



How does a clear layer modify the appearance of a halftone print?

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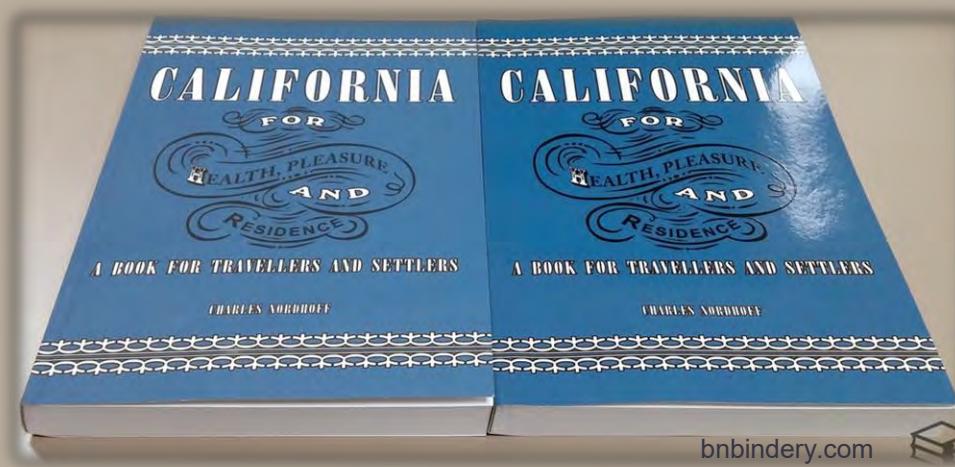
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HOW DOES A CLEAR LAYER MODIFY THE APPEARANCE OF A HALFTONE PRINT?

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10/06/22



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Anne Blayo, Lionel Chagas,
Thierry Fournel, Mathieu Hébert

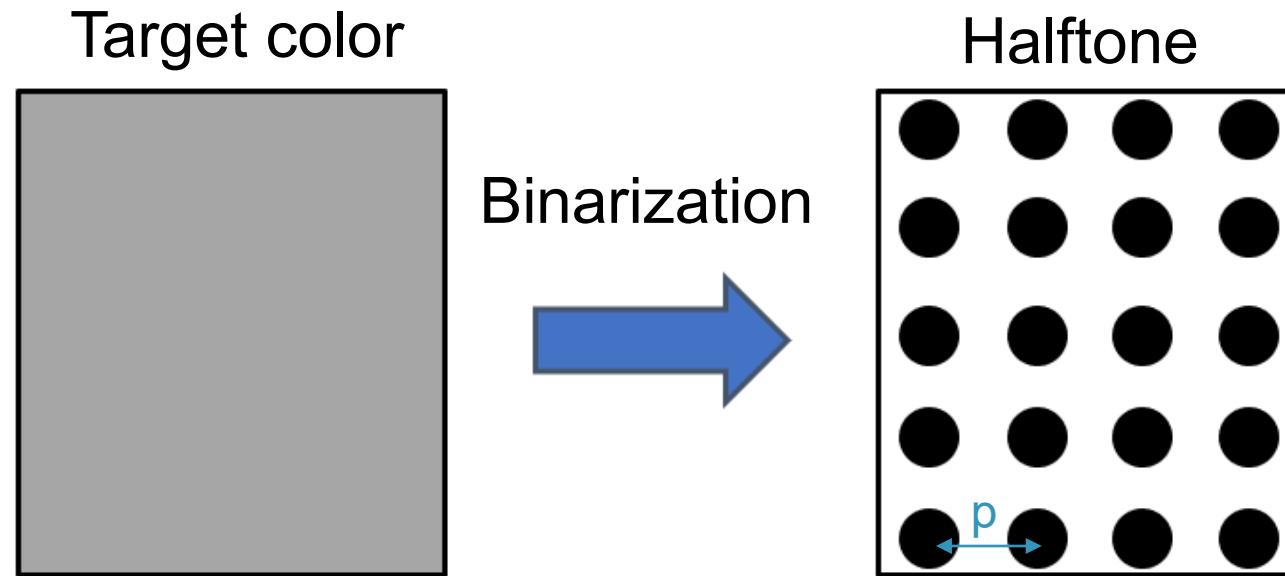
CCIW22

LGP²

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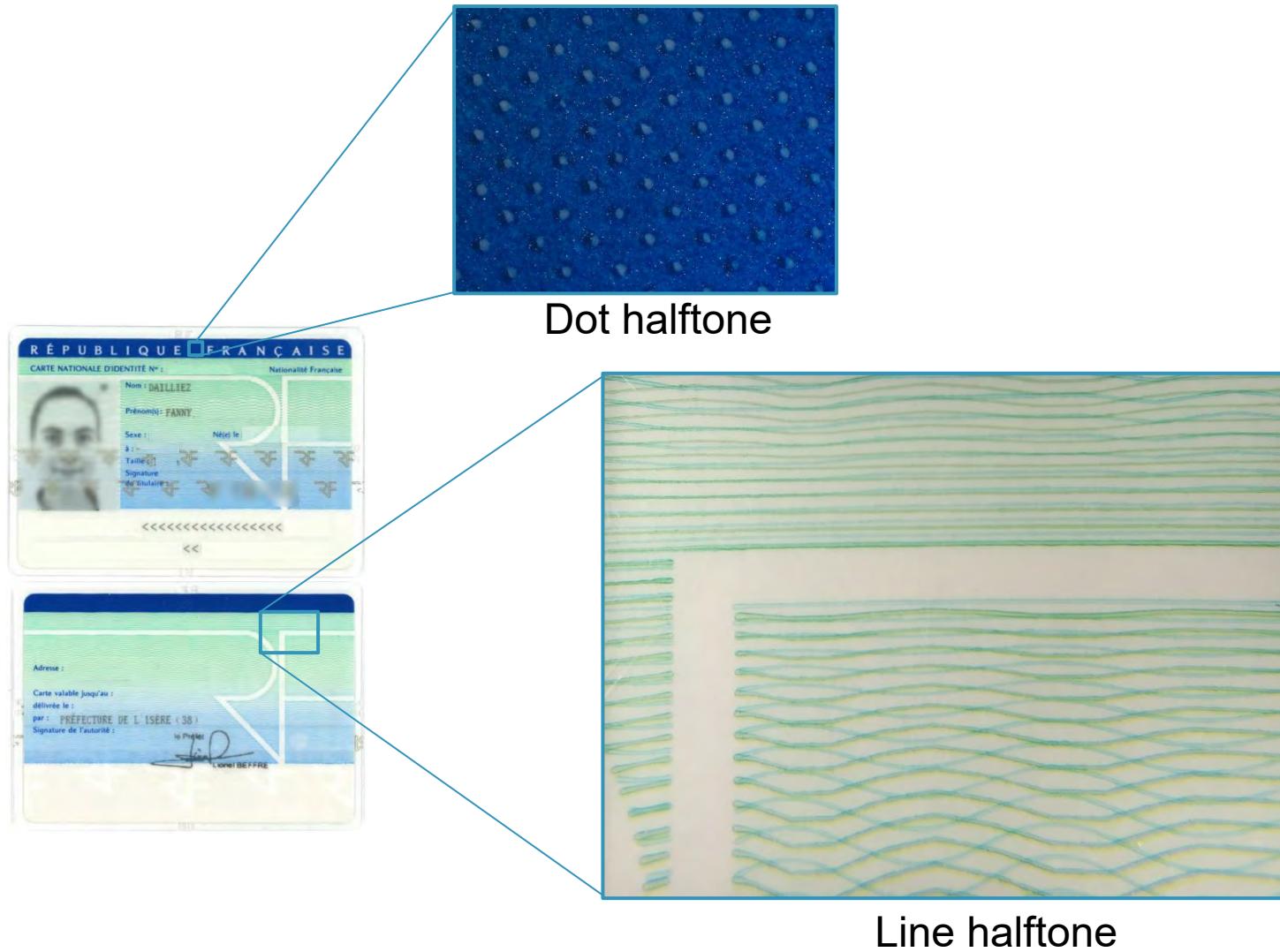


Halftoning

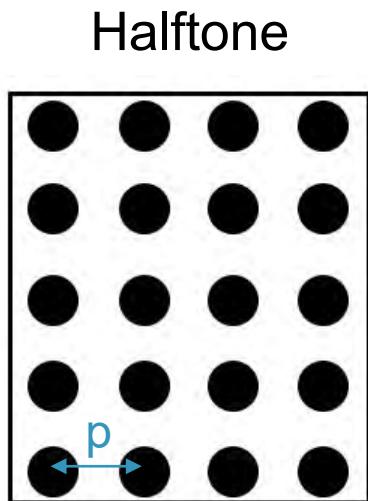


Screening parameters:

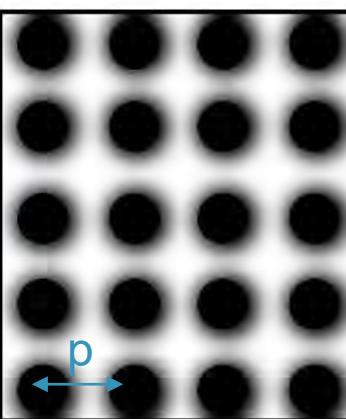
- Dot shape
- Spatial frequency
- Surface coverage



Printing



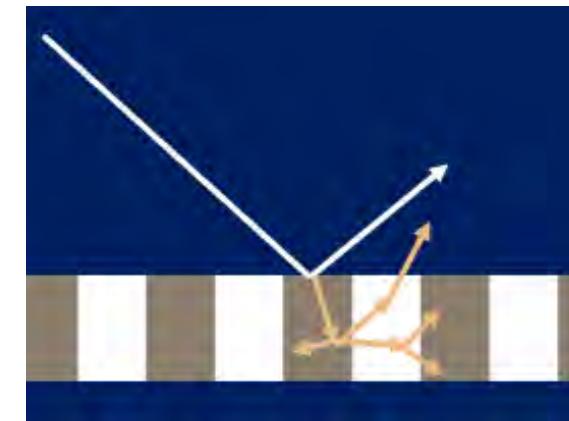
Printing



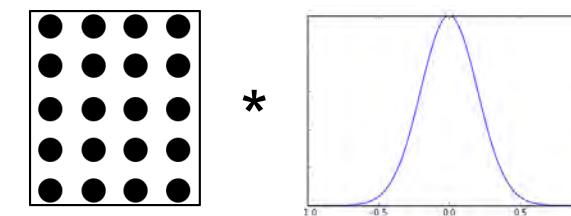
Dot gain

- Mechanical
- Optical

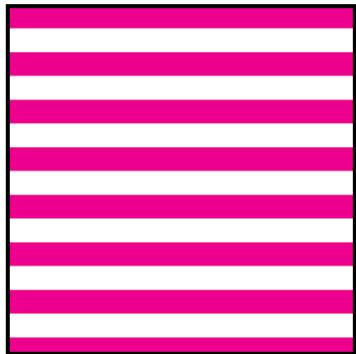
Diffusion of light
inside the substrate



Convolution with the paper
Point Spread Function (PSF)



