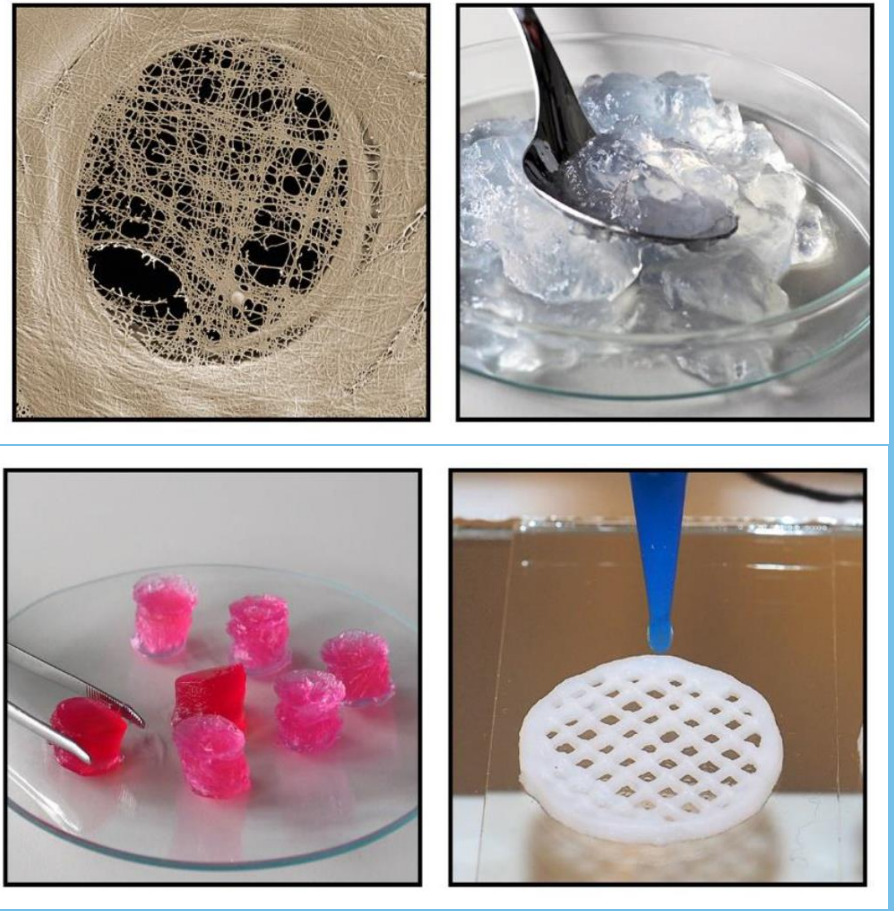
Transmittance and reflectance of cellulose nanofibrils (CNF)



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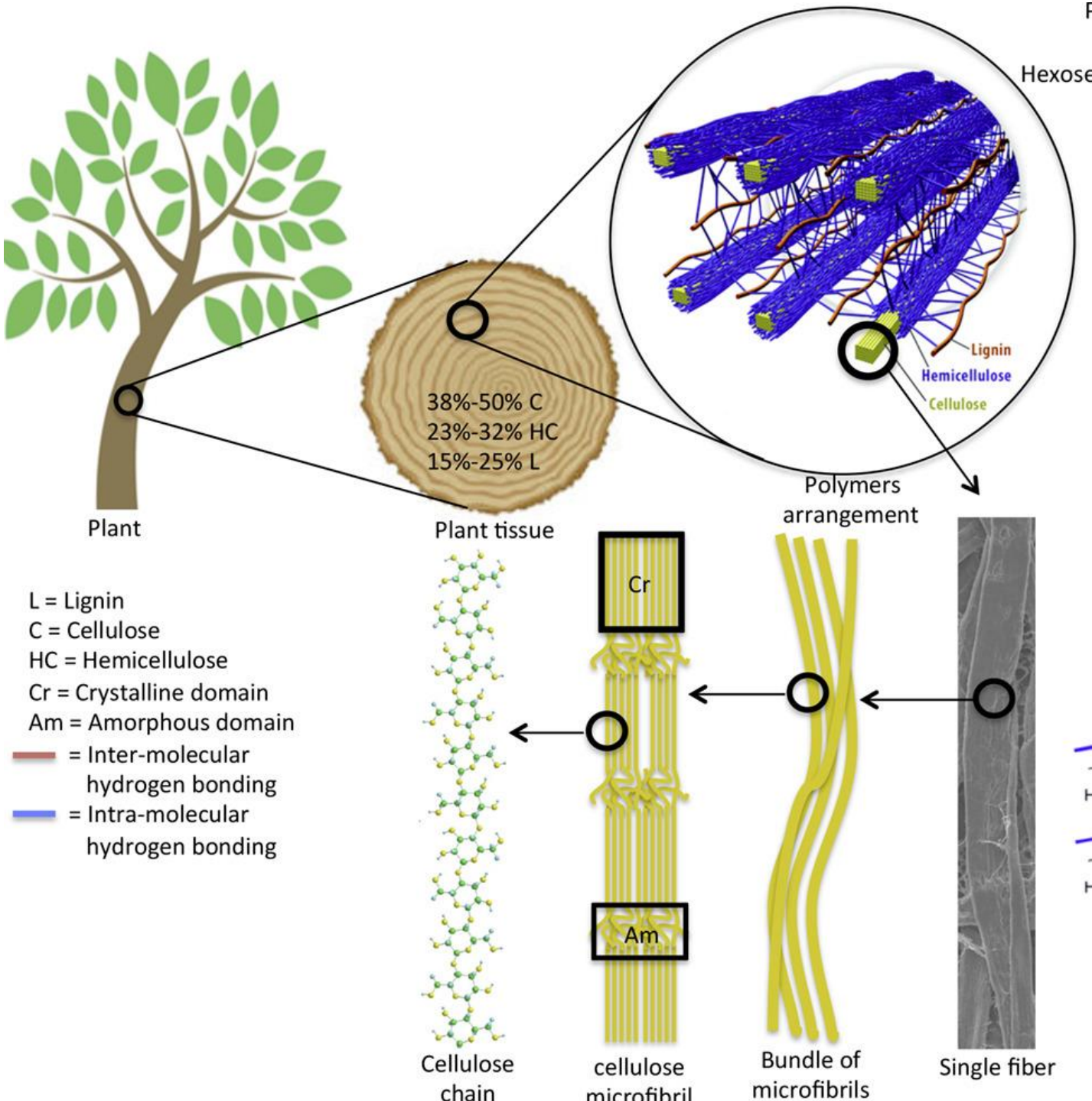
Outline

