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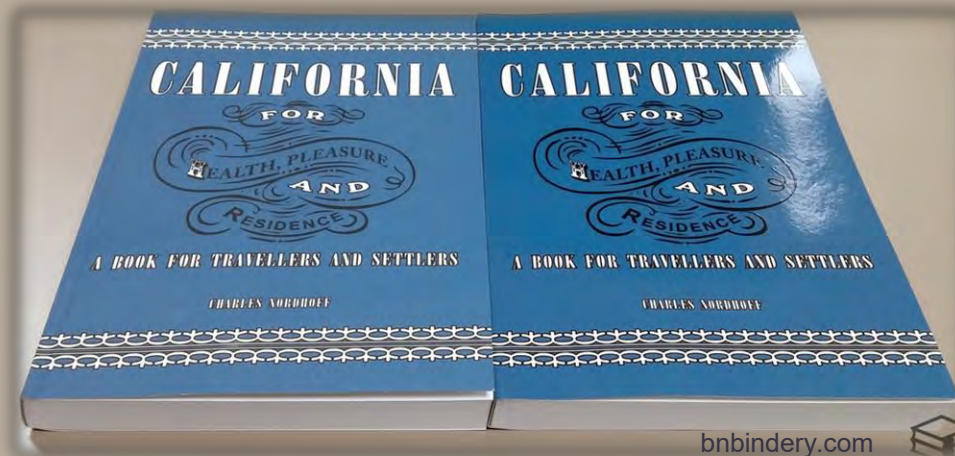
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HOW DOES A CLEAR LAYER MODIFY THE APPEARANCE OF A HALFTONE PRINT?

Fanny Dailliez

fanny.dailliez@lgp2.grenoble-inp.fr

10/06/22

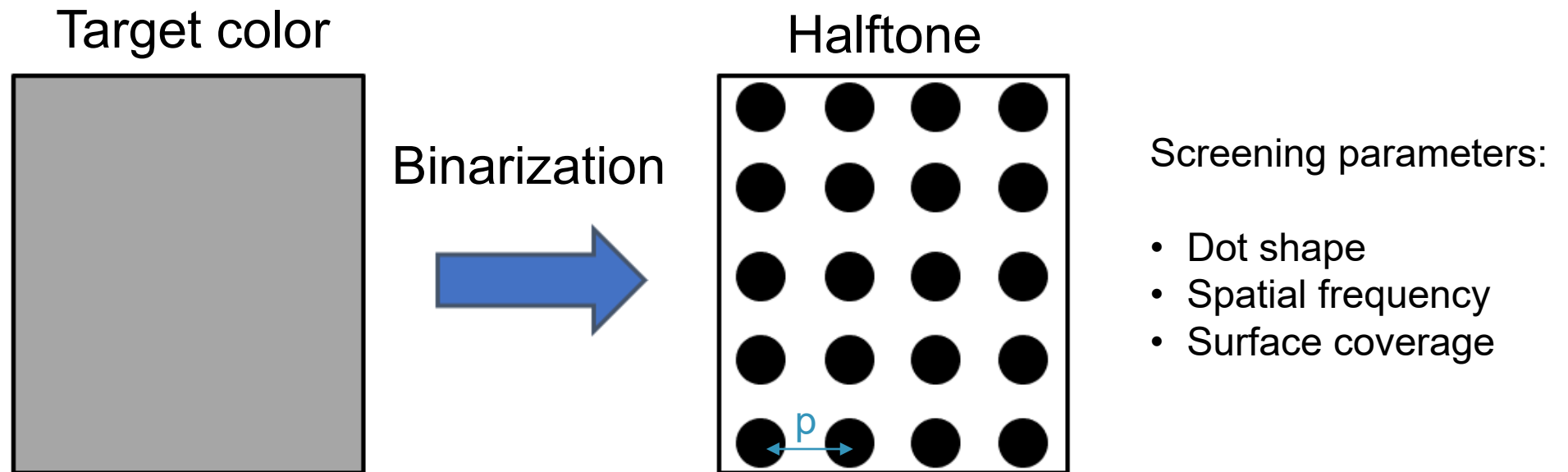


Supervised by:

Anne Blayo, Lionel Chagas,
Thierry Fournel, Mathieu Hébert

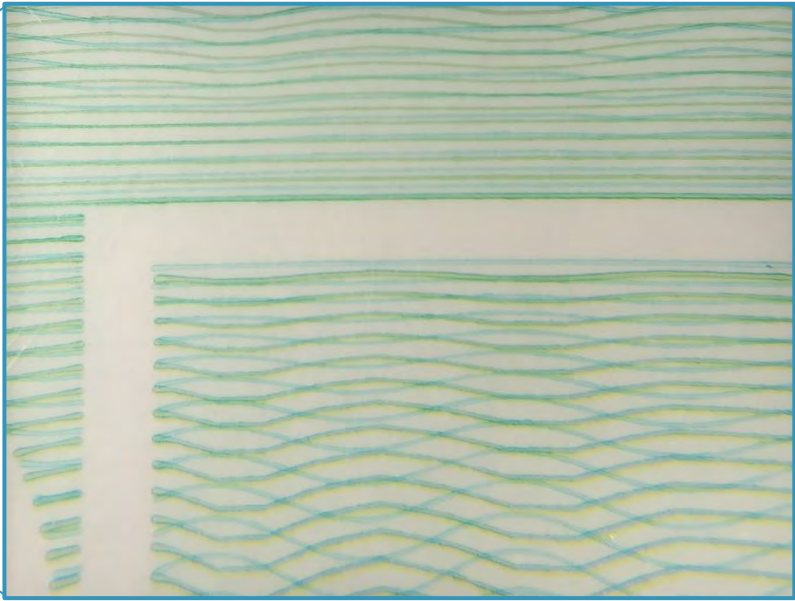


Halftoning





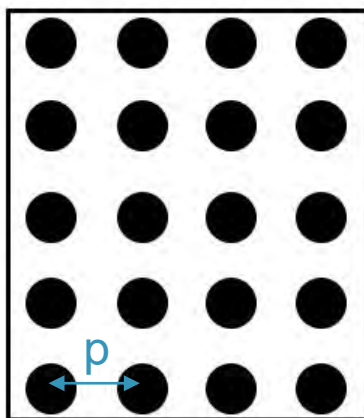
Dot halftone



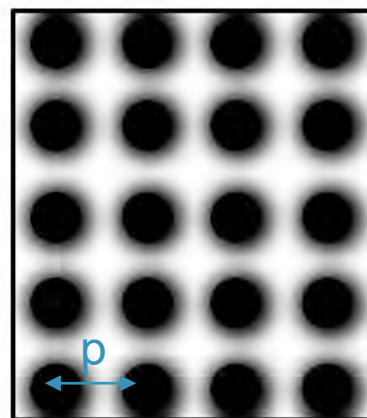
Line halftone

Printing

Halftone



Printing



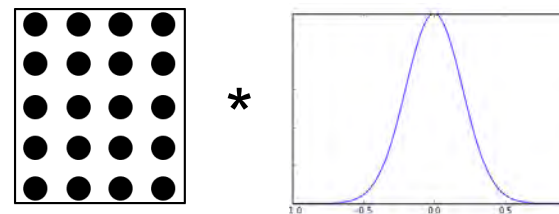
Dot gain

- Mechanical
- Optical

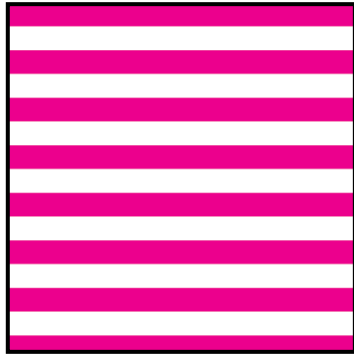
Diffusion of light
inside the substrate



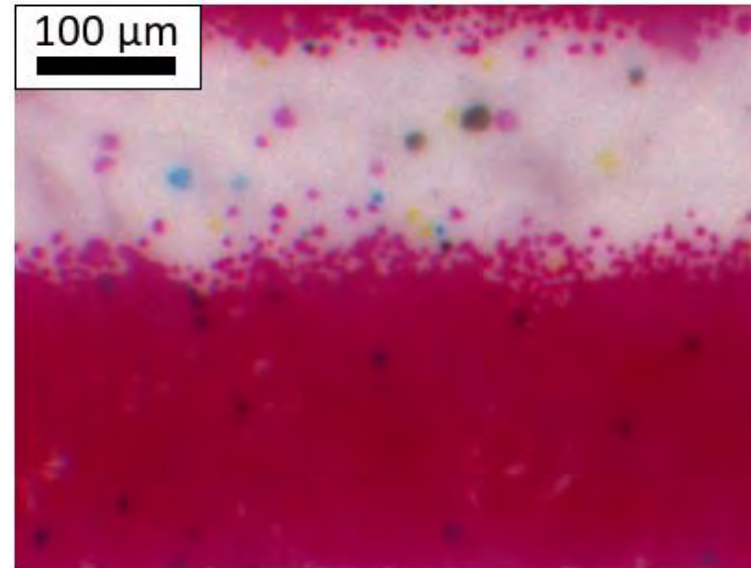
Convolution with the paper
Point Spread Function (PSF)