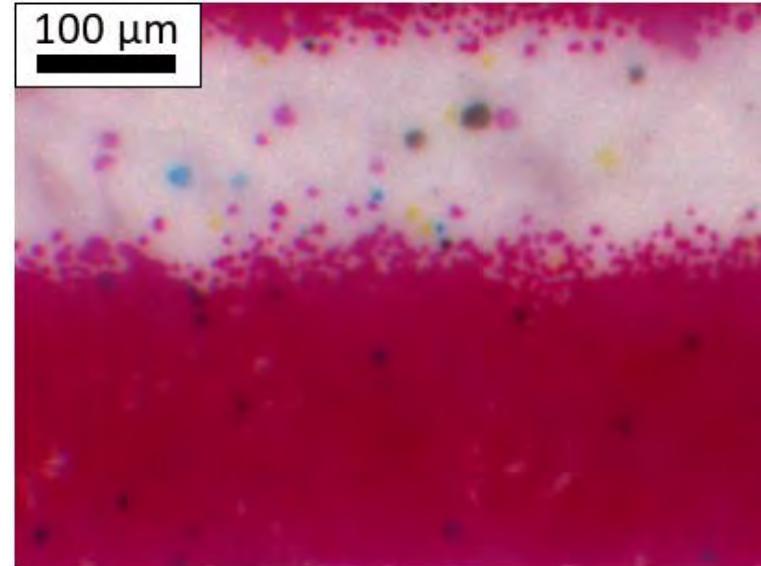
Dot gain



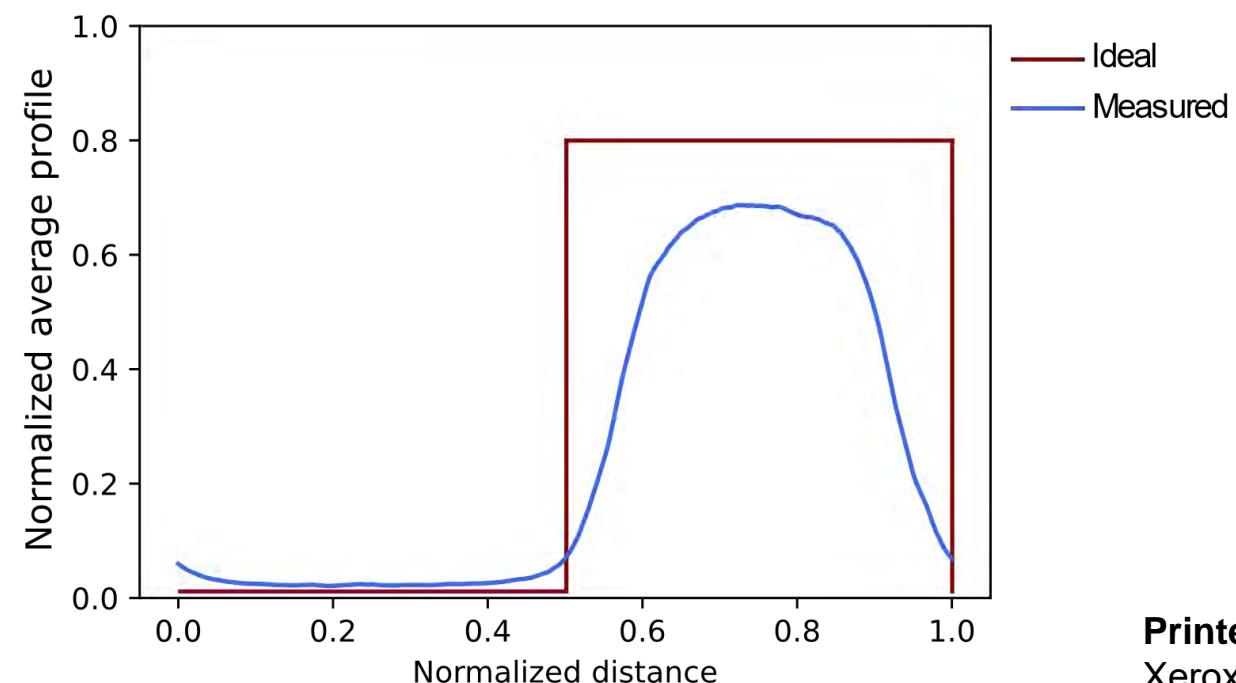
Halftone



Printing



Microscope image of a halftone period



Printer

Xerox Versant 180 (Electrophotography)

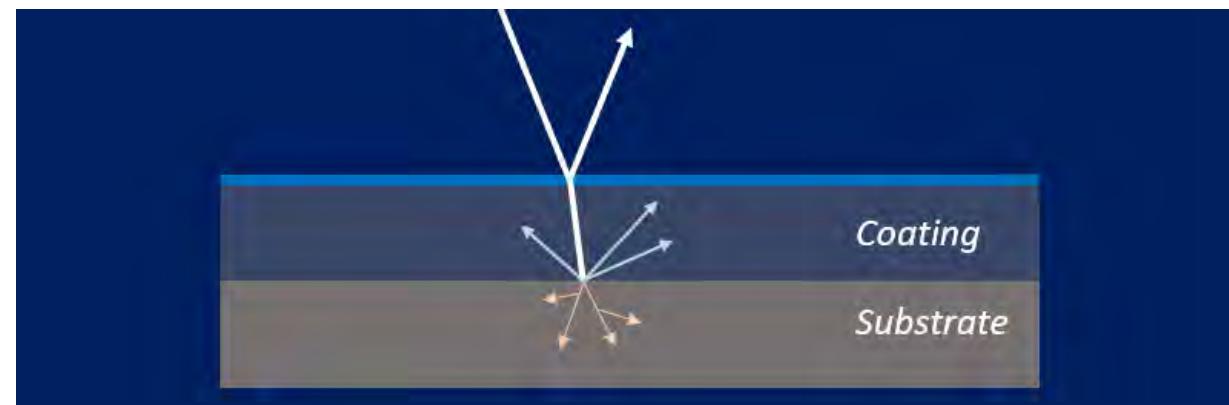
Coating

Varnish



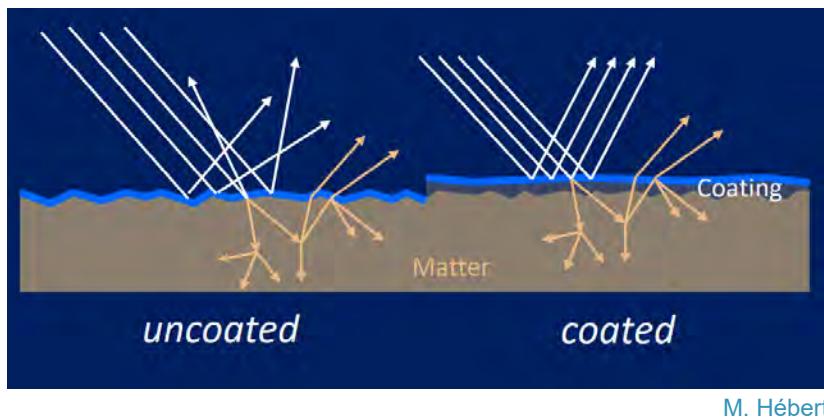
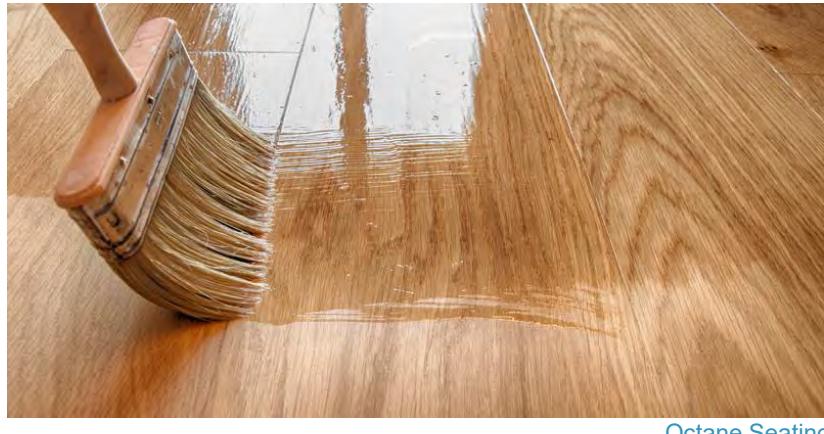
i.pinimg.com

Lamination

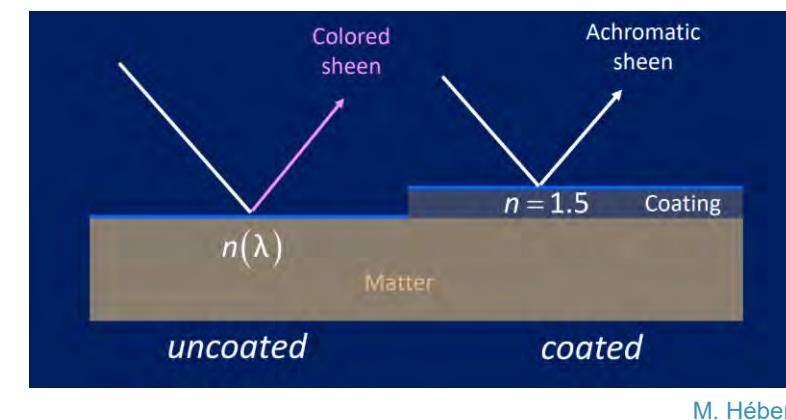
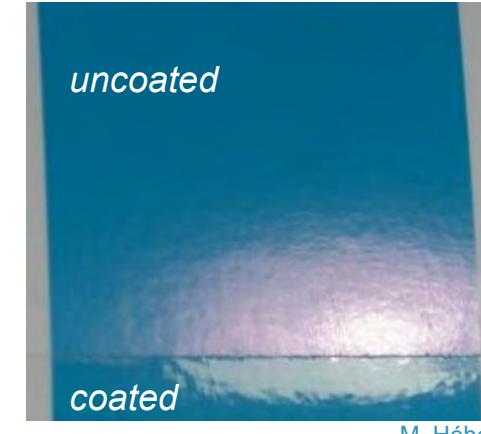