- Preparation of the NCF films
- Measurement of spectral transmittance and Haze
- Measurement of BRDF and BTDF

Some facts of CNF

- A high aspect ratio
  - 5–20 nm in width and a few μm in length.
- Films made from CNF have high strength (over 200 MPa) and high stiffness (around 20 GPa)
  - Its strength/weight ratio is 8 times that of stainless steel

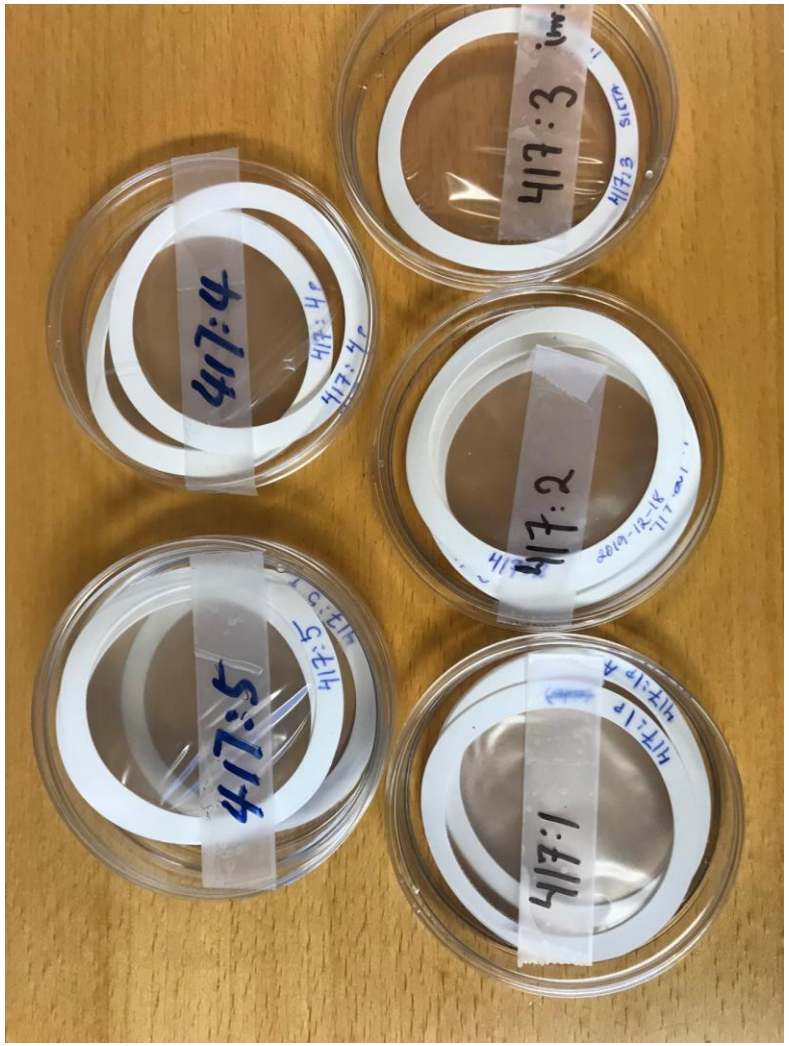


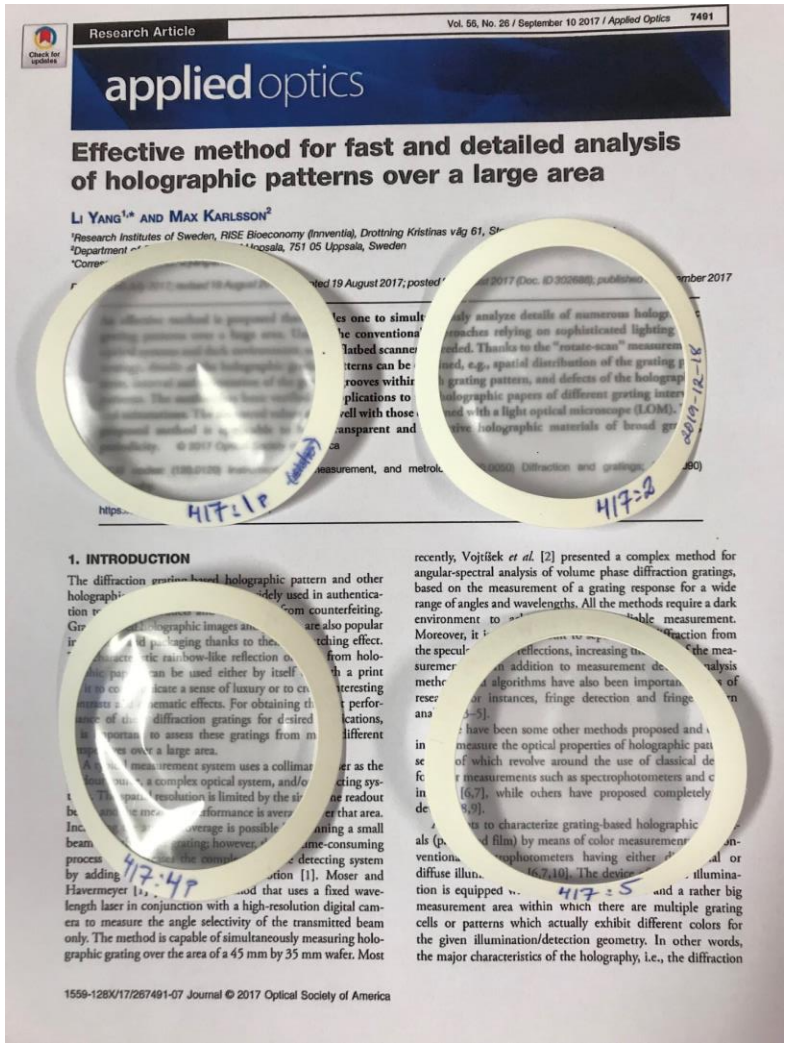
Production of CNF films

- Mechanical fibrillation using a high-pressure homogenization.
