

# Effect of Micro- and Nanostructures on Optical Performance of Greenhouse Cover Materials

Vida Mohammadkhani<sup>1</sup>, Jim van Ruijven<sup>1</sup>, Henk Jan Holterman<sup>2</sup>, Robert Herre<sup>3</sup>, Volkmar Boerner<sup>4</sup>, Gert-Jan Swinkels<sup>1</sup>, Theo Gieling<sup>1</sup> <sup>1</sup>Wageningen UR Greenhouse Horticulture; <sup>2</sup>Wageningen UR Agrosystems Research; <sup>3</sup>Nanoptics GmbH; <sup>4</sup>Holotools GmbH

100

## Introduction

Diffuse light improves crop production in greenhouses. With the latest developments in nanotechnology area, it is possible to conduct and control the light propagation through transparent materials. The designed microstructure surfaces convert direct light to diffuse light and nanostructure patterns decrease the reflection from the surface. The optical properties of some micro- and nano-patterned cover materials are investigated.

## Materials & methods

- Samples
  - PET/PMMA substrate material
  - –UV-curable resin
  - Structures pressed in resin
- Measurements
  - Angular transmittance measurements on Transvision according to NEN 2675
  - Hemispherical transmittance calculated from numerical integration of angular transmittance
- Simulation software (raytracing and electromagnetic theory)



-----Blank PET

**Figure 2.** Angular transmittances of micro- and nano-structured materials compared to reference plate material.

#### Hemispherical transmittance & haze



#### **Results**

#### Micro V-grooves



**Figure 1.** Angular transmittances of micro-V grooved materials compared to reference plate material. Sharp edges with a 49° bottom angle from horizontal, 100µm pitch.

 Resin is responsible for 1% transmittance loss per side, largest part in UV-region Figure 3. Hemispherical transmittance and haze of investigated samples. Red columns for haze.

- Diffusive samples all have high haze values
- Hemispherical transmittance decreases by diffusing the samples

### Conclusions

- Resin, as required in production process, decreases transmittance
- Structures should overcompensate this to be useful as greenhouse cover material
- With this production method, currently chosen structures from PV industry diffuse the light, but decrease hemispherical transmittance
- Structured samples lose light at most important angles of incidence
- Losses probably due to internal reflections

#### Structure combinations

- Combinations of diffusing and AR structures (Nanoptics/Holotools)
  - Microstructures for diffusion
  - Nanostructures for anti-reflection
- Motheye on top works good for perpendicular transmittance
- Double-sided motheye is non-diffusive

#### Acknowledgements

This project is financed by the Dutch Ministry of Economics, Agriculture & Innovation, Productschap Tuinbouw and AgentschapNL

Partners in this project are Wageningen UR Greenhouse Horticulture, Aquamarijn Micro Filtration B.V. and Utrecht University



Wageningen UR Greenhouse Horticulture
P.O. Box 644, 6700 AP Wageningen
Contact: vida.mohammadkhani@wur.nl
T + 31 (0)317 48 33 32
www.glastuinbouw.wur.nl