Optical effects of coating

Surface topology



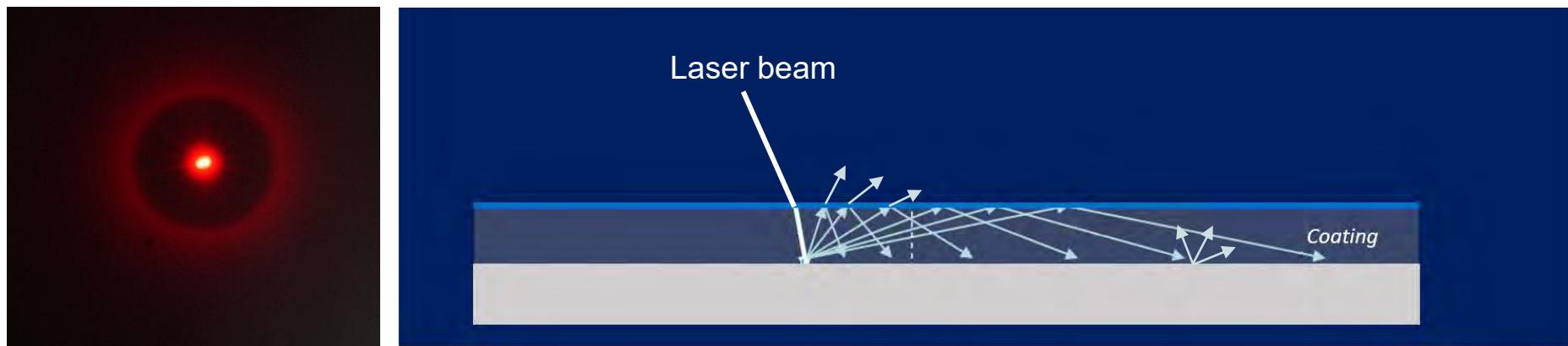
Bronzing effect



Lionel Simonot *et al.*, 'Halo and subsurface scattering in the transparent coating on top of a diffusing material', *Journal of the Optical Society of America A*, vol. 35, no. 7, pp. 1192–12, Jun. 2018

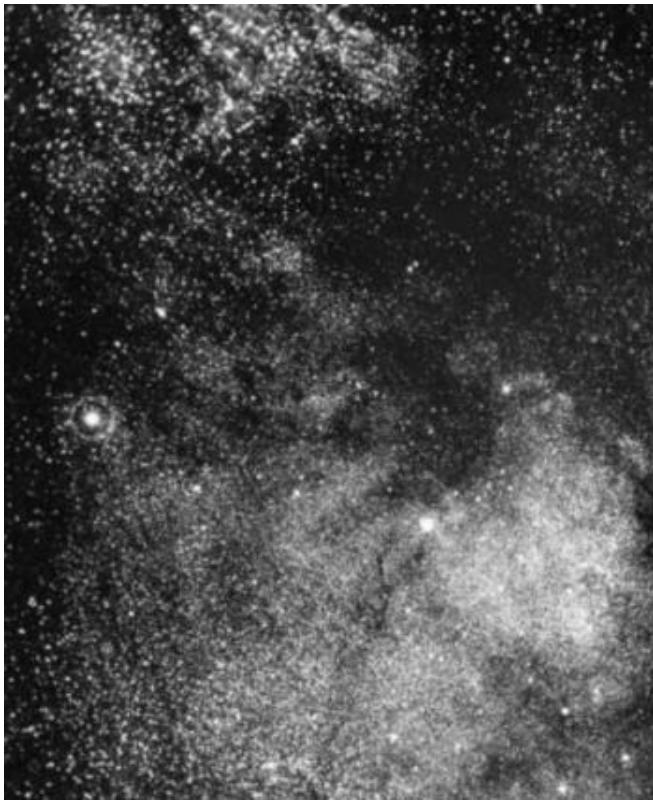
Mathieu Hébert *et al.*, 'Exploring the bronzing effect at the surface of ink layers', presented at the Proceedings of SPIE - The International Society for Optical Engineering, 2015.

Optical effects of coating

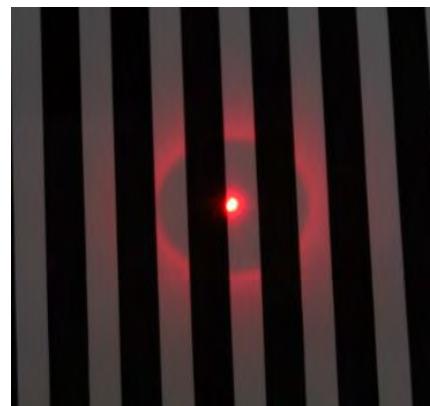


Lionel Simonot et al., 'Halo and subsurface scattering in the transparent coating on top of a diffusing material', *Journal of the Optical Society of America A*, vol. 35, no. 7, pp. 1192–12, Jun. 2018
Mathieu Hébert et al., 'Why a clear coating modifies halftone color prints', presented at the Material Appearance, IS&T Electronic Imaging Symposium, Jan. 2021.

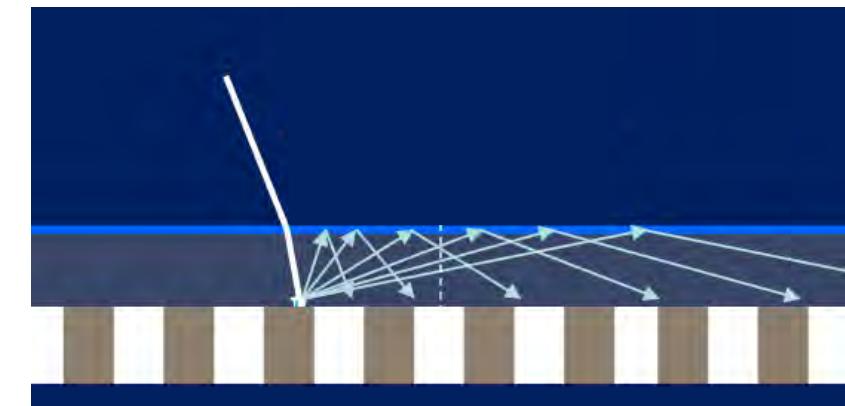
Optical effects of coating



STAR CLOUD IN THE MILKY WAY.
Near Messier II. 1892, June 29.
Taken By Prof. E.E. Barnard at the Lick Observatory,
Exposure 3 hours 25 minutes
Collotype



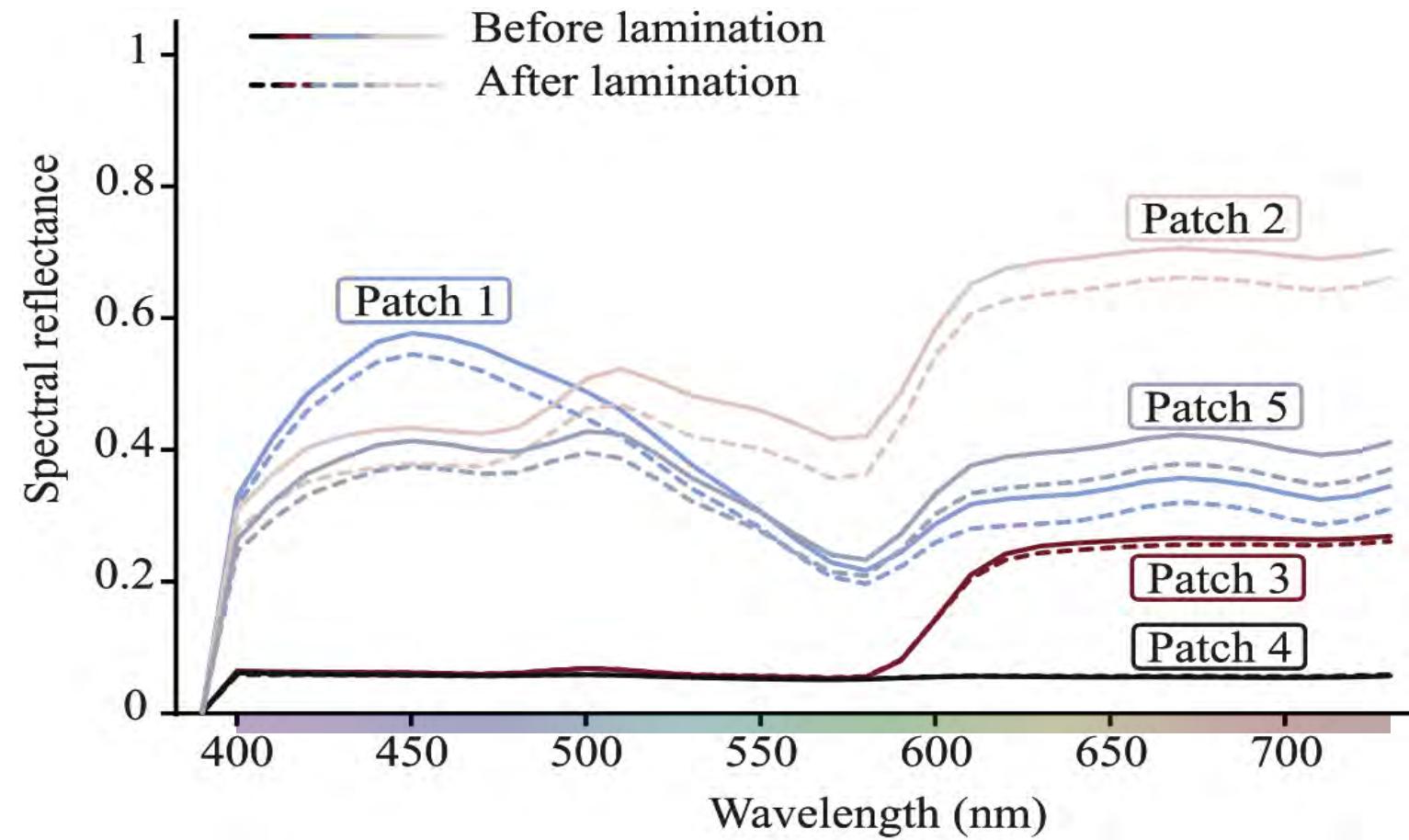
Darkening effect
on halftones



Halo effect inside photographs explained by A. Cornu

Cornu, A. Sur le halo des lames épaisses, ou halo photographique, et les moyens de le faire disparaître. J. Phys. Theor. Appl. 9, 270–277 (1890).