- 1–5 passes through the homogenizer.
- More the passes ➔ purer CNF content (fewer fiber residuals)
  - optical properties improved
- CNF suspension in a jarl and dry.

Gel contains up to 98% water

Image of the CNF films





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Effective method for fast and detailed analysis of holographic patterns over a large area

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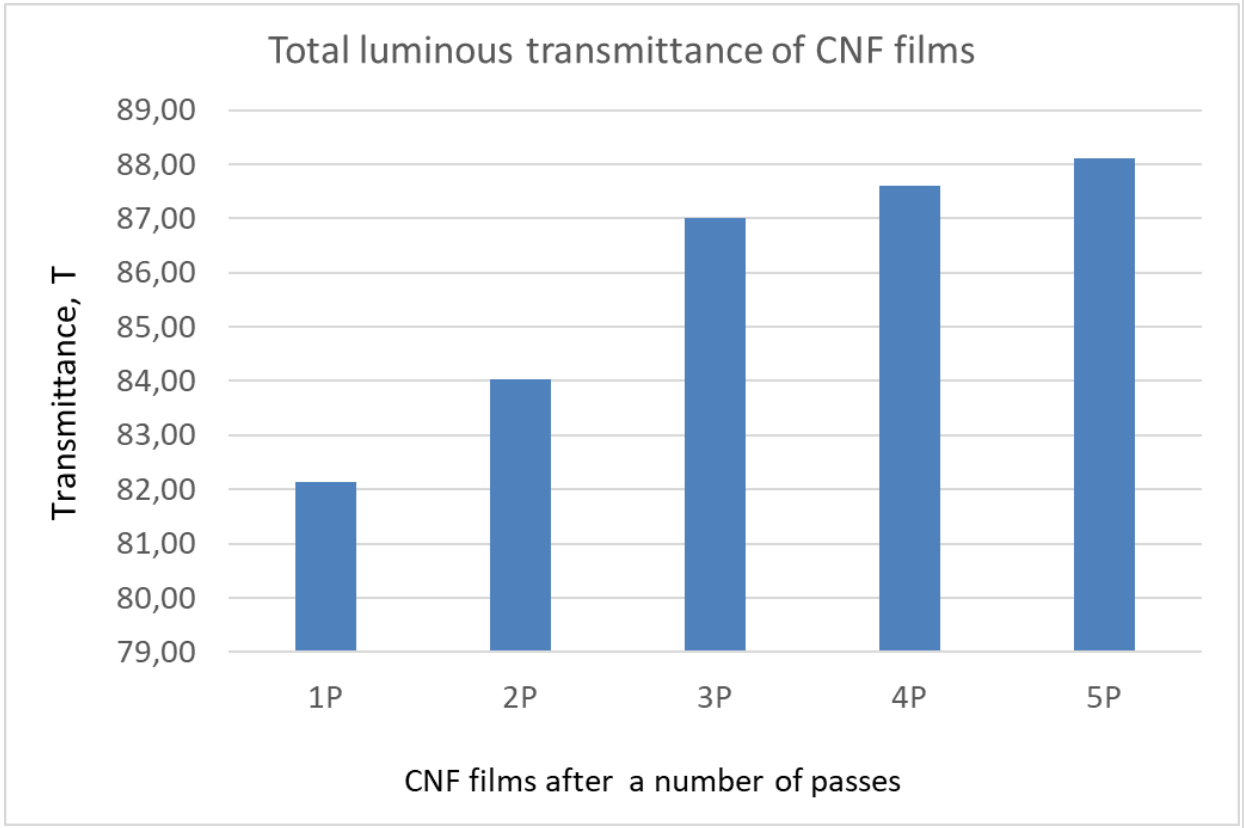
1. INTRODUCTION

