Smart materials in buildings

Albert Schenning

TU/e

Smart materials for greenhouses

Workshop April 13, 2016, Wageningen UR

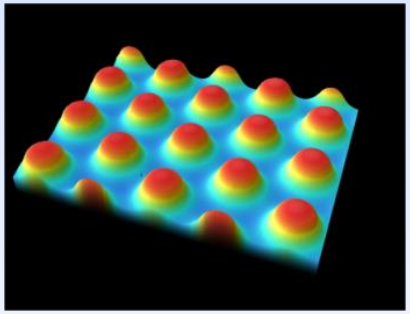
HIGH TECH TO FEED THE WORLD

Functional Organic Materials and Devices

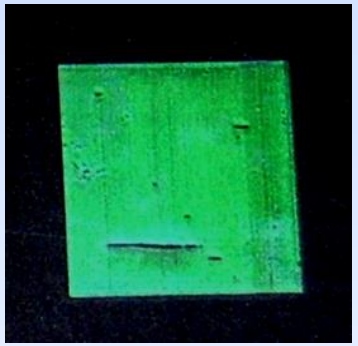
TU/e
Sfd
MOLECULE → DEVICE

Functional Organic Materials and Devices Mission and Vision

- New functionalities into polymer materials towards new applications or solutions in



» energy management
» water management
» healthcare & personal comfort

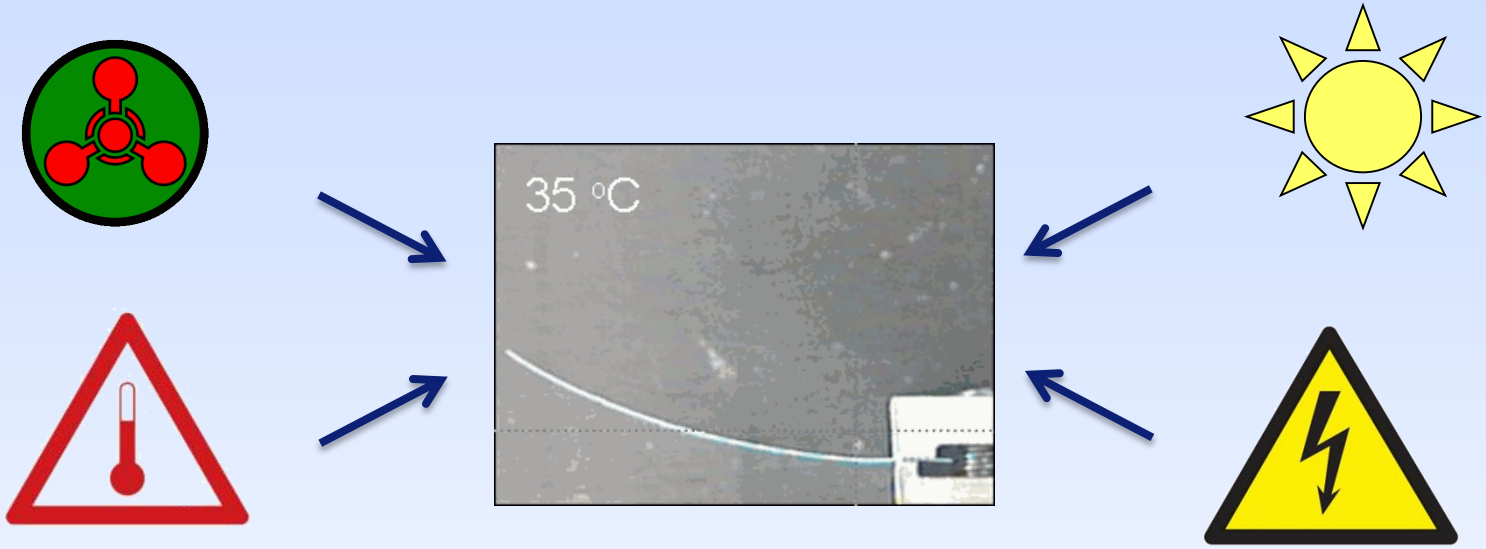


- Integration of these new polymers in (prototype) devices to employ their functionality

General approach

- The complete chain of knowledge from synthesis to prototype devices is used
- Top-down and bottom-up methods are employed
- Fundamental and applied science and education
- Collaborations with multinationals, small- and medium-size enterprises and facilitation of start-ups

Stimuli-responsive polymer materials



Materials that change shape, reflectivity, color, porosity when being addressed by an external trigger and can be adjusted autonomously depending on user needs or upon environmental changes