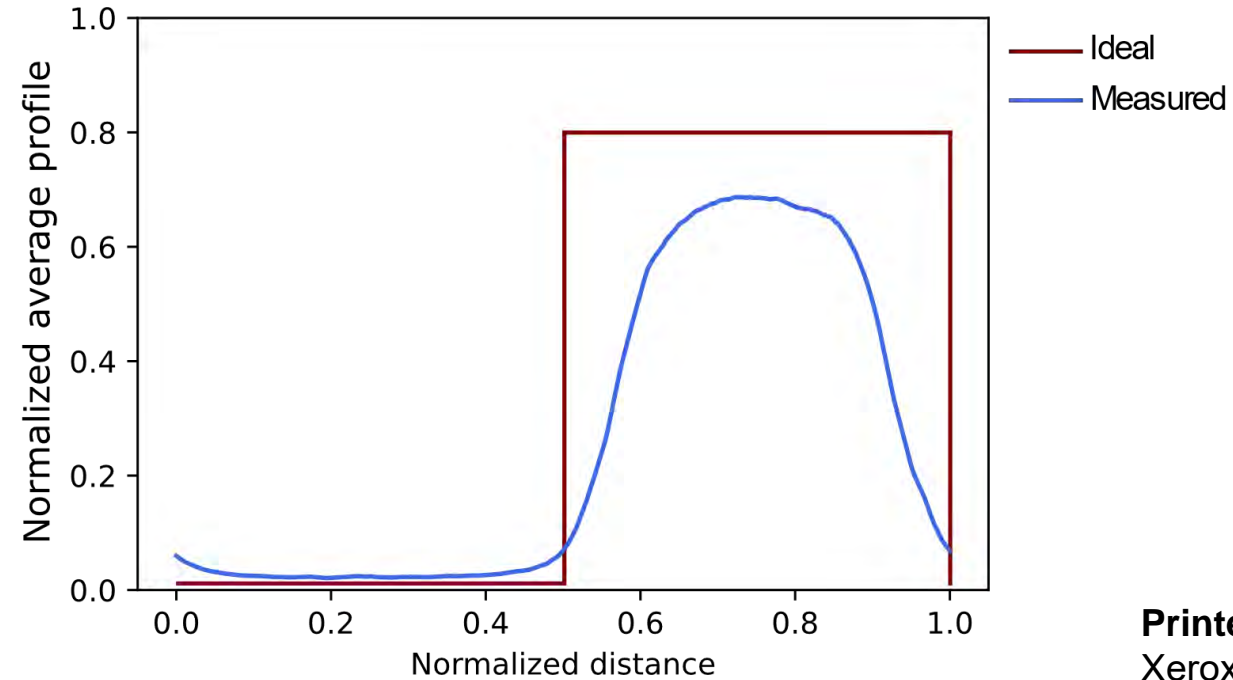
Dot gain



Halftone



Microscope image of a halftone period



Printer
Xerox Versant 180 (Electrophotography)