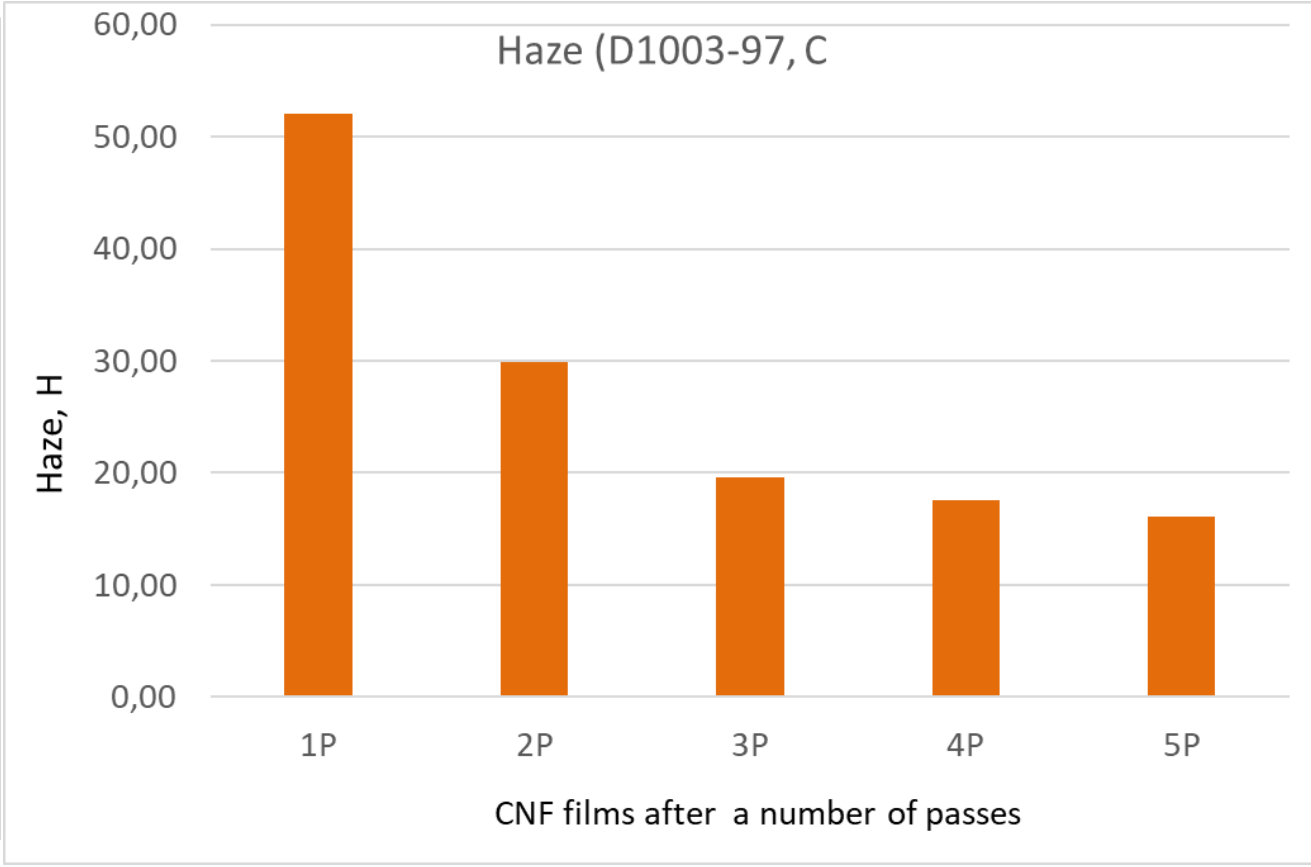
The diffraction grating based holographic pattern and other holographi
idely used in authentica-
tion m
om counterfeiting.
Gra
are also popular
ir
tching effect.
ic rainbow-like reflection o
from holo-
can be used either by itself
h a print
to co
icate a sense of luxury or to cr
teresting
matic effects. For obtaining th
perfor-
ance of th
diffraction gratings for desired
lications,
portant to assess these gratings from m
different
ves over a large area.
measurement system uses a collimat
er as the
a complex optical system, and/o
cting sys-
resolution is limited by the si
e readout
mea
formance is aver
er that area.
verage is possible
ning a small
grating; however,
me-consuming
detecting system
tion [1]. Moser and
od that uses a fixed wave-
length laser in conjunction with a high-resolution digital cam-
era to measure the angle selectivity of the transmitted beam only. The method is capable of simultaneously measuring holographic grating over the area of a 45 mm by 35 mm wafer. Most recently, Vojtíšek *et al.* [2] presented a complex method for angular-spectral analysis of volume phase diffraction gratings, based on the measurement of a grating response for a wide range of angles and wavelengths. All the methods require a dark environment to
measurement.
Moreover, it
ffraction from
the specul
reflections, increasing th
the mea-
surem
addition to measurement de
nalysis
metho
algorithms have also been importan
of
rese
or instances, fringe detection and fringe
ana
5–5].
have been some other methods proposed and
in
measure the optical properties of holographic patt
se
of which revolve around the use of classical de
fo
measurements such as spectrophotometers and c
in
[6,7], while others have proposed completely
de
8,9].
to characterize grating-based holographic
als (p
d film) by means of color measurement
sn-
vention
photometers having either
al or
diffuse illum
[6,7,10]. The device
illumina-
tion is equipped
and a rather big measurement area within which there are multiple grating cells or patterns which actually exhibit different colors for the given illumination/detection geometry. In other words, the major characteristics of the holography, i.e., the diffraction

Measurement of spectral transmittance and Haze

- Spectrophotometer CM3610d,
  - D/8° illumination / measurement geometry
  - 360:10:740 nm
- Spectral transmittance
- Haze

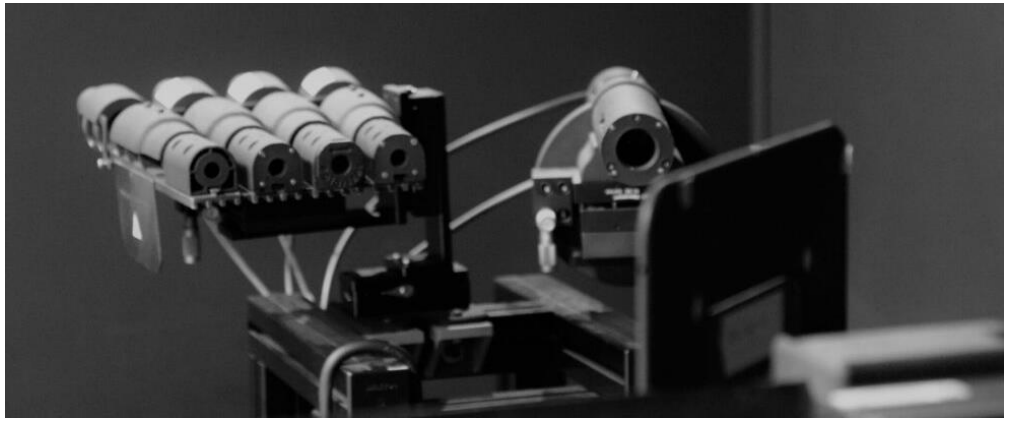
Measurement with D/8º geometry





Measurement setup

Goniospectrophotometer OMS4 (OPTIS→ANSYS)