Are key to the future societal challenges from energy-efficient buildings to food safety

Collaborations

Member of ICMS and EPL

Academic groups

TU/e

University of Twente
Enschede - The Netherlands

KENT STATE UNIVERSITY

華南師範大學
SOUTH CHINA NORMAL UNIVERSITY

Universidad Zaragoza
1542

UNIVERSITY OF CAMBRIDGE

Queen Mary University of London

Industry

FUJIFILM

PHILIPS

ASML

NXP

DSM
BRIGHT SCIENCE. BRIGHTER LIVING.

sabic

MERCK

heijmans

Start-ups generated from the group

MAXXUN

VALIDUS technologies
novel authentication solutions

peer+

NOVAMEER®
LIGHTWEIGHT HIGH PERFORMANCE COMPOSITES

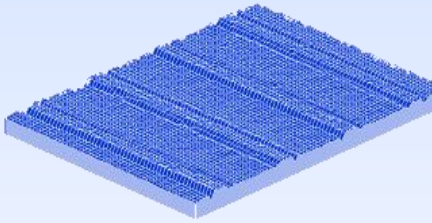
Collaboration with South China Normal University, Guangzhou, China

Laboratory for Device Integrated Responsive Materials (DIRM), Prof. Dr. Guofu Zhou

Mission statement:

New functional materials are being developed that

- connect the areas of optics, electronics and mechanics
- improving existing electro-optical devices and
- creating new devices for energy management

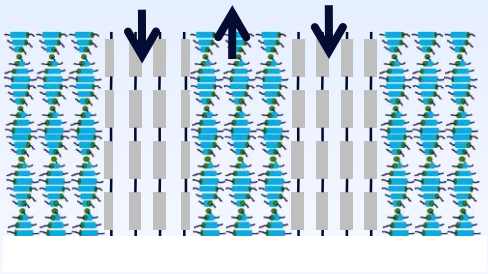


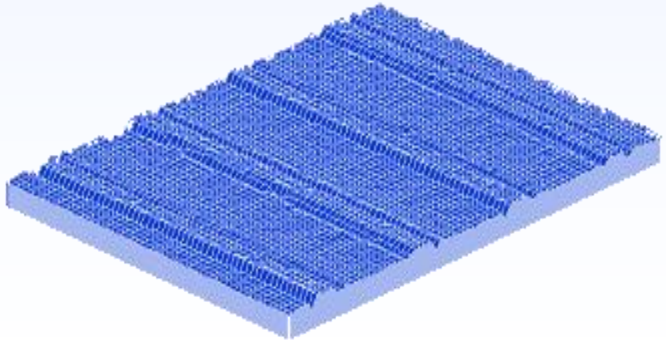
We contribute:

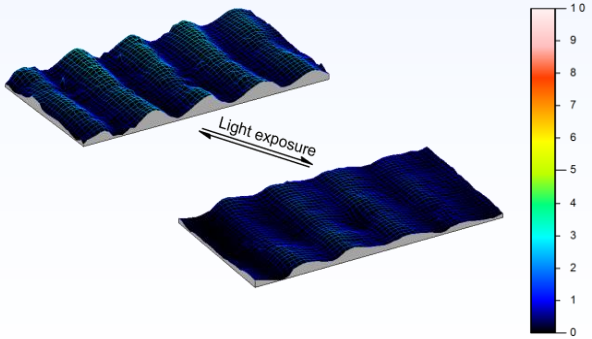
- Our knowledge on hierarchical materials that generate a function upon actuation
- Our knowledge to process these materials into a device
- Our infrastructure to control materials on molecular level at dimensions of device level

Energy Management

Smart coatings for anti-fouling, self-cleaning, etc







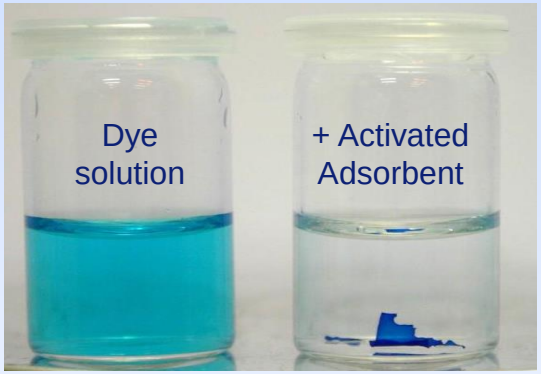
TU/e Technische Universiteit Eindhoven University of Technology