Optical effects of coating

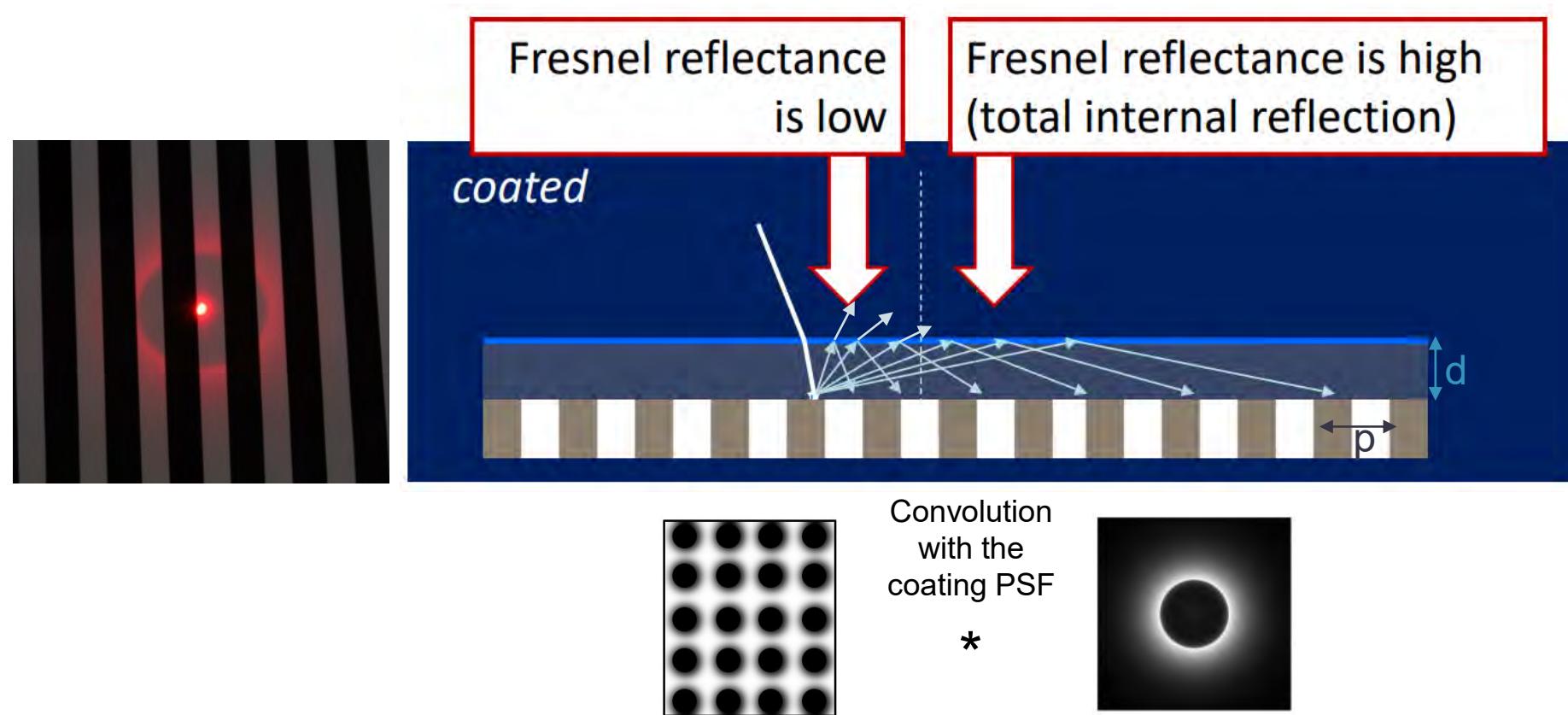


Microscope images of halftones
with a lamination layer

Material

Spectrophotometer: CM 2600d from Konica Minolta, 8 mm aperture,
with geometry di:8°, with a UV filter avoiding fluorescence

Optical effects of coating

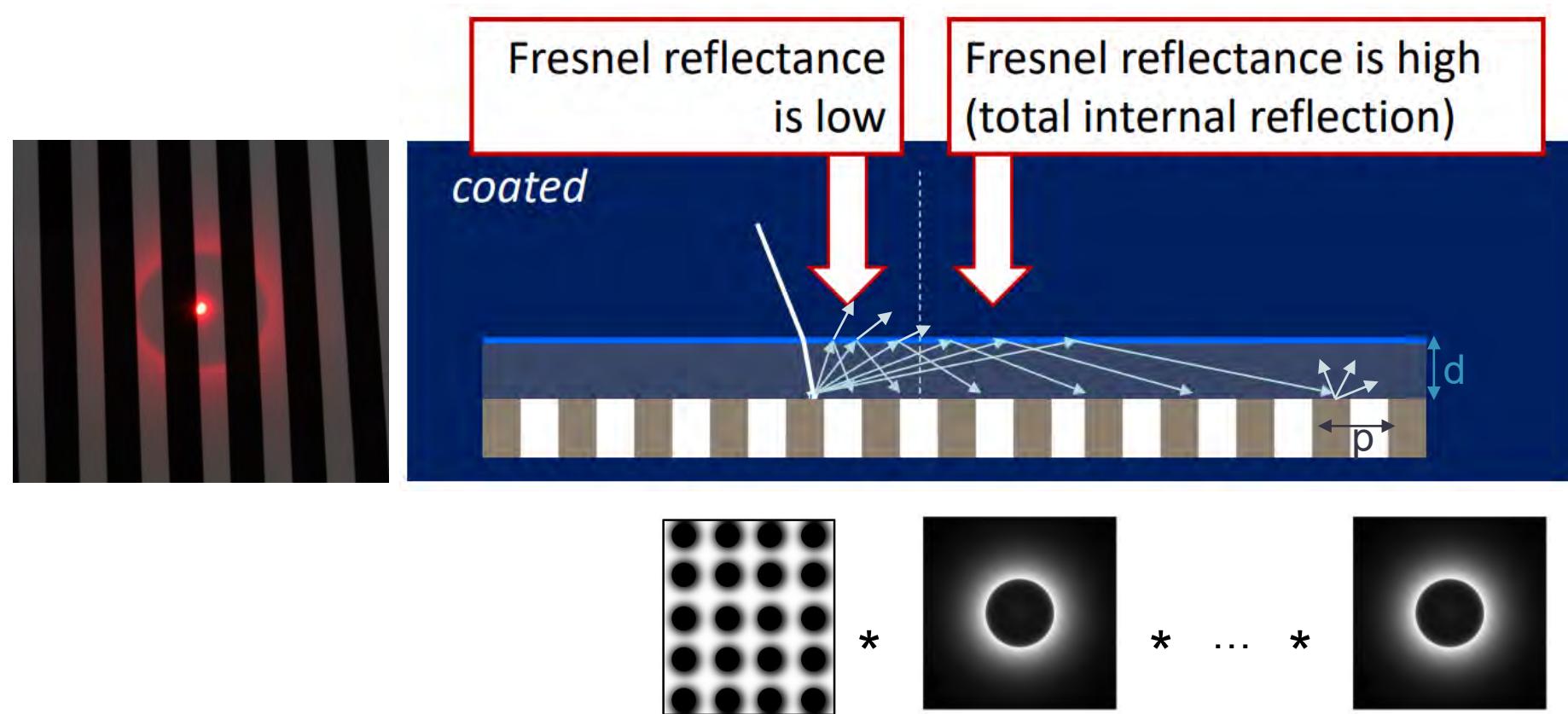


Lionel Simonot et al., 'Halo and subsurface scattering in the transparent coating on top of a diffusing material', *Journal of the Optical Society of America A*, vol. 35, no. 7, pp. 1192–12, Jun. 2018

Mathieu Hébert et al., 'Why a clear coating modifies halftone color prints', presented at the Material Appearance, IS&T Electronic Imaging Symposium, Jan. 2021.

Daillez, F., Hébert, M., Blayo, A., Chagas, L. & Fournel, T. Impact of a Transparent Coating on the Reflectance of a Line Halftone Pattern. *Coatings* 11, 1465 (2021).

Optical effects of coating



Lionel Simonot et al., 'Halo and subsurface scattering in the transparent coating on top of a diffusing material', *Journal of the Optical Society of America A*, vol. 35, no. 7, pp. 1192–12, Jun. 2018

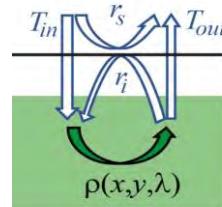
Mathieu Hébert et al., 'Why a clear coating modifies halftone color prints', presented at the Material Appearance, IS&T Electronic Imaging Symposium, Jan. 2021.

Daillez, F., Hébert, M., Blayo, A., Chagas, L. & Fournel, T. Impact of a Transparent Coating on the Reflectance of a Line Halftone Pattern. *Coatings* 11, 1465 (2021).