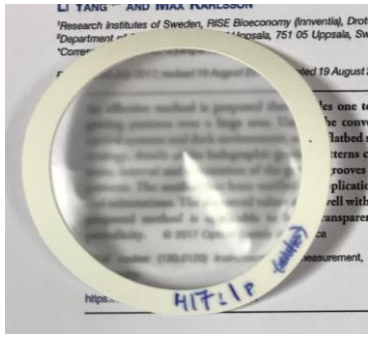


Credit: Matteo Balestrieri

Dynamic range: 10^8
Angular position ±0.01°
Repeatability : < ±5%
Sample Size : 5mm x 10mm → 200mm x 200mm
Thickness up to 30mm
Max. Sample weight : 500gr

3 laser sources:
450nm, 520nm,635nm

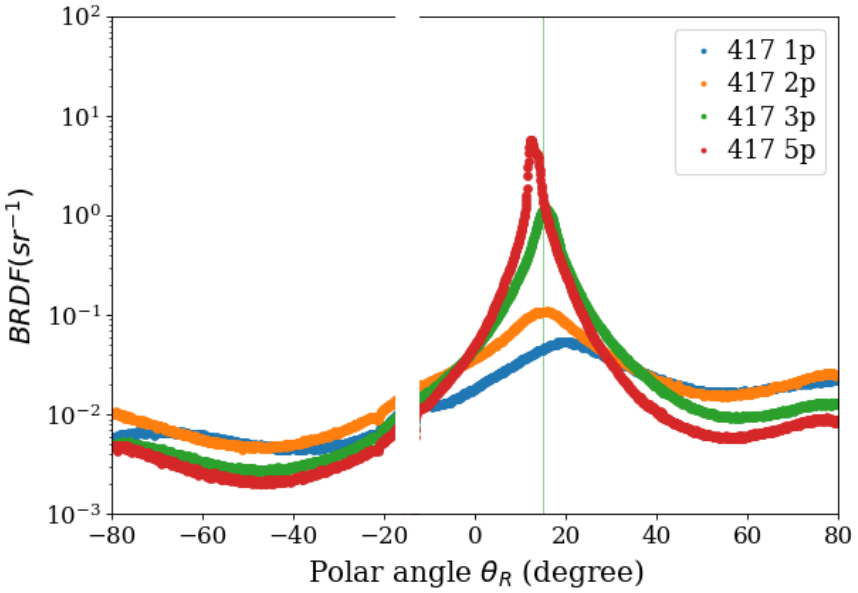
Xenon lamp
+20 spectral filters



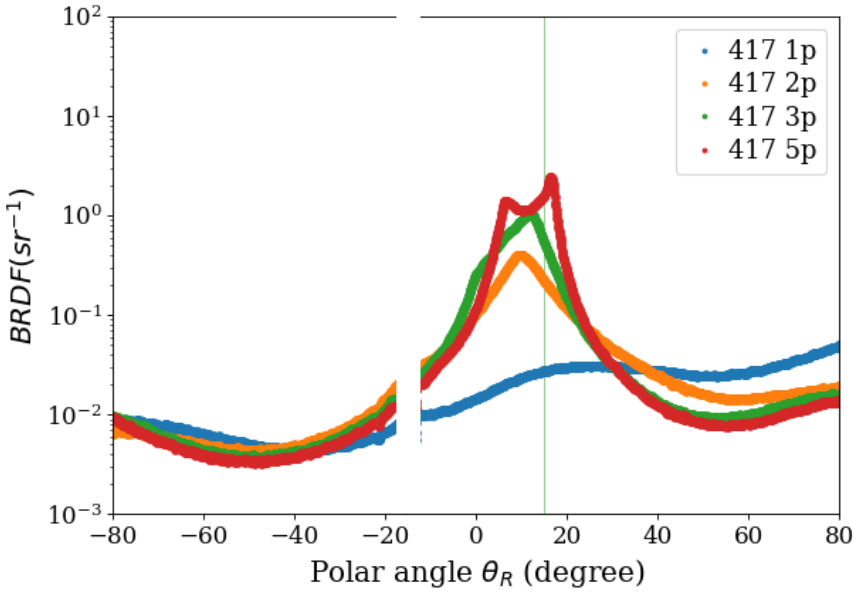
Measurement of BRDF

- θ_i= 15°, illumination from different sides

sample front



sample back

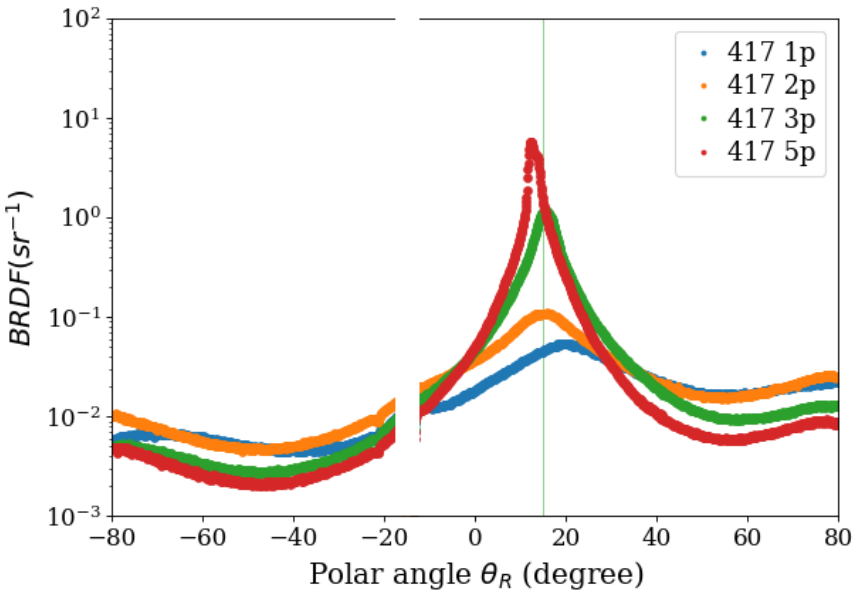


- Random local curvatures → impact on BRDF
