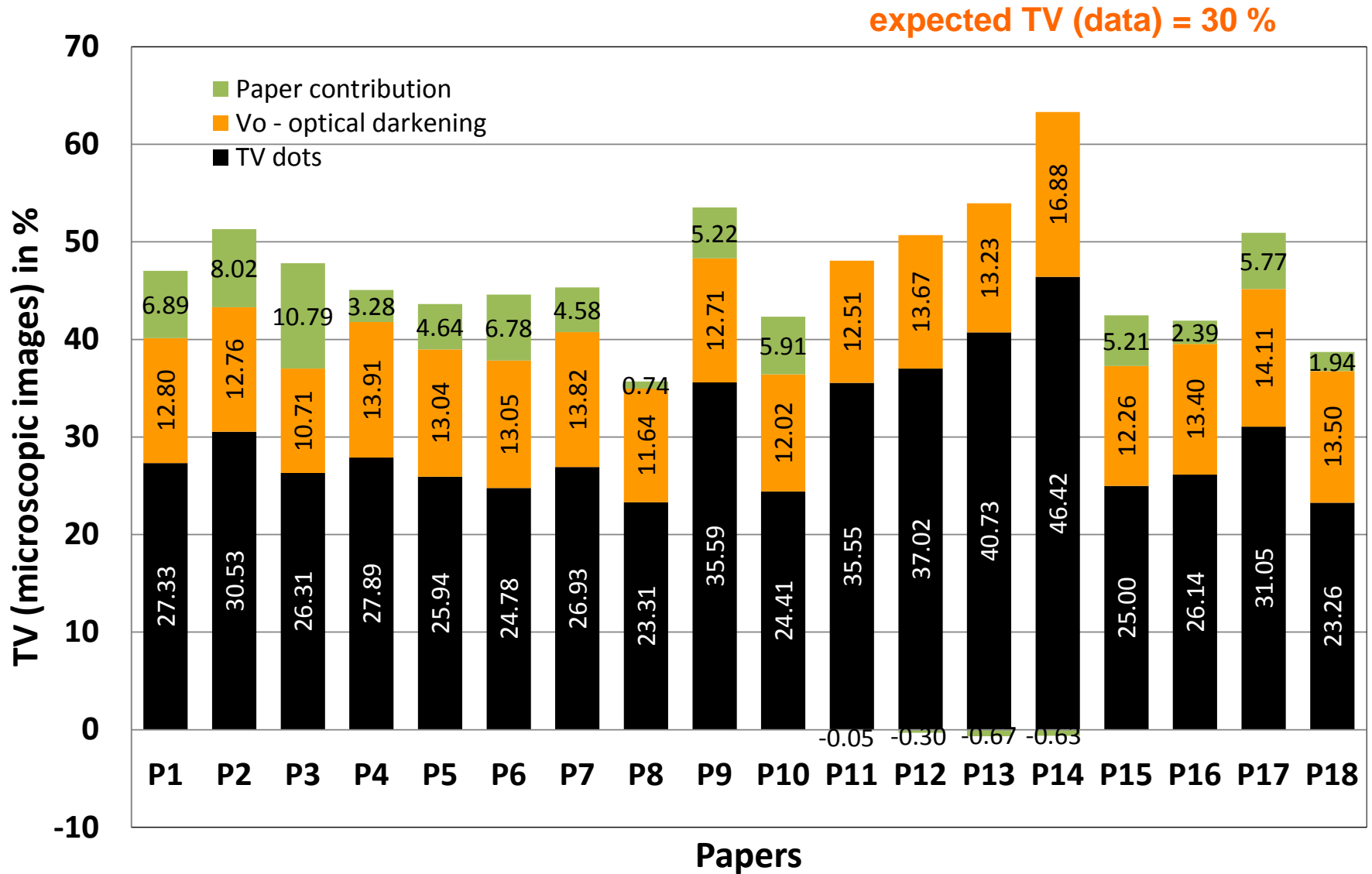


TV (PD) = 23.3 %
Ø (PD) = 93.4 µm

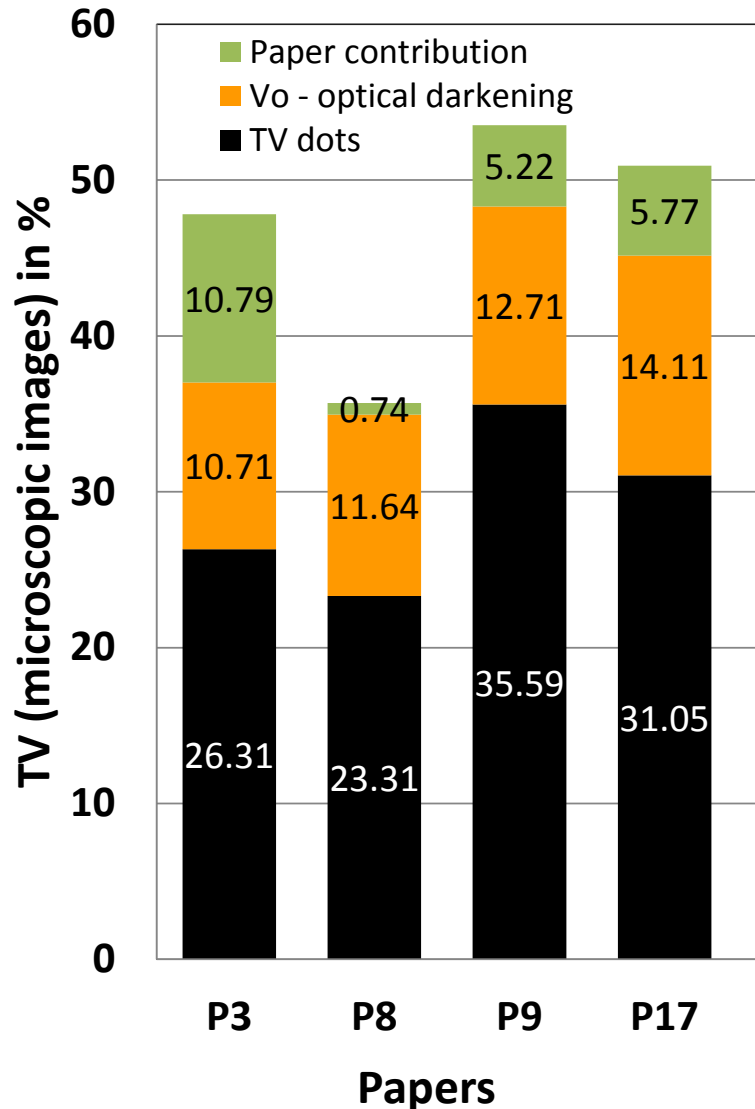


TV (PAP between dots) = 12.4 %

TV (print) = 36 % → TVI of 6 %



ONLY FOUR PAPER DIFFER ENOUGH!



P	Vo %	m _A g/m ²	Th. mm	R ₄₅₇ %	O %	Sa μm	CLT* μm	
							MV	σ
3	10.7	59	0.04	75.6	90.5	0.44	6.03	3.61
8	11.6	70	0.05	87.0	95.1	0.22	7.45	3.53
9	12.7	70	0.06	78.2	96.2	0.76	3.41	2.92
17	14.1	70	0.08	79.5	97.2	1.53	2.30	2.08

- By const. m_A and ↑ thickness → Vo ↑
- If thickness ↑ and opacity ↑ → probability of scattering in paper body ↑ → Vo ↑
- If roughness ↑ → Vo ↑ (→ probability of scattering in the surface layers ↑)

Exception: P8 highest coating layer thickness!

Generally the rougher the paper and thicker and smoother the coating layer, the lower the optical darkening.

**coating layer thickness*

Regression-Statistics

Multiple correlation coefficient	R=0,82
Coefficient of determination	R²=0,67
Adjusted R ²	R²_{adj}=0,65
Standard error	1,66
Observations	15

- TV of dots and their size are dominant part in the TV of an image
- Paper contribution to the TV of investigated papers can be described by:
 - ✓ paper whiteness to 67 % at comparable level of Vo (!)
- Optical darkening (Vo) of paper is a dominant part of the paper contribution and a significant part in the cumulative TV of an image (!)
- For analysis of paper parameters influencing Vo data material of the investigated papers is insufficient

Model variables

- $x_1 =$ Paper whiteness (R457)
- $y =$ TV (cumulative paper contribution)

Imperative: wider paper spectrum and novel characterisation of paper!

Thank You For Your Attention!

Questions?

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