Optical model

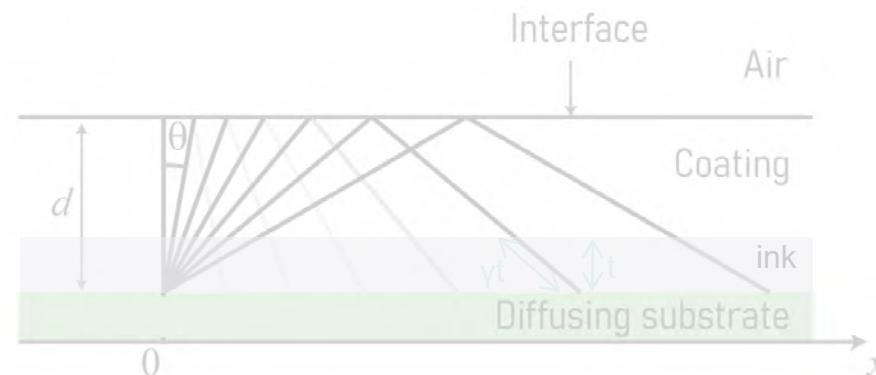
Reflectance model **input** parameters:

- Material physical characteristics: $n, d, \gamma, R_0(\lambda), R_{NC}(x,y,\lambda)$
- Measurement geometry: $r_s, r_i, T_{in}, T_{out}$



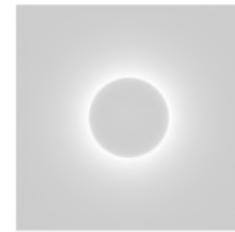
$$\rho(x, y) = \frac{R_{NC}(x, y) - r_s}{T_{in}T_{out} + r_i[R_{NC}(x, y, \lambda) - r_s]}$$

$$t(x, y) = \sqrt{\frac{\rho(x, y)}{\rho_0}}$$

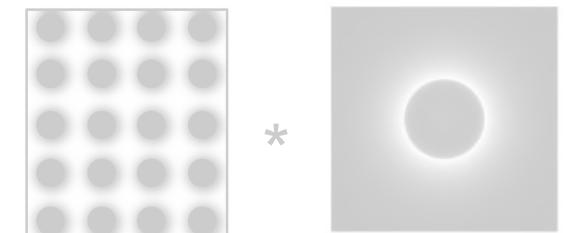


$$M_1(x, y) = T_{in}t^2(x, y)\rho_0$$

$$h(x, y) = \frac{4d^2R_{n_1,n_0}\left(\arctan\left[\frac{\sqrt{x^2 + y^2}}{(2d)}\right]\right)}{\pi(x^2 + y^2 + 4d^2)^2}$$



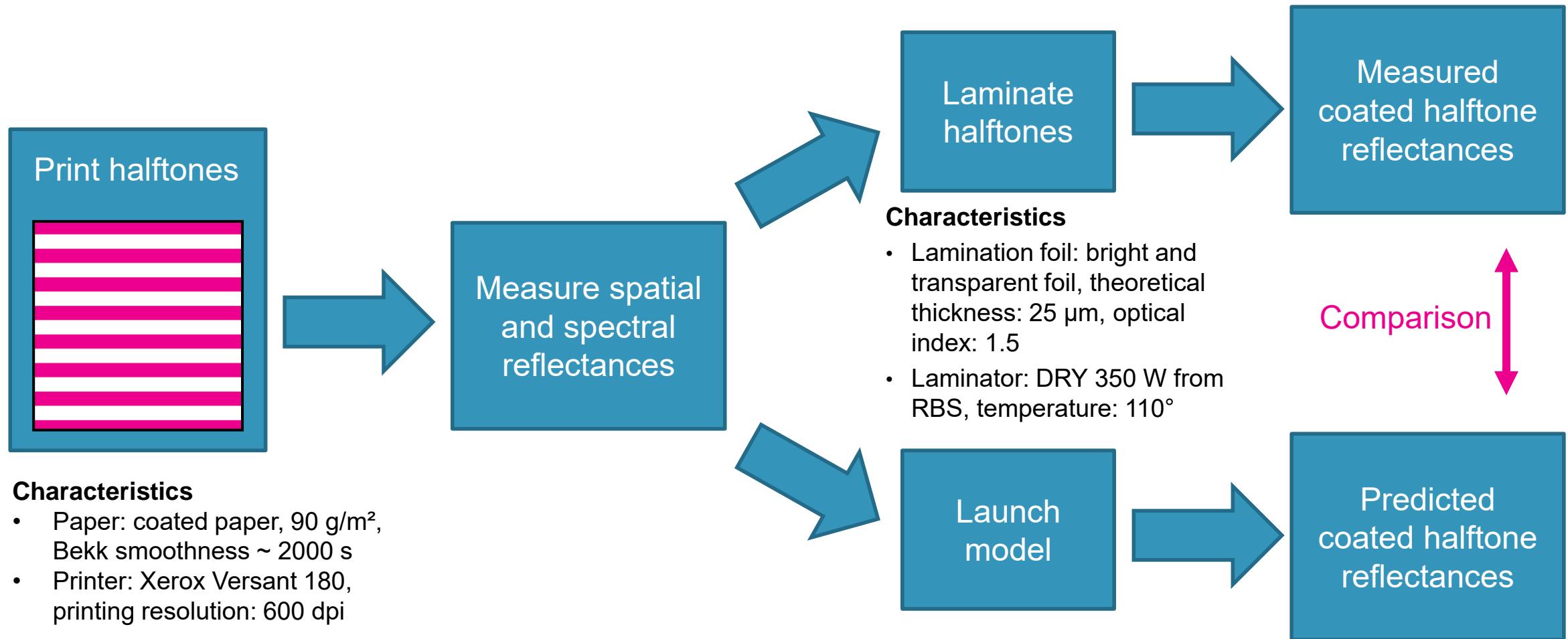
$$M_k(x, y) = \rho_0 t^{\gamma+1}(x, y)[t^{\gamma-1} M_{k-1} * h](x, y)$$



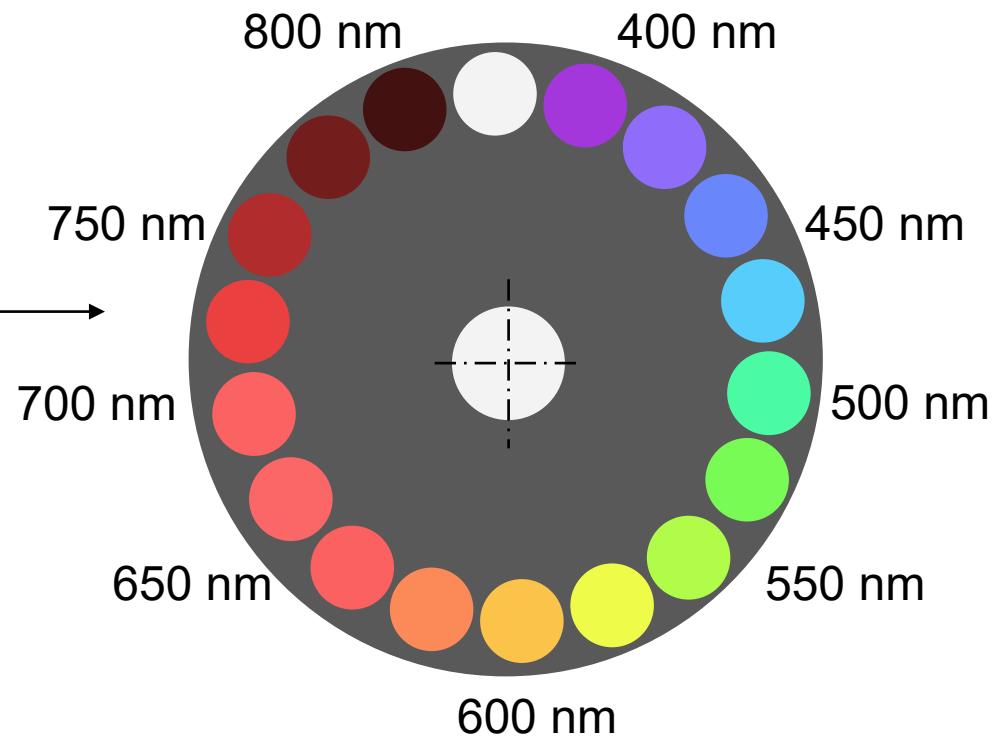
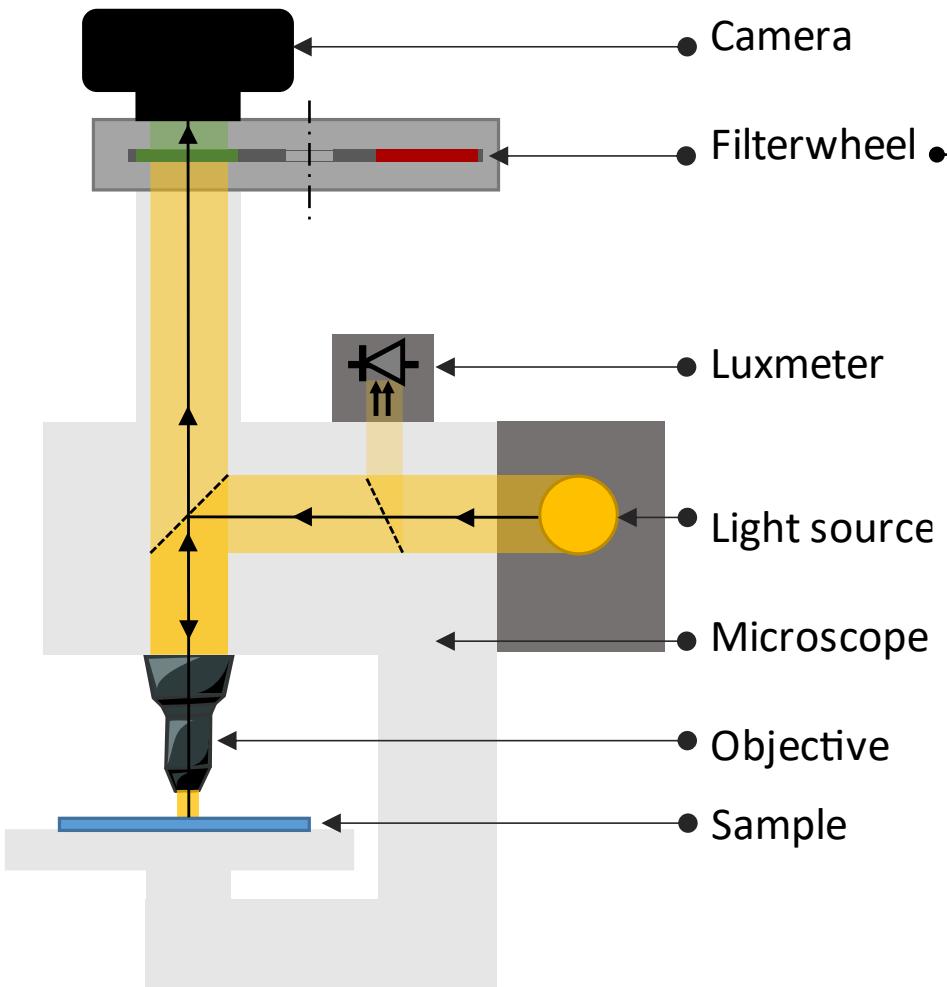
Output: reflectance of the coated halftone:

$$R(x, y, \lambda) = r_s + T_{out} \sum_{k=1}^{10} M_k(x, y, \lambda)$$

Experiment



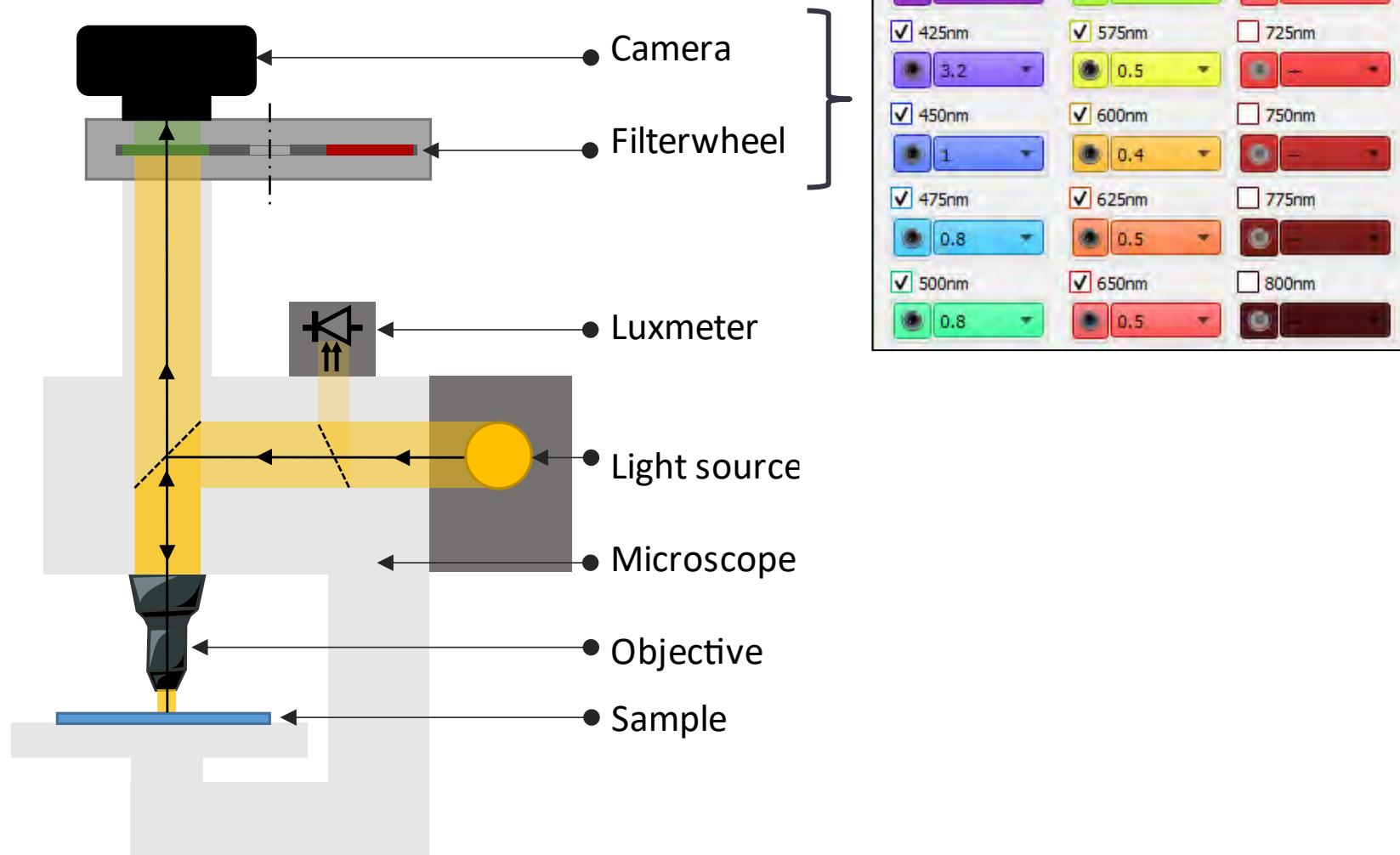
Multispectral microscope



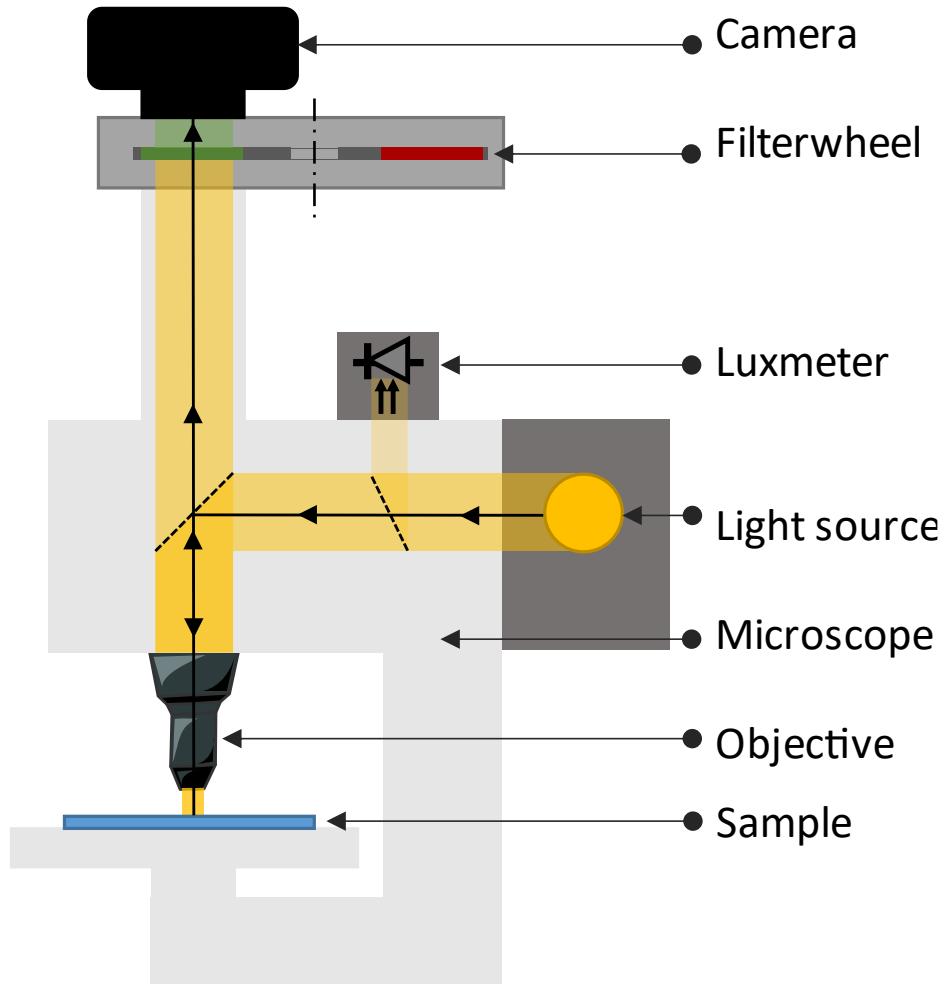
Material

- Microscope: Zeiss Axio Imager M1m, polarizer and analyzer in crossed configuration, objective: EC Epiplan Neofluar 5×/0.13 HD DIC, light source: Zeiss HAL 100 tungsten-halogen lamp set at 3200 K,
- Photodiode: Yocto-Light-V3 LIGHTMK3 from Yoctopuce,
- Camera: Canon 1200D with a RGGB CMOS sensor. ISO at 800. Sensor: 14-bit encoding, resolution of 3516×5344 pixels,
- Filterwheel: 17 filters (Hard Coated OD 4.0 25nm Bandpass Filters from Edmund Optics), 13 are used in the range [400, 700 nm].

Multispectral microscope



Multispectral microscope



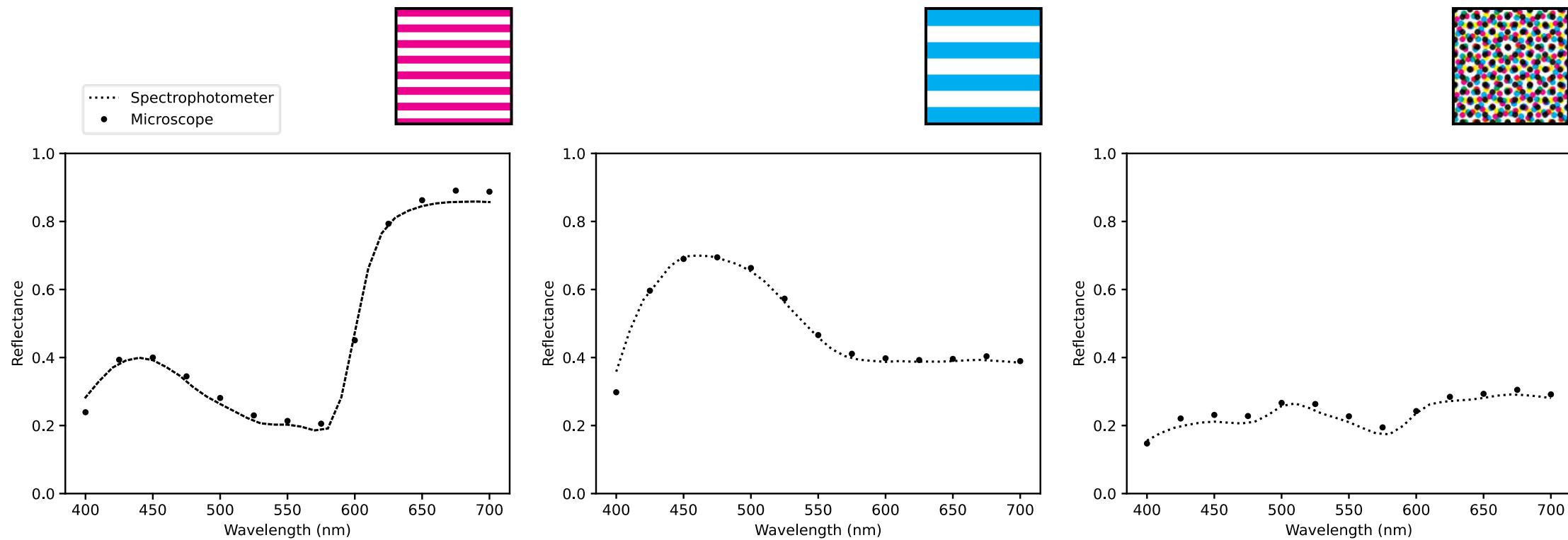
White calibration

$$R(x, y, \lambda) = \frac{V - V_k}{TeQ}$$

where,

- $R(x, y, \lambda)$ is the reflectance of the sample at pixel (x,y) for wavelength λ of the filter,
- V is the pixel value,
- T is the exposure time,
- e is the irradiance of the light source,
- V_k is a constant equal to the pixel value in the dark,
- Q is the calibration value measured on a white calibration patch