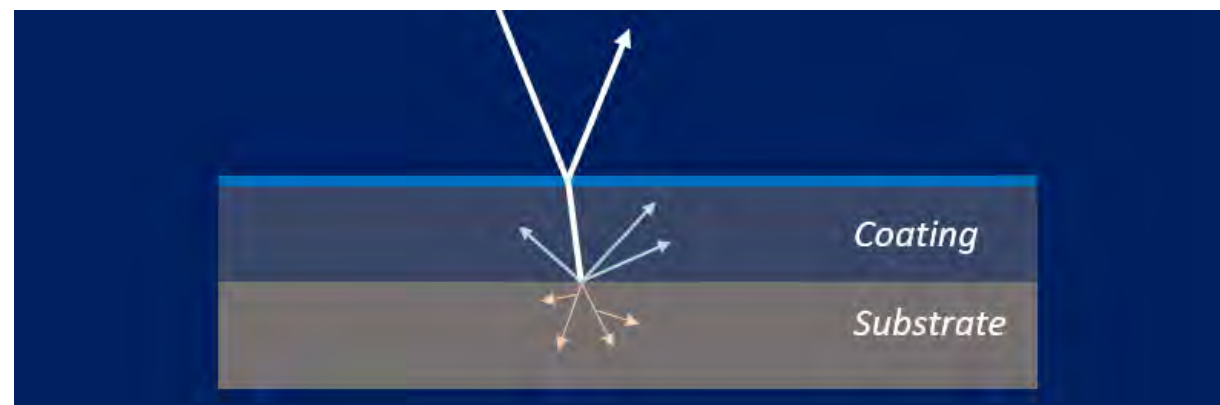
Coating

Varnish



i.pinimg.com

Lamination



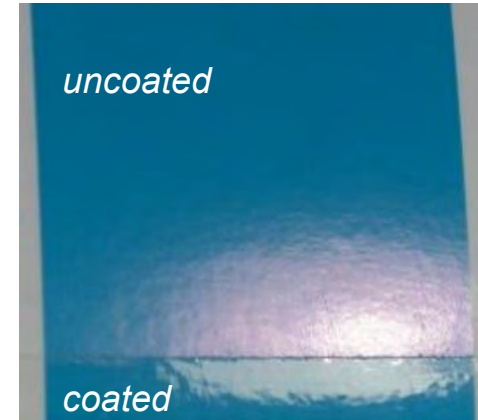
Optical effects of coating

Surface topology

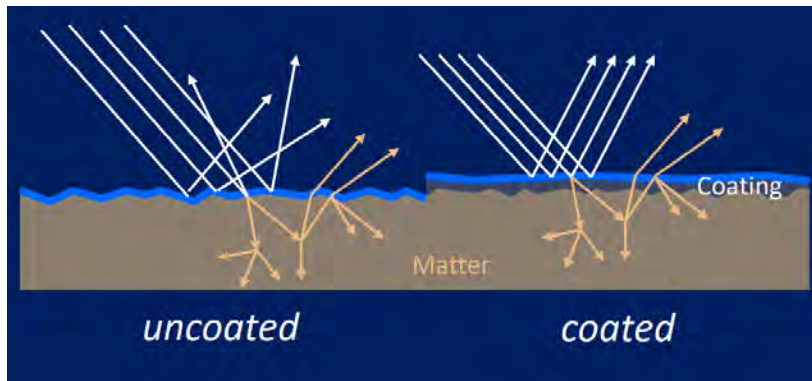


Octane Seating

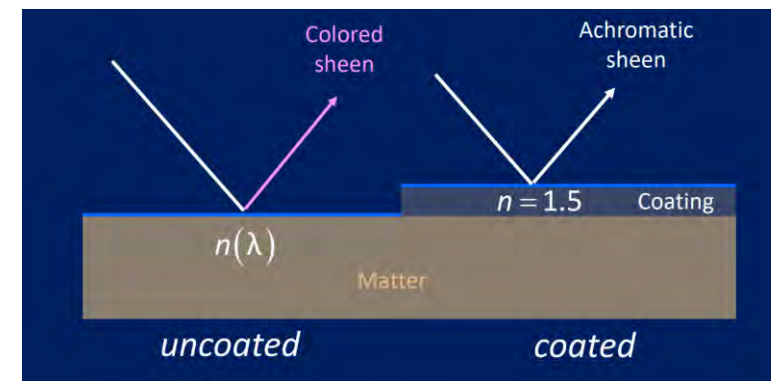
Bronzing effect



M. Hébert



M. Hébert



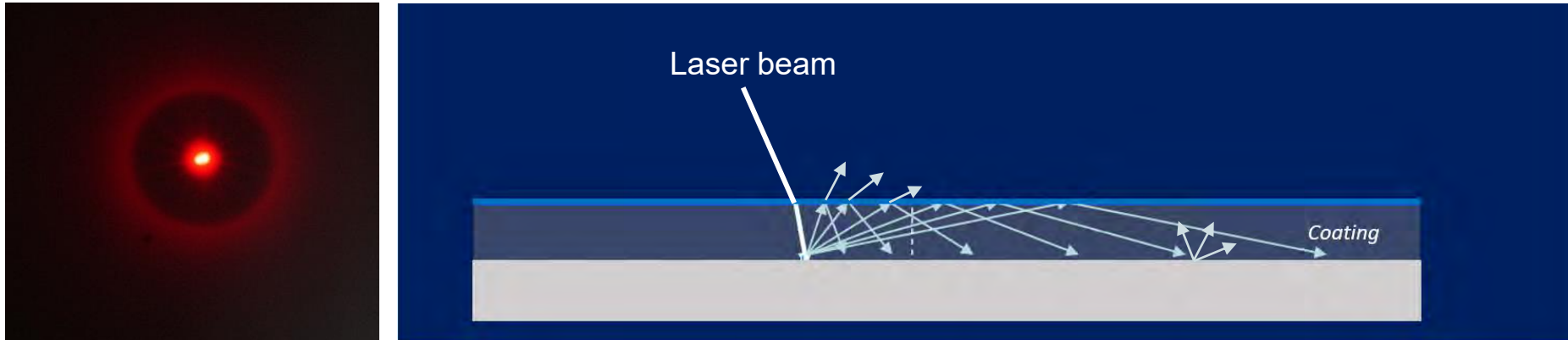
M. Hébert

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

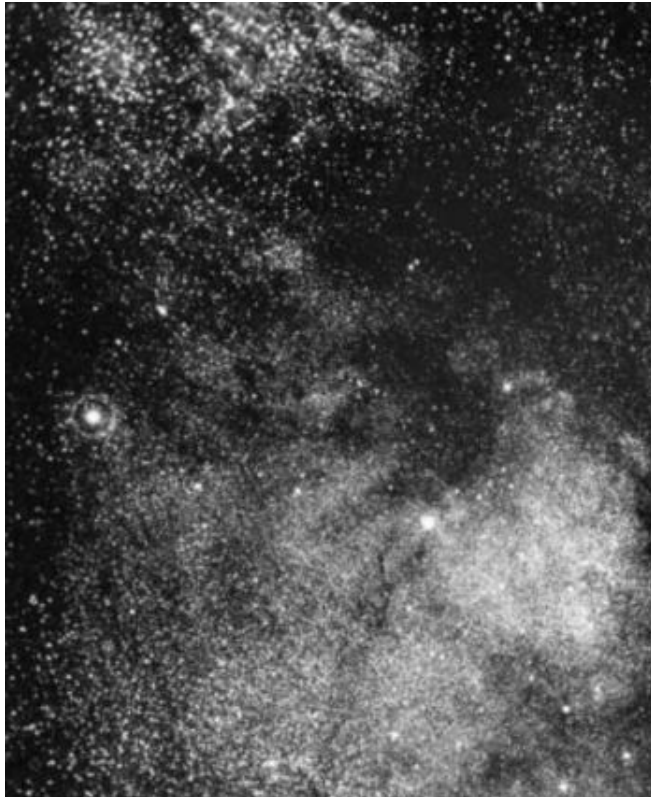
Halo effect



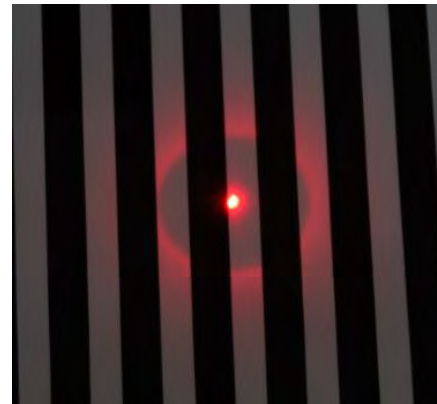
Lionel Simonot *et al.*, 'Halo and subsurface scattering in the transparent coating on top of a diffusing material', *Journal of the Optical Society of America A*, vol. 35, no. 7, pp. 1192–12, Jun. 2018

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

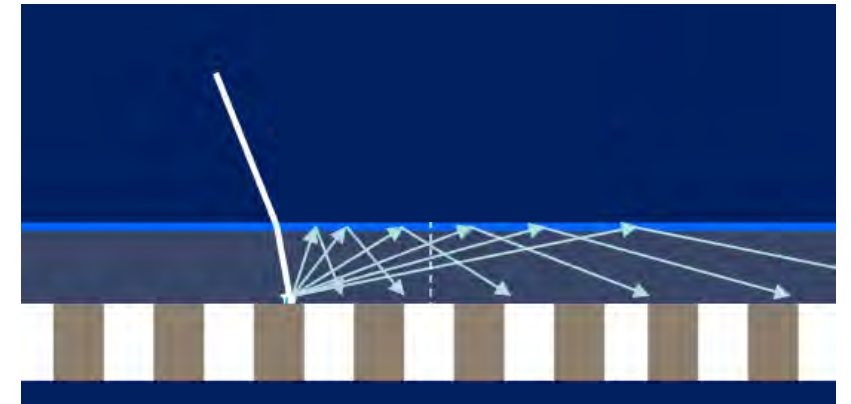
Optical effects of coating



*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



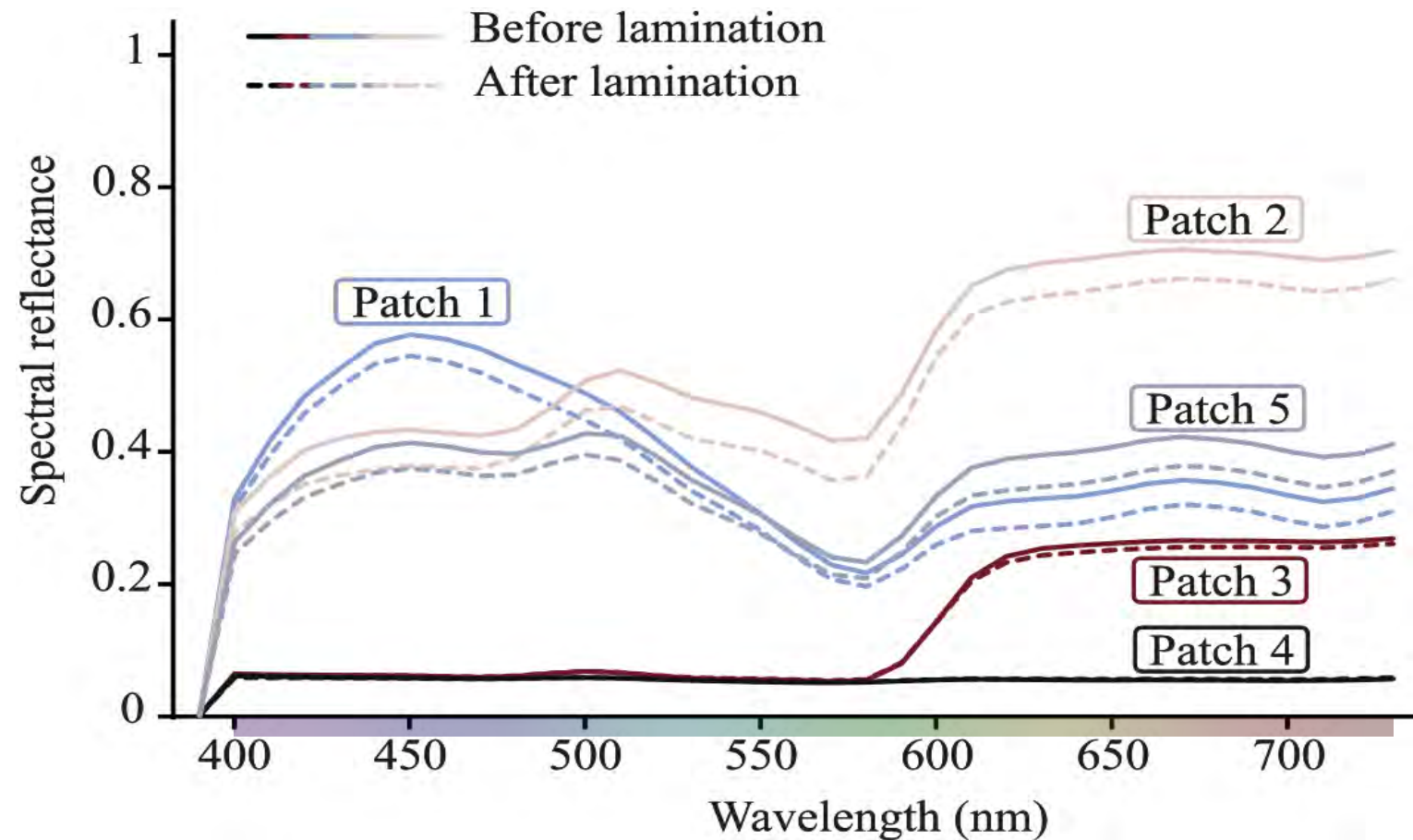
Halo effect inside photographs explained by A. Cornu

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



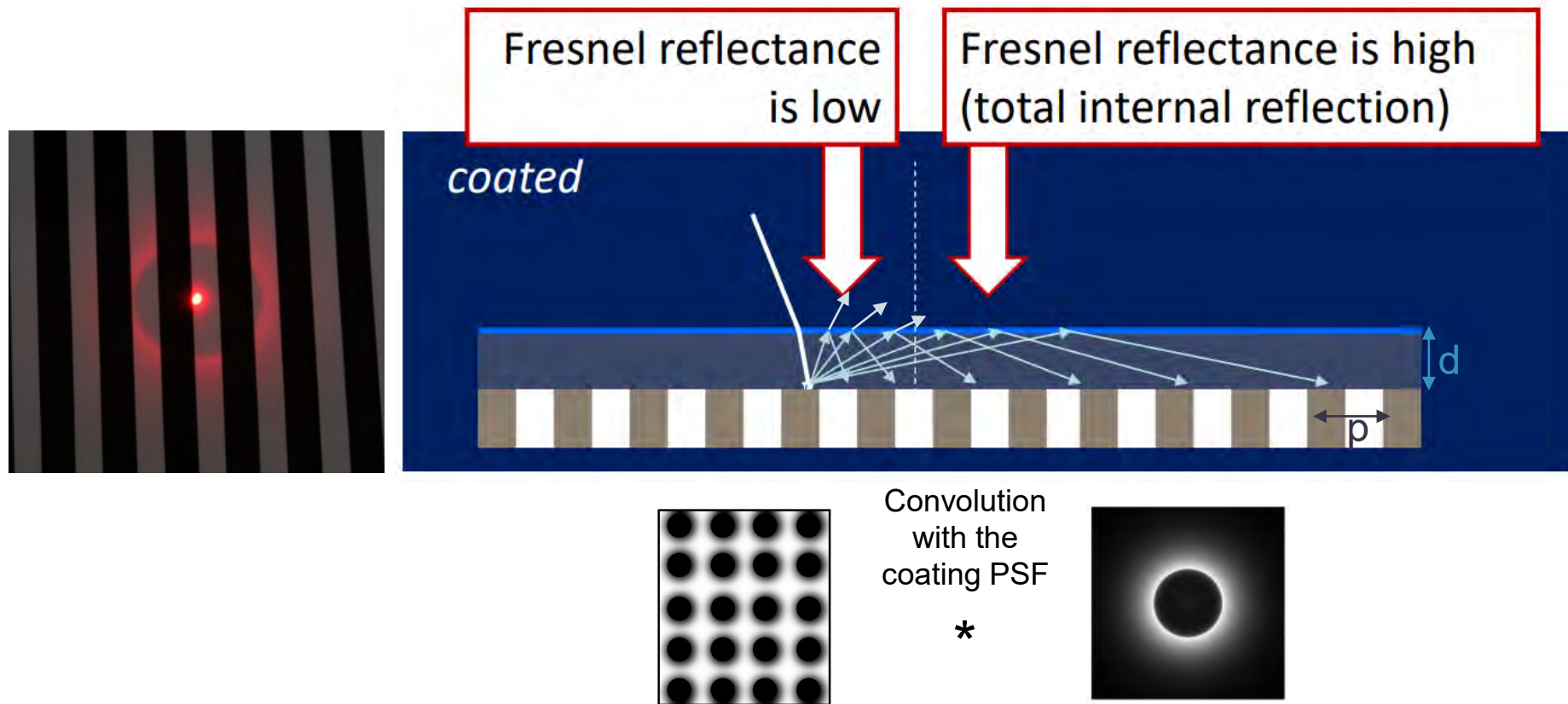
Microscope images of halftones with a lamination layer