- Shape is corrupted, but integral should be more reliable
- Increase in BRDF from 417 1p to 417 5p

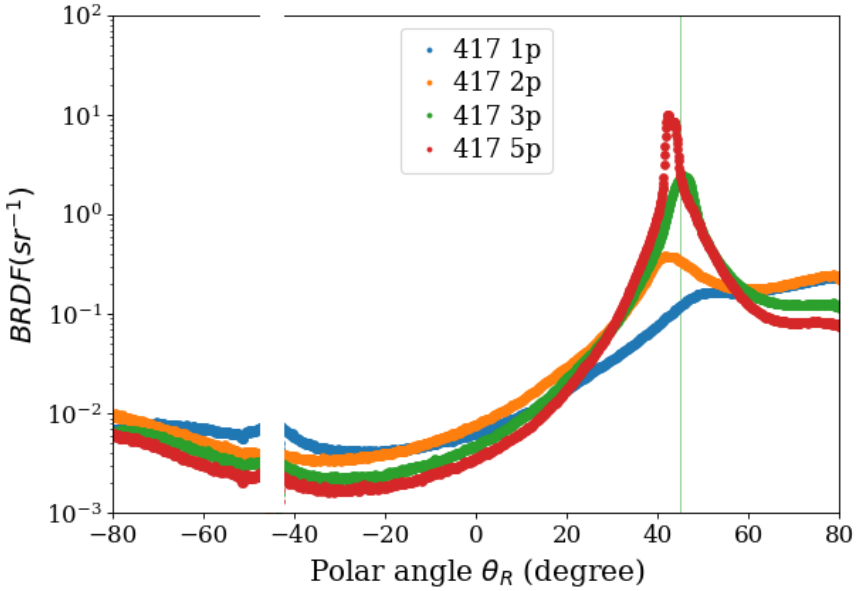
Measurement of BRDF

- illumination from sample back

θ_i= 15°



θ_i= 45°

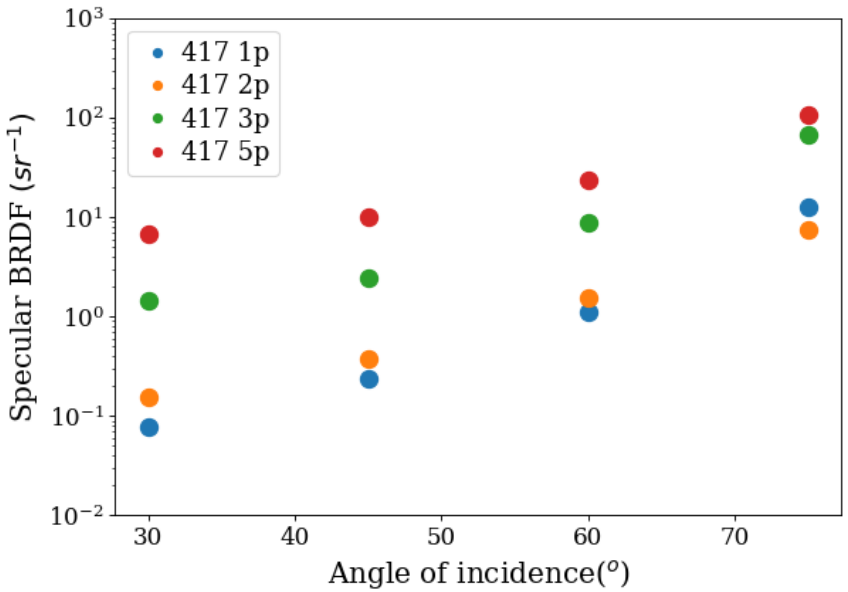


- Random local curvatures → impact on BRDF
- Shape is corrupted, but integral should be more reliable
- Increase in BRDF from 417 1p to 417 5p

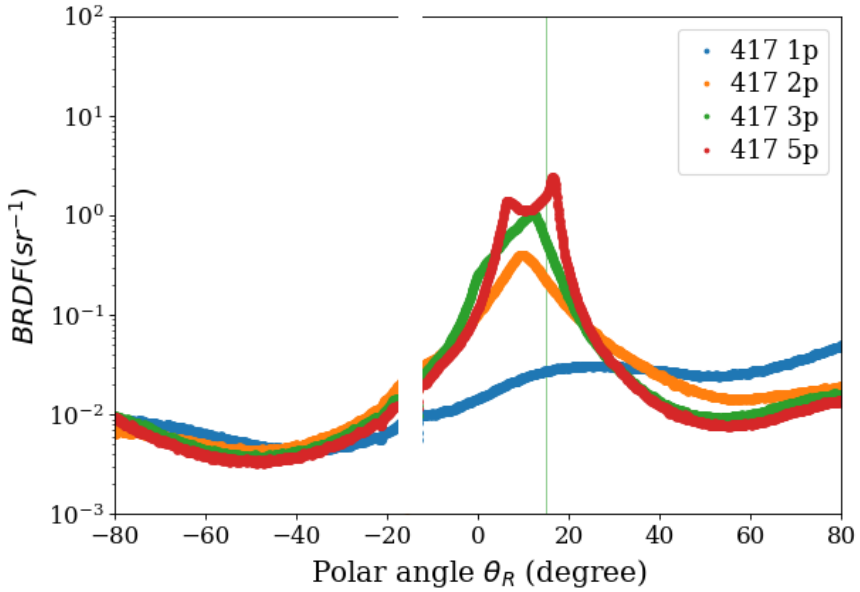
Measurement of BRDF

- BRDF values at specular reflection direction, illumination from different sides