Agreement microscale/macroscale



Good agreement over 23 samples

Material

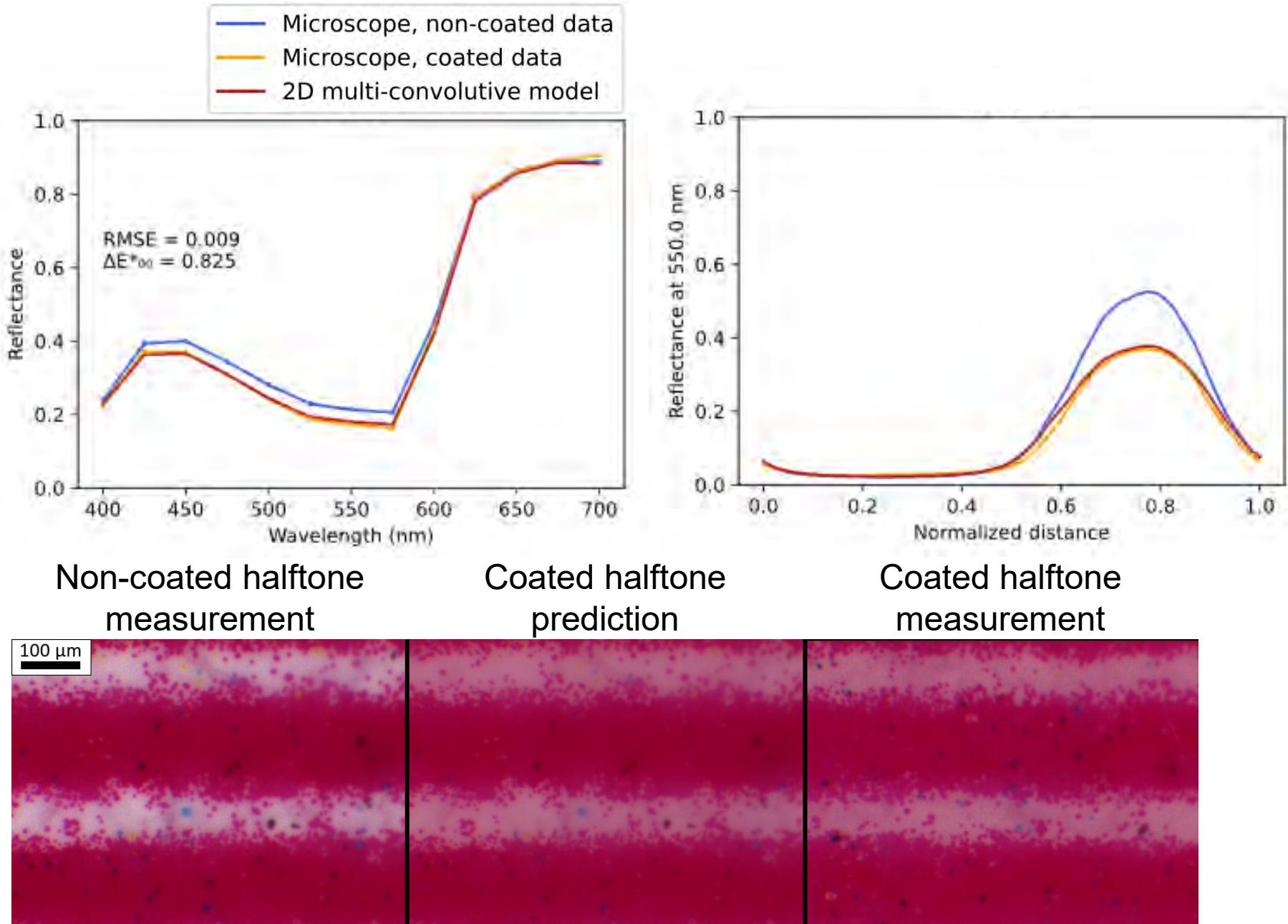
Spectrophotometer: CM 2600d from Konica Minolta, 8 mm aperture, with geometry di:8°, with a UV filter avoiding fluorescence

Results

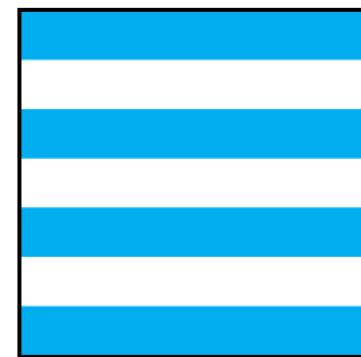
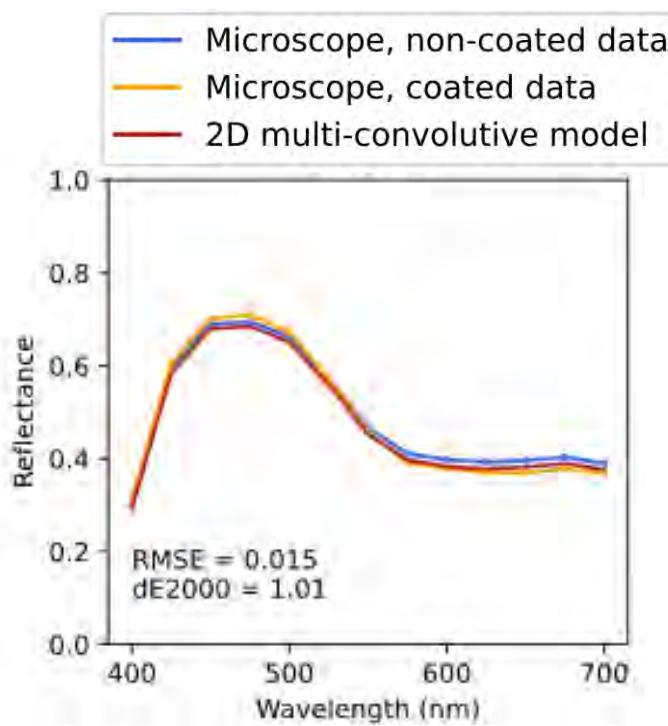