Material

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

Optical effects of coating

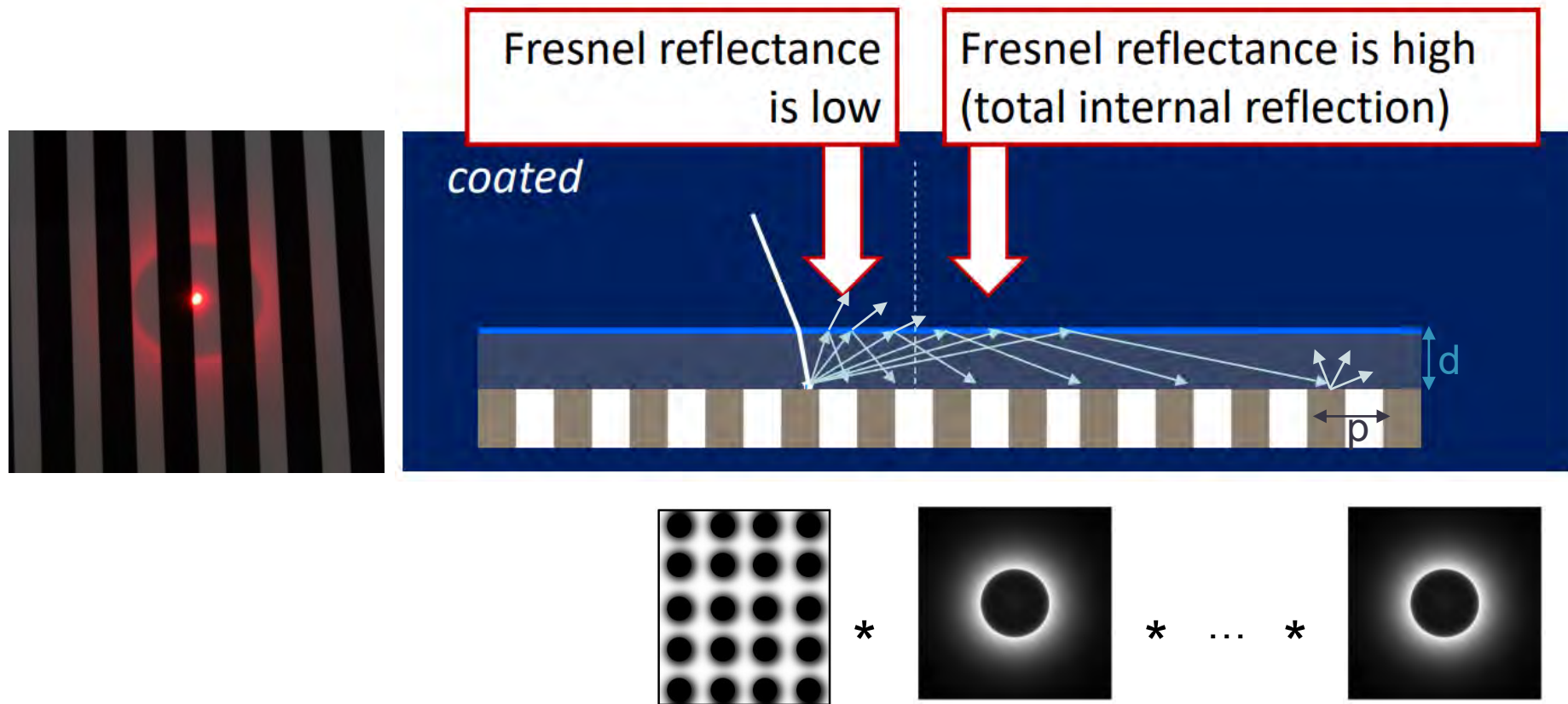


Lionel Simonot *et al.*, 'Halo and subsurface scattering in the transparent coating on top of a diffusing material', *Journal of the Optical Society of America A*, vol. 35, no. 7, pp. 1192–12, Jun. 2018

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Dailliez, 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

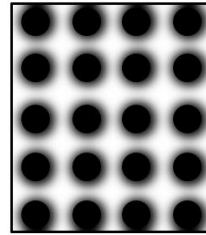
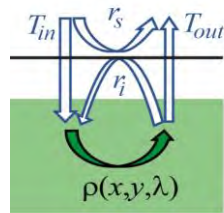
Mathieu Hébert *et al.*, 'Why a clear coating modifies halftone color prints', presented at the Material Appearance, IS&T Electronic Imaging Symposium, Jan. 2021.

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

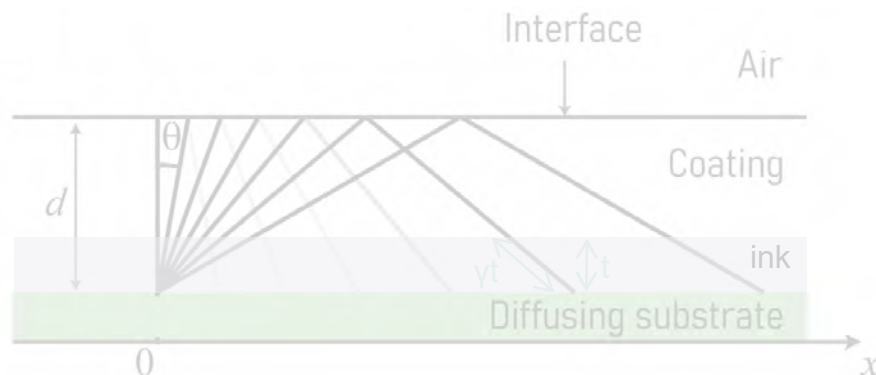
Reflectance model **input** parameters:

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



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

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

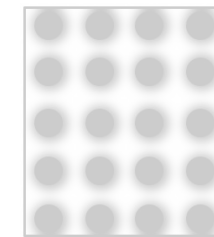


$$M_1(x, y) = T_{in}t^2(x, y)\rho_0$$

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



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

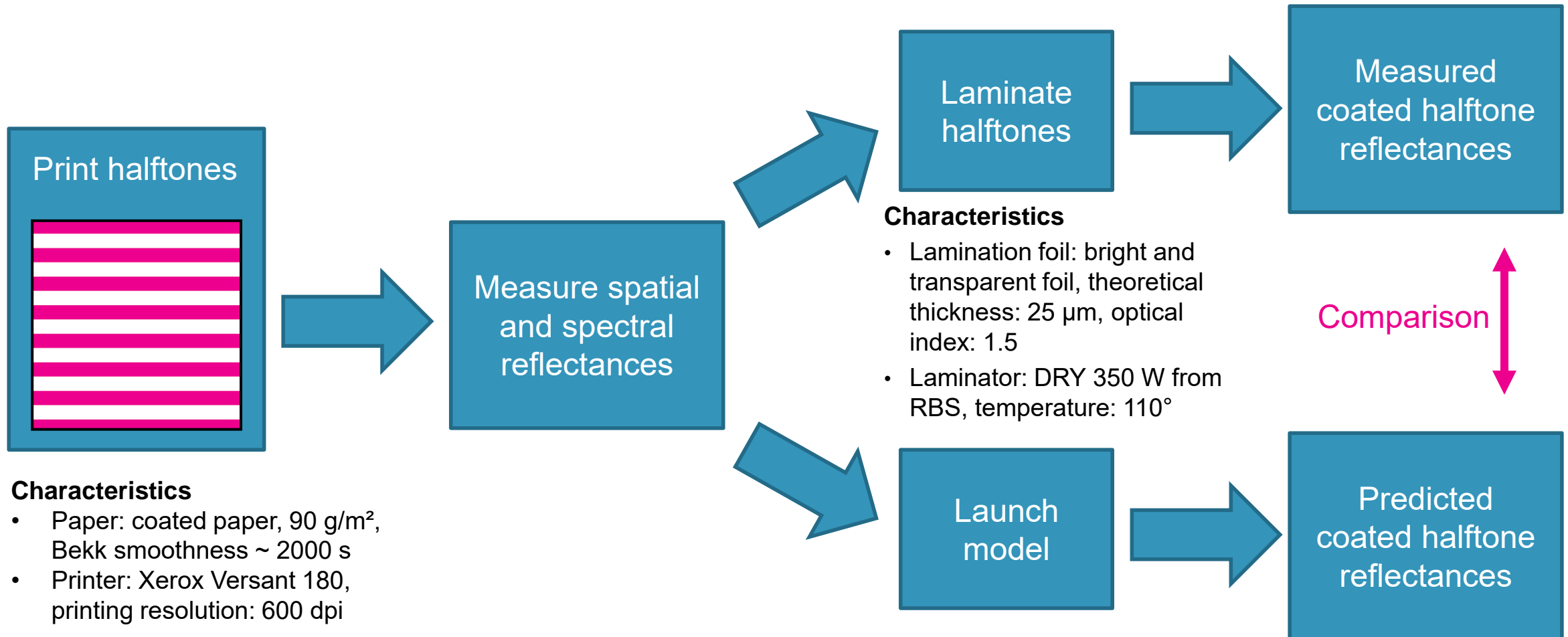


*

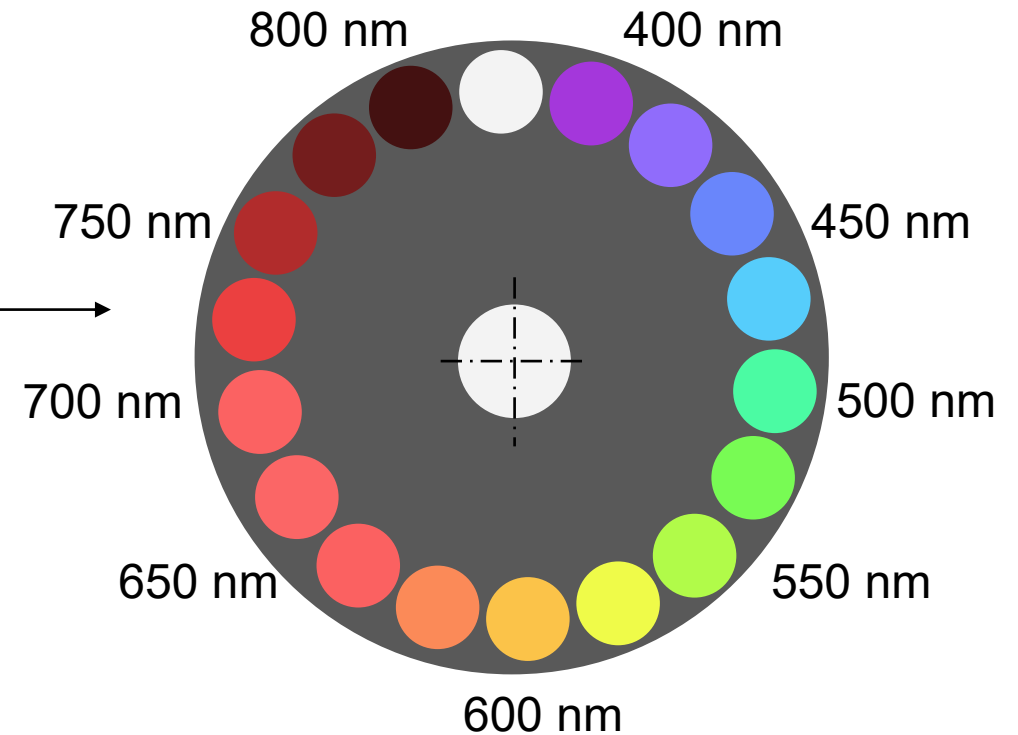
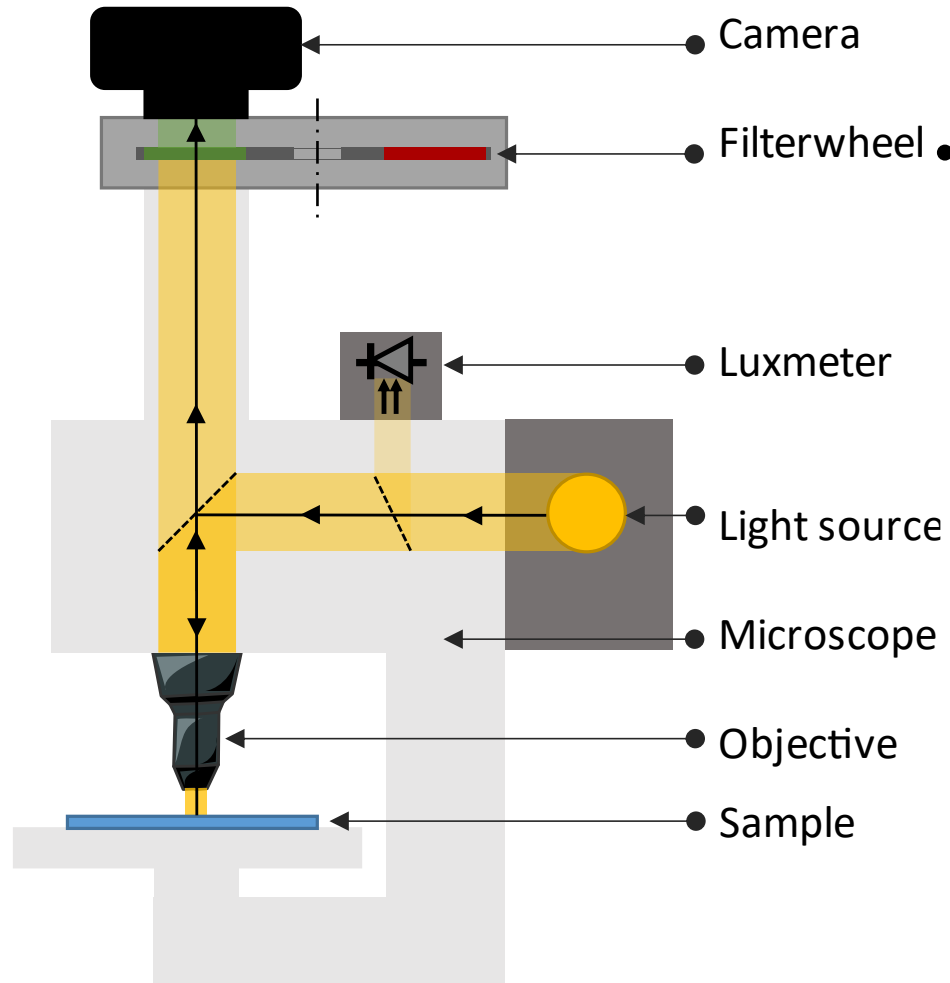
Output: reflectance of the coated half-tone:

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

Experiment



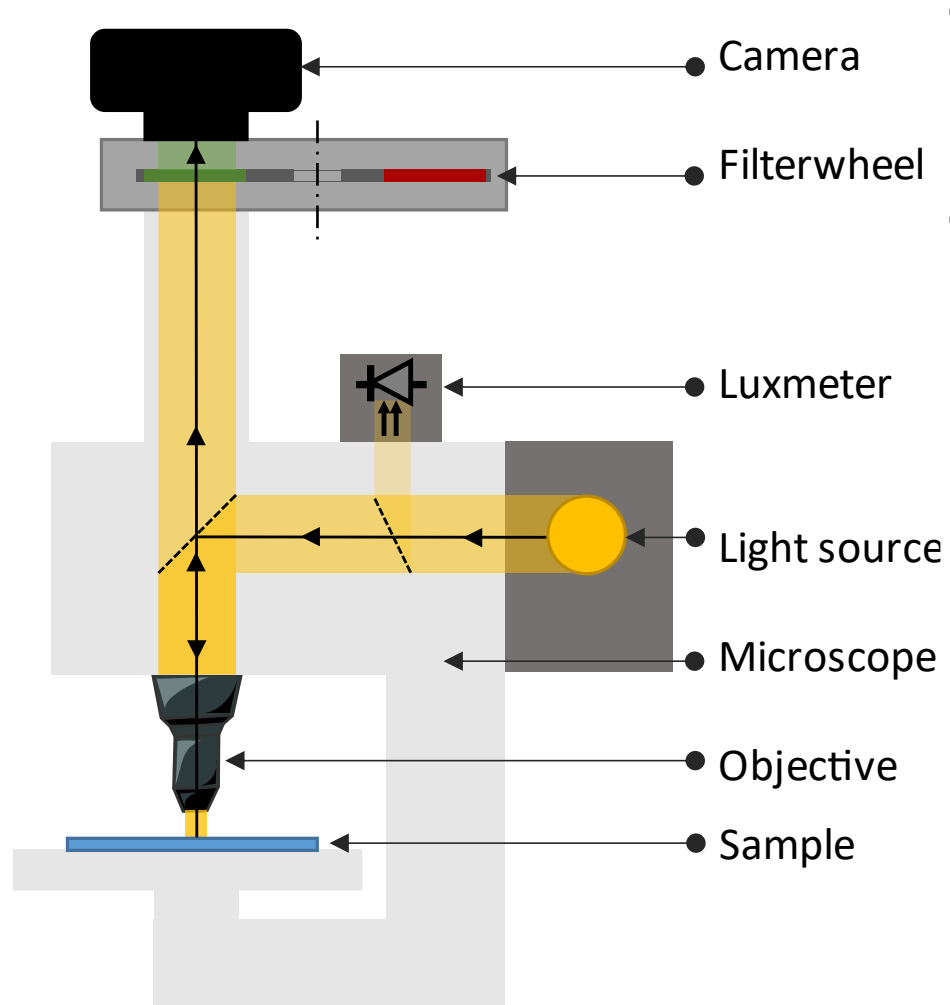
Multispectral microscope



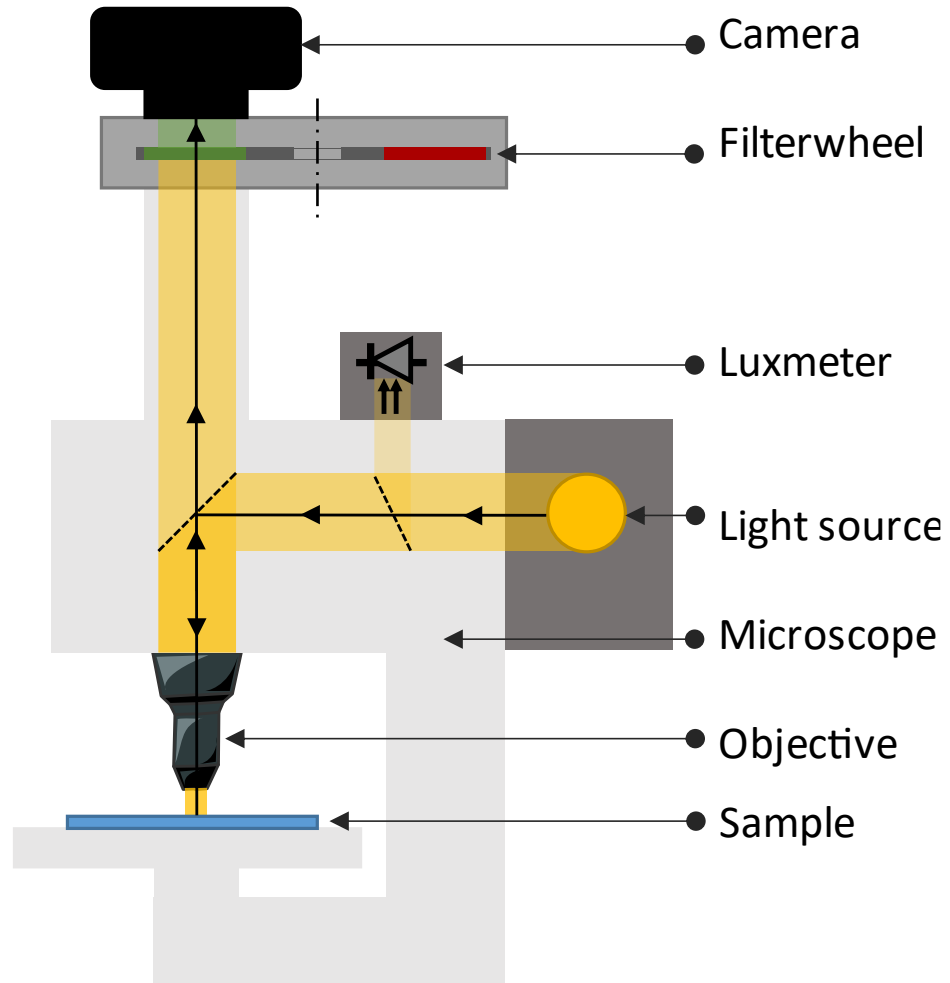
Material

- 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



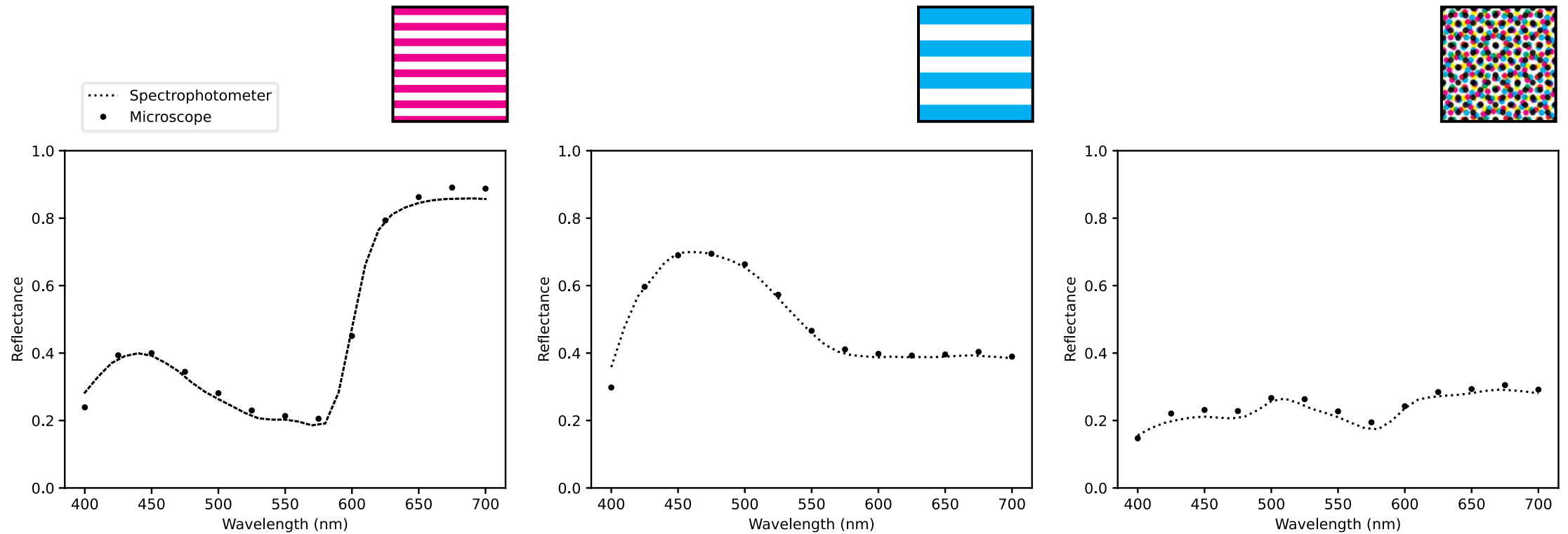
White calibration

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

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

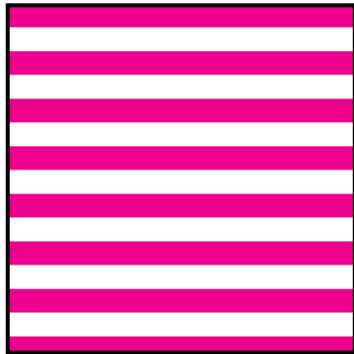