sample front



sample back

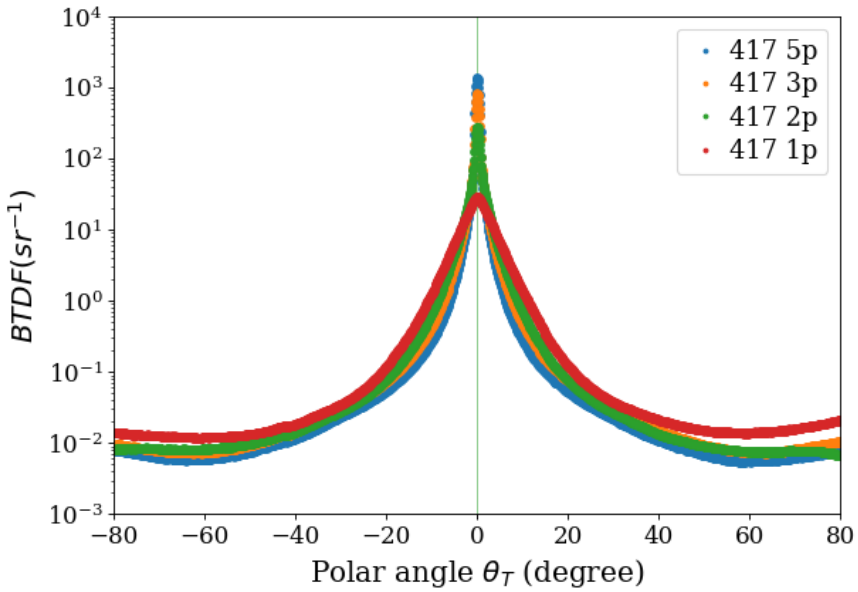


- Random local curvatures → impact on BRDF
- Shape is corrupted, but integral should be more reliable
- Increase in BRDF from 417 1p to 417 5p

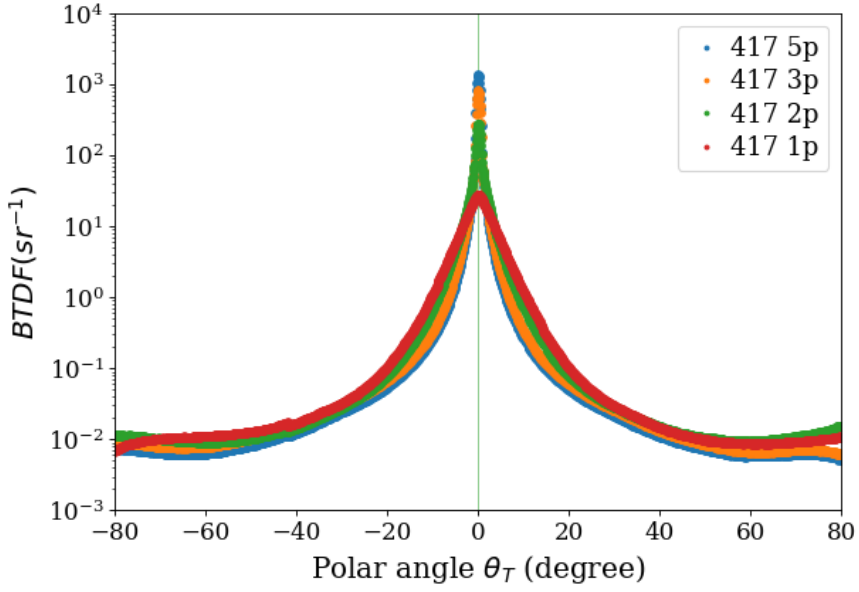
Measurement of BTDF

- $\theta_i = 0°$, illumination from different sides

sample front



sample back

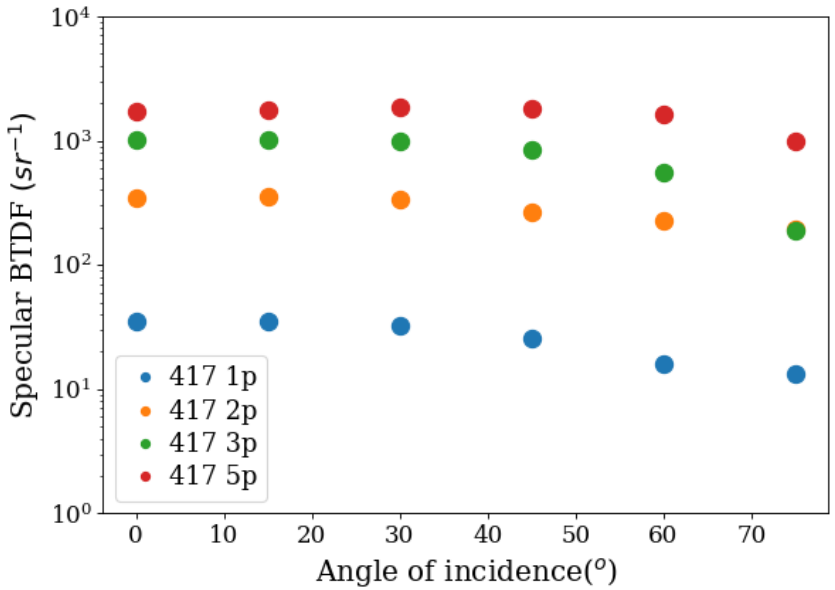


- Random local curvatures → no striking impact on BTDF
- Increase in specular BTDF from 417 1p to 417 5p