Magenta
halftone

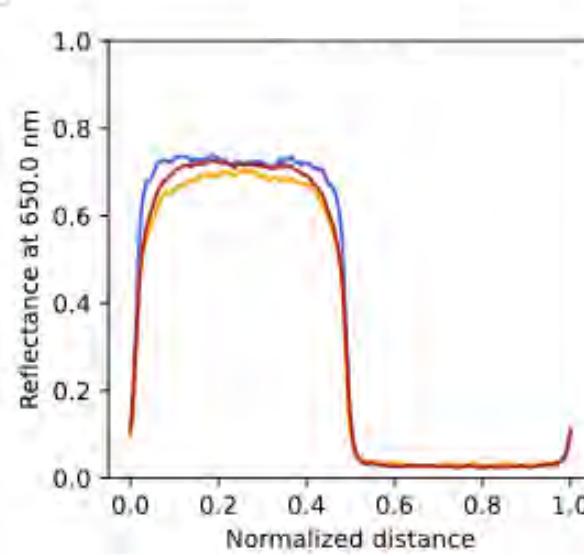
sRGB
images



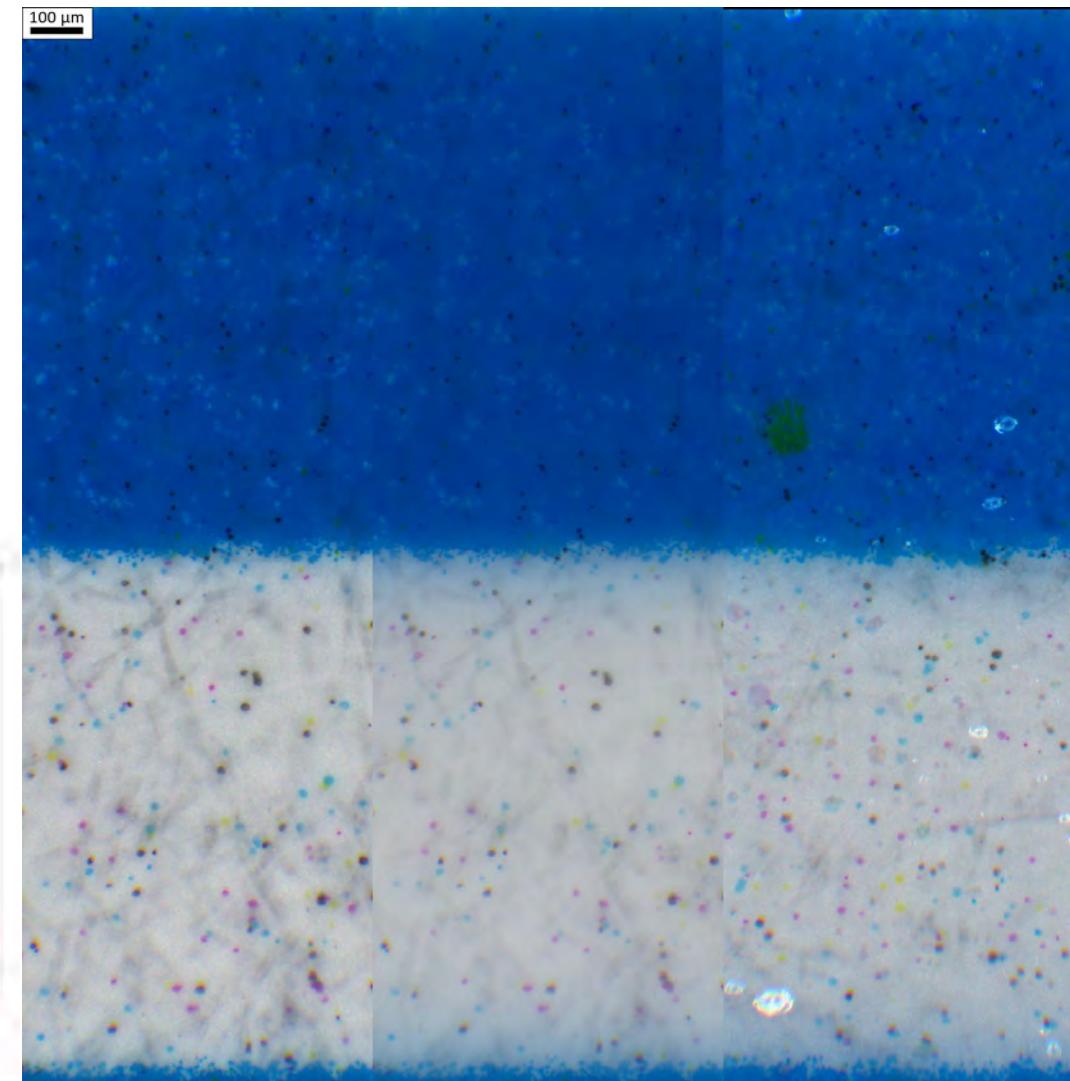
Results



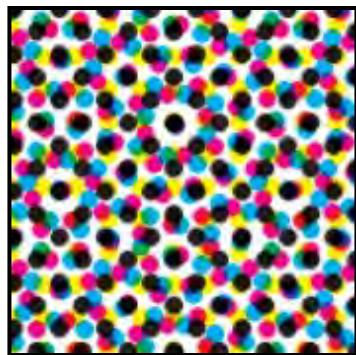
Cyan halftone



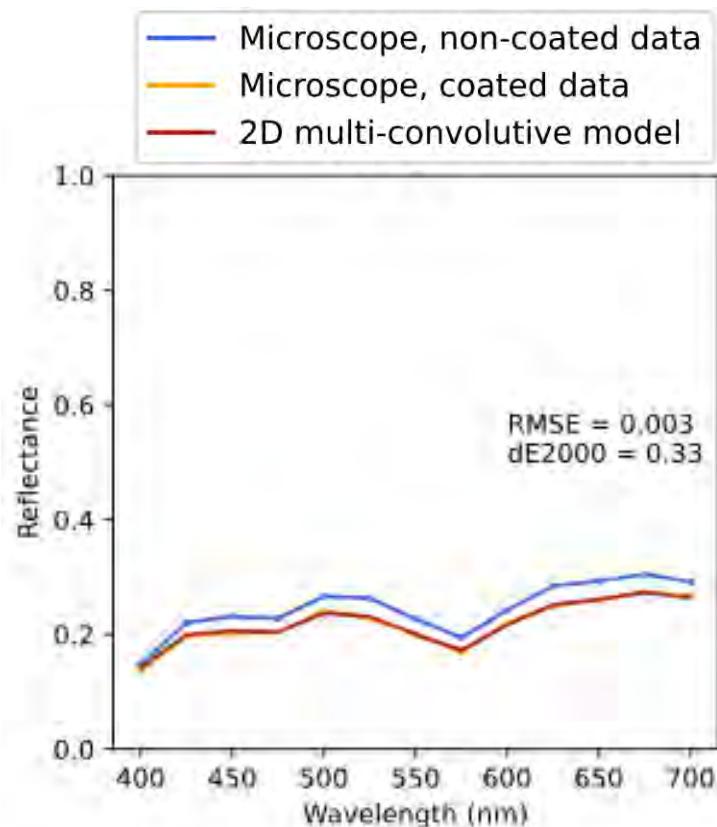
Non-coated halftone measurement	Coated halftone prediction	Coated halftone measurement
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Results



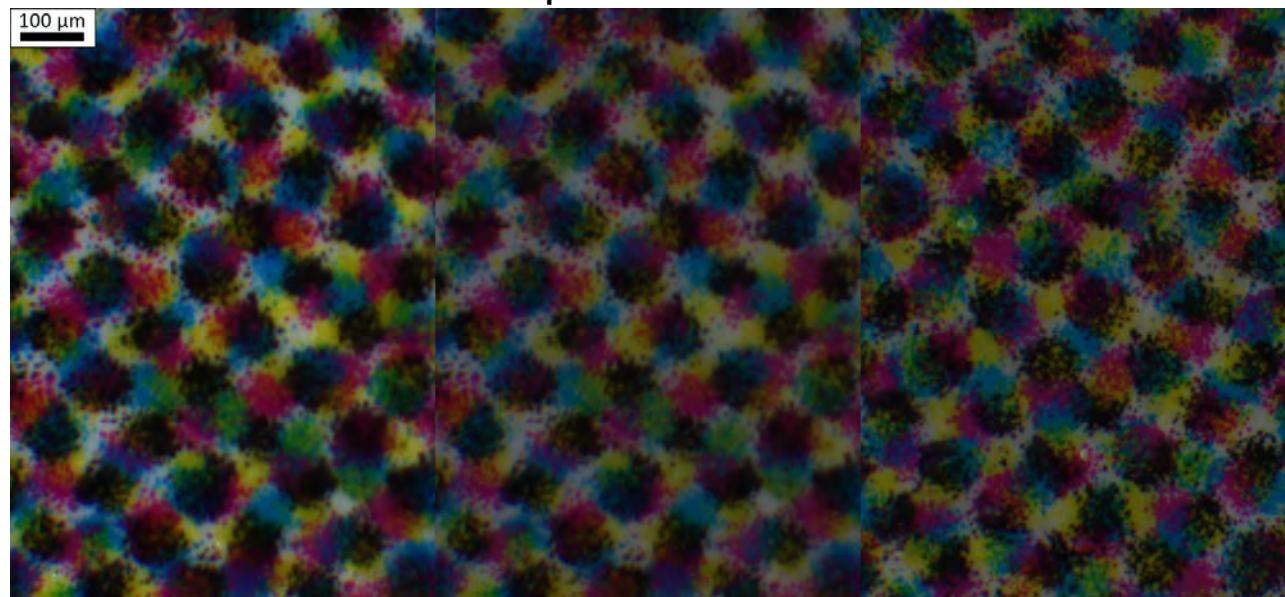
Ordinary multi-colored halftone



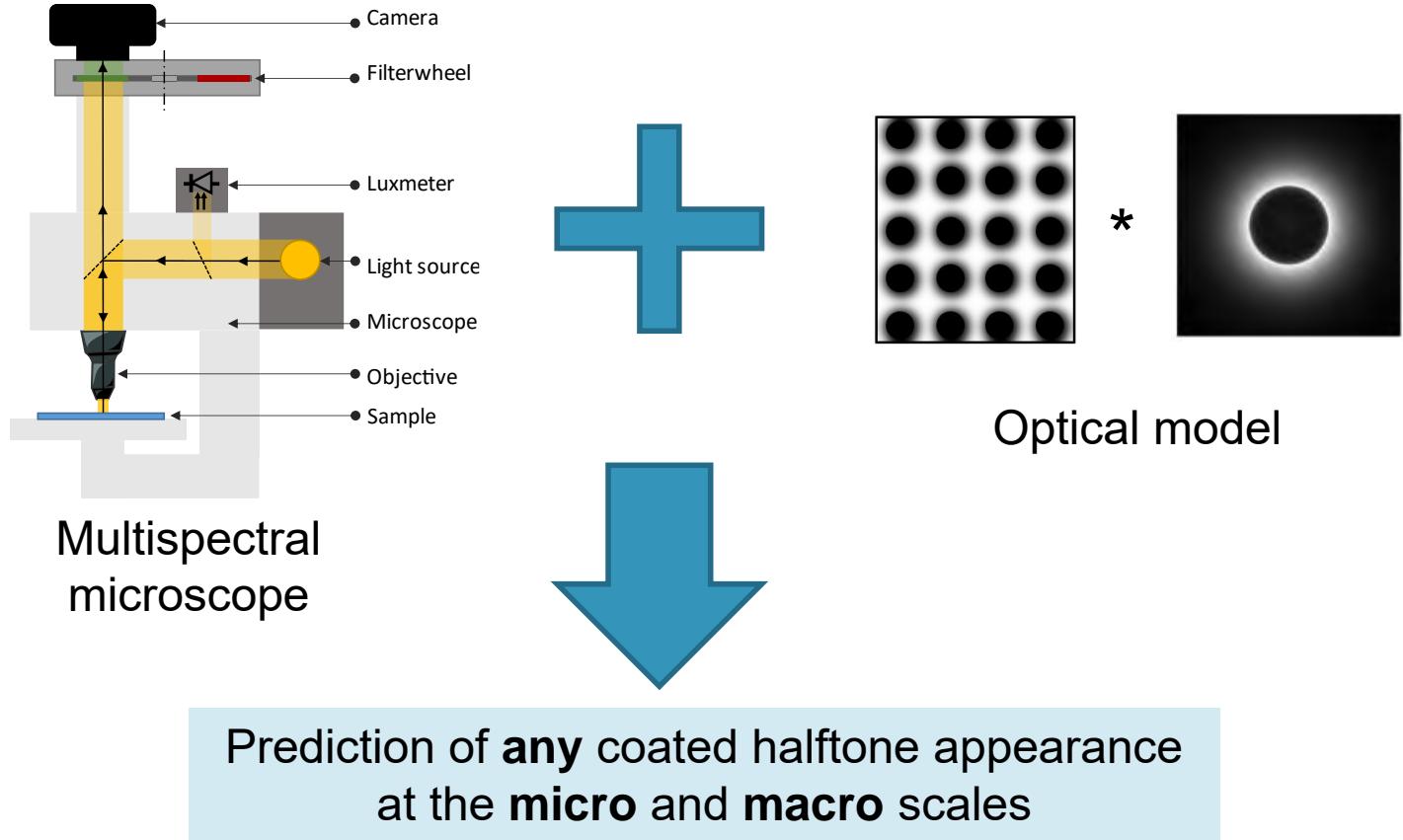
Non-coated
halftone
measurement

Coated halftone
prediction

Coated halftone
measurement



Conclusion



Perspectives

- Color management for printing industry
- Contactless measurements of the thicknesses of thin transparent layers
- Security printing: printed and coated watermarks



Thank you for your attention



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