Good agreement over 23 samples

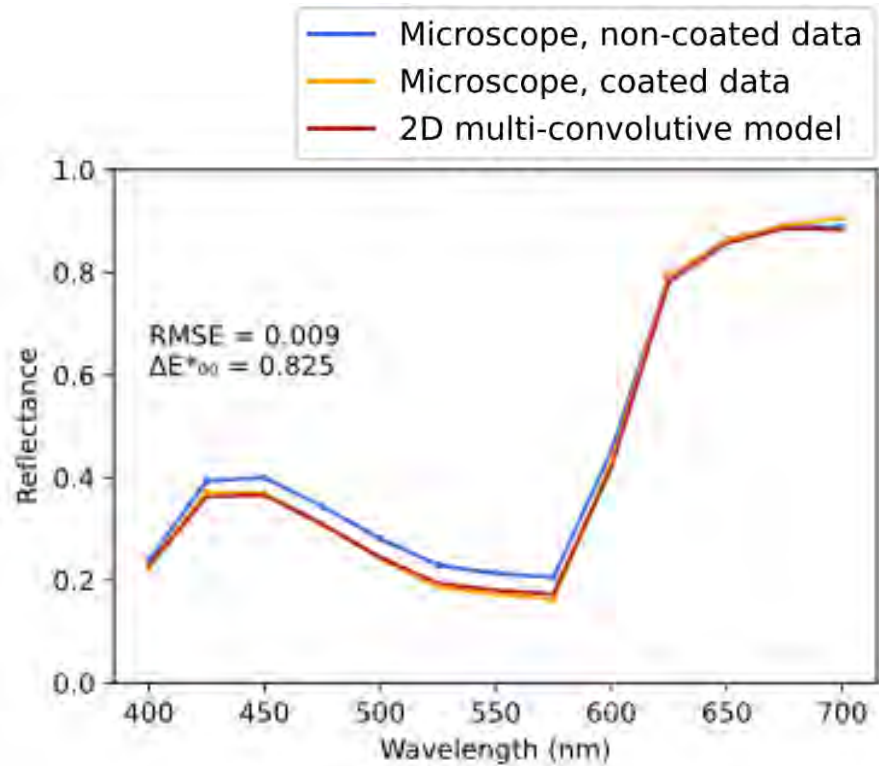
Material

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

Results

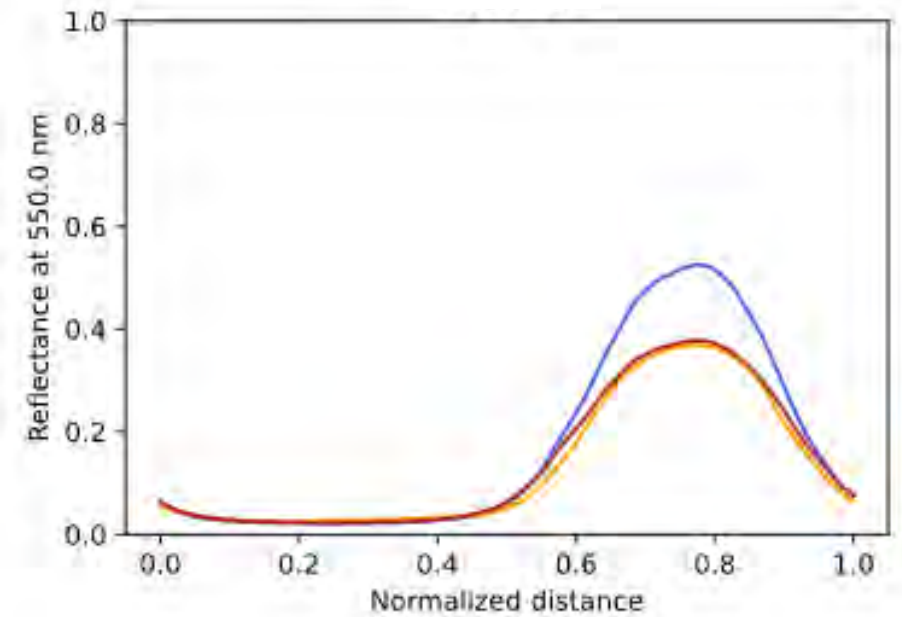


Magenta
halftone



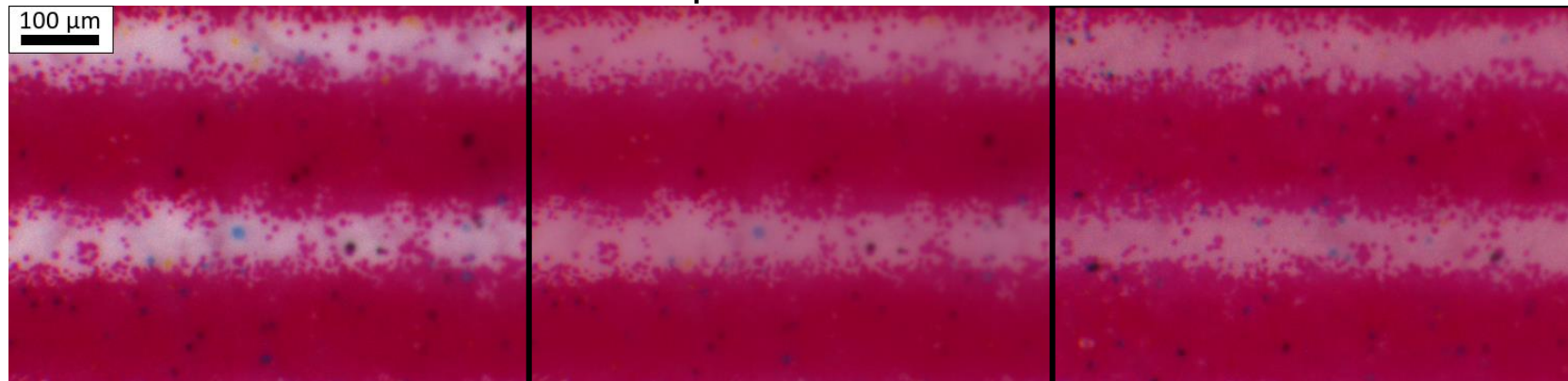
Non-coated halftone
measurement

Coated halftone
prediction

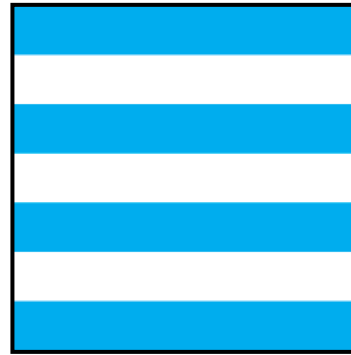


Coated halftone
measurement

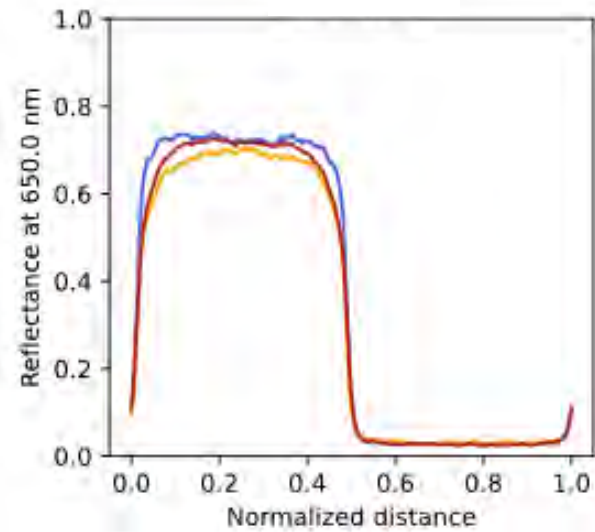
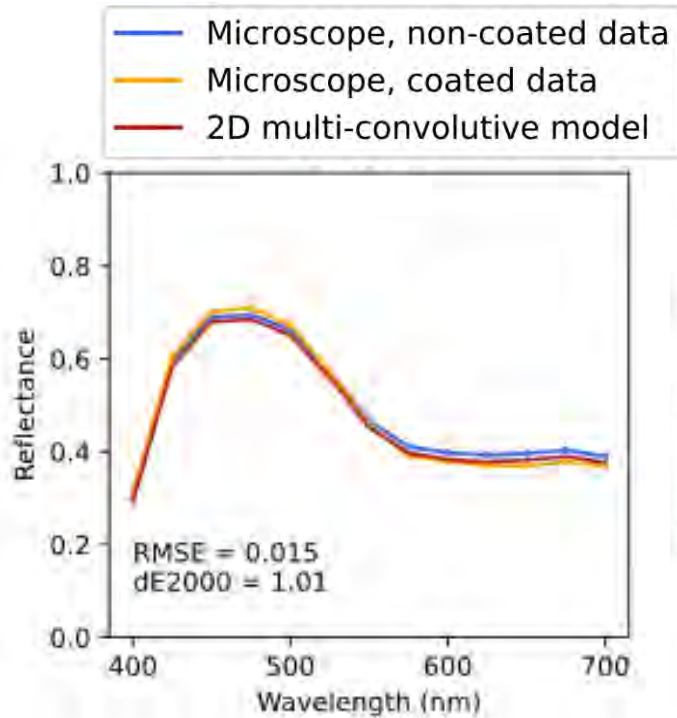
sRGB
images