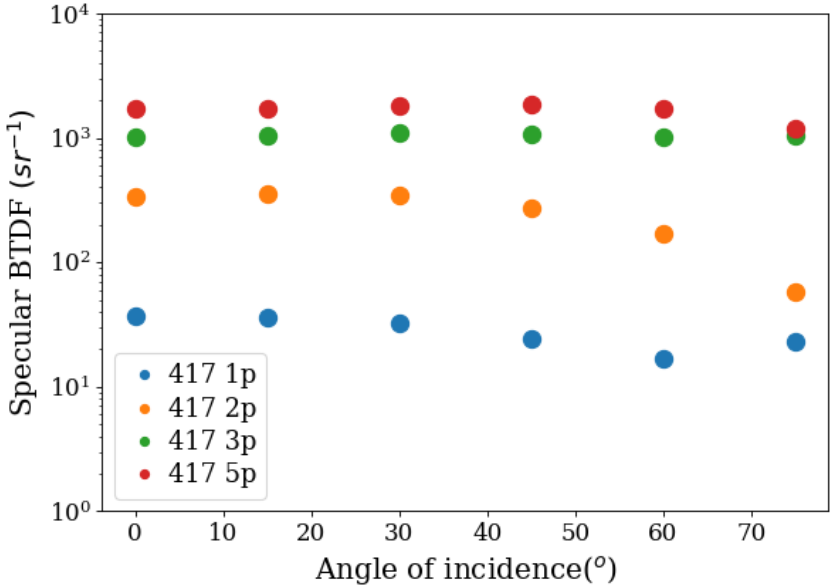
Measurement of BTDF

- BRDF values at specular reflection direction, illumination from different sides

sample front



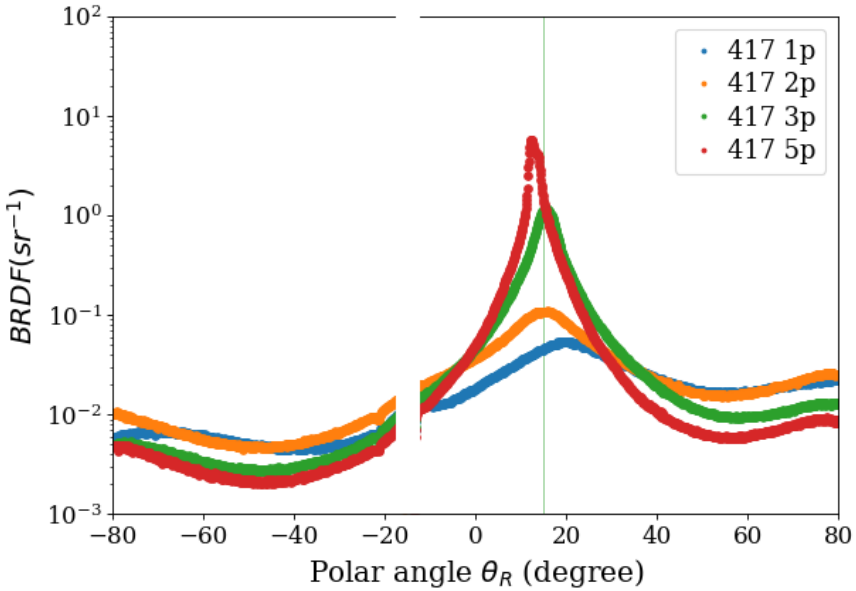
sample back

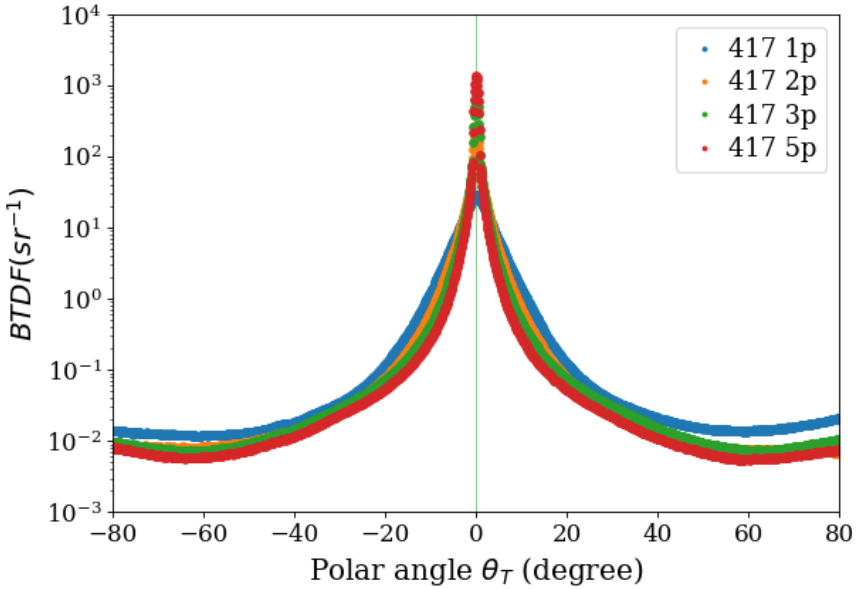


- Random local curvatures → no striking impact on BTDF
- Increase in specular BTDF from 417 1p to 417 5p

Summary

- Good reproducibility of BTDF
- Discrimination of samples based on BTDF





What more profound analysis?