Results



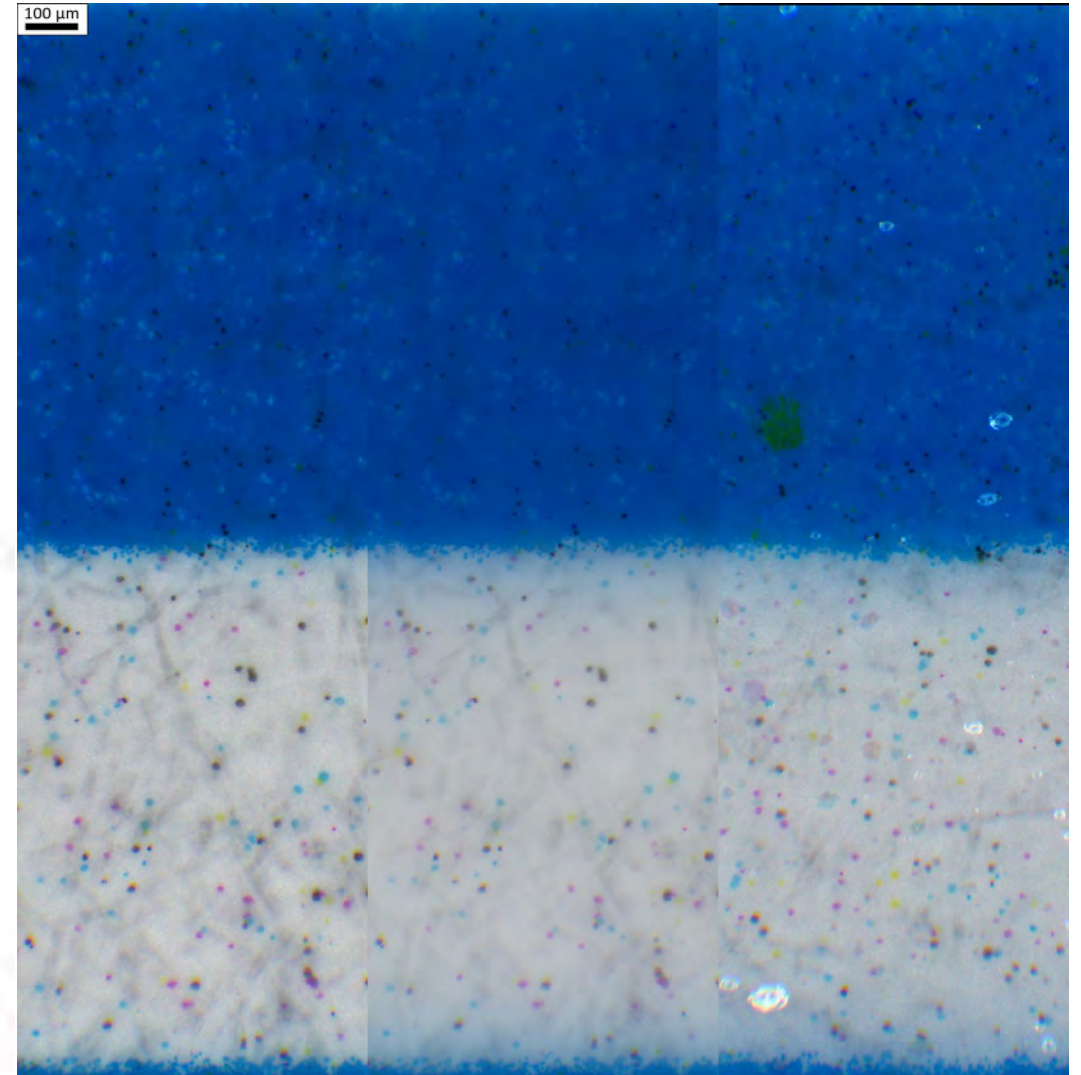
Cyan halftone



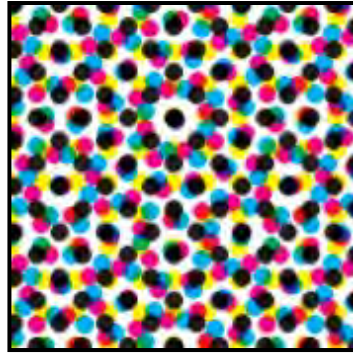
Non-coated
halftone
measurement

Coated
halftone
prediction

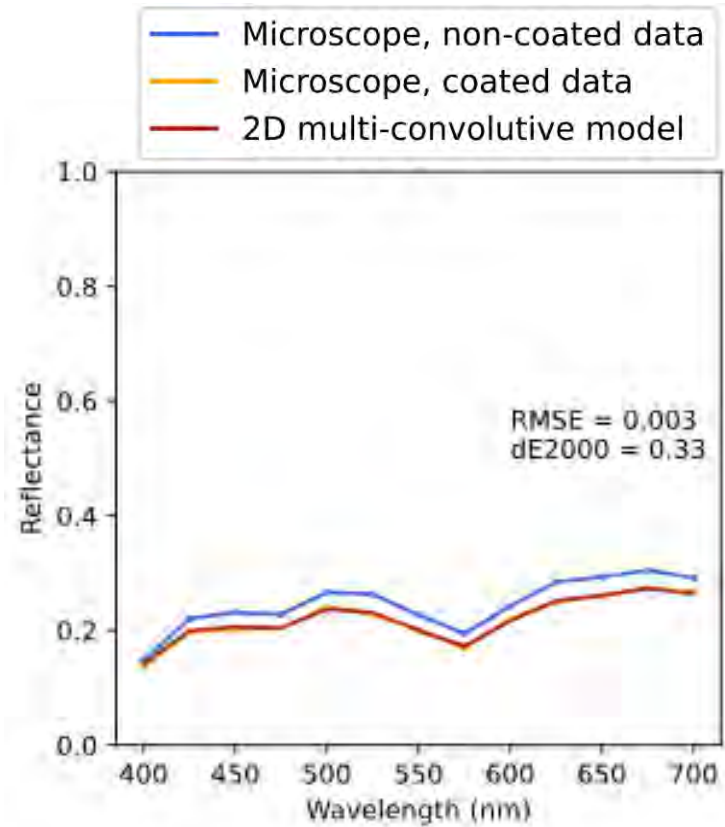
Coated
halftone
measurement



Results



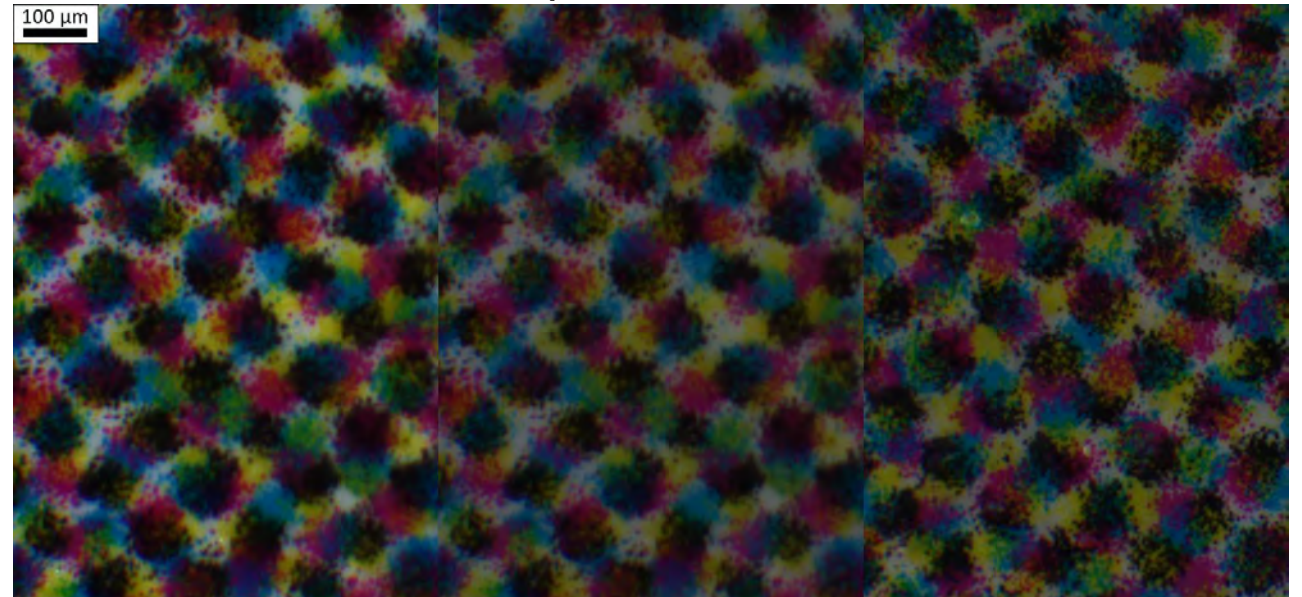
Ordinary multi-colored halftone



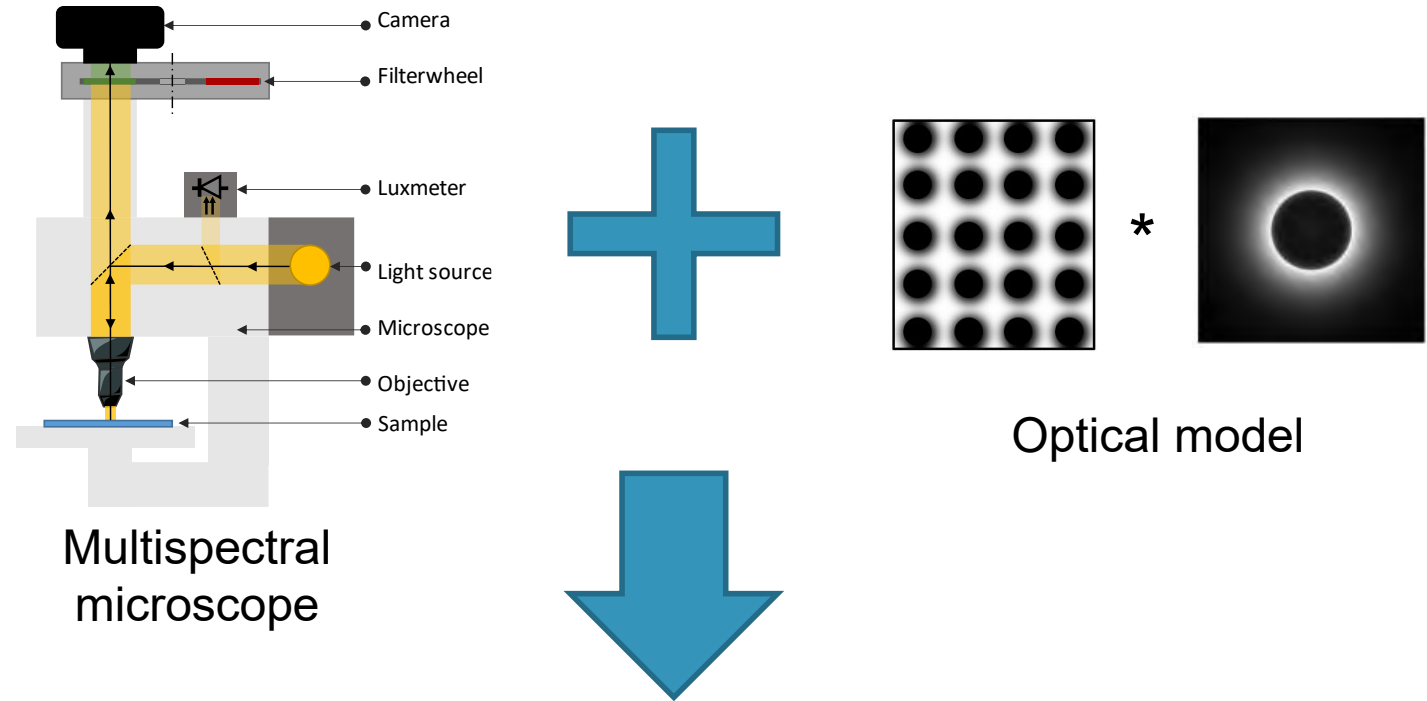
Non-coated
halftone
measurement

Coated halftone
prediction

Coated halftone
measurement



Conclusion



Optical model

Prediction of **any** coated halftone appearance
at the **micro** and **macro** scales

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



fanny.dailliez@lgp2.grenoble-inp.fr