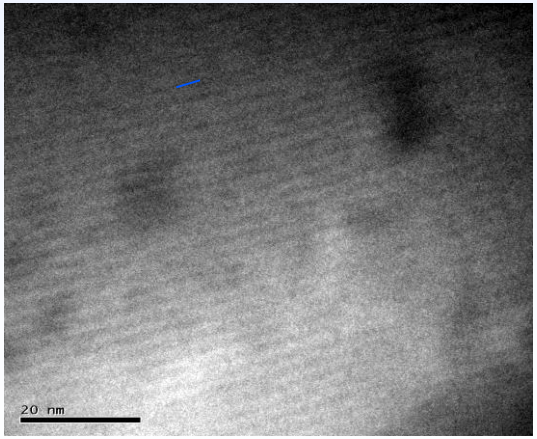
Sander van Kommeren, Danqing Liu, Jelle Stumpel, Jeroen ter Schiphorst

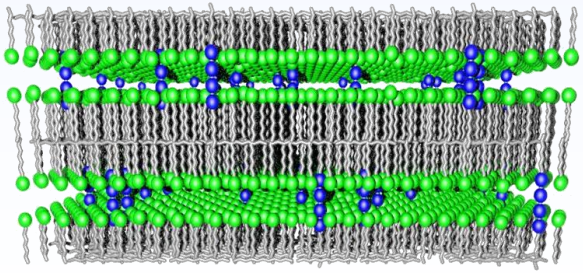
Water Management

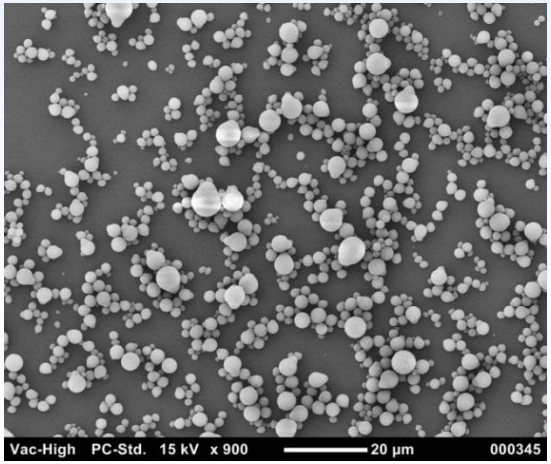
Nanoporous Materials

- Ion-selective membranes
- Water desalination
- Recovery of valuable salts
- Removal of contaminants
- Drug delivery
- Lithium batteries









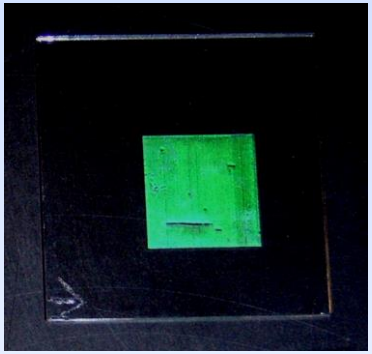
Huub van Kuringen, Dirk Jan Mulder

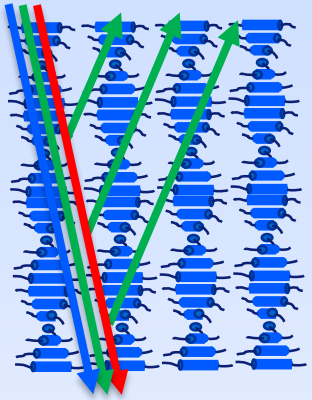
Health, Personal Comfort

Optical Sensors

Battery free

Printable
on a foil

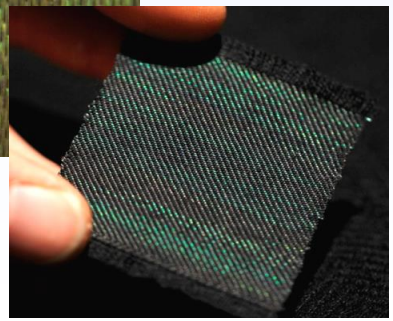


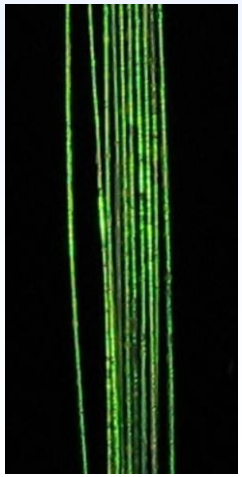


Cold chain in package industry

Responsive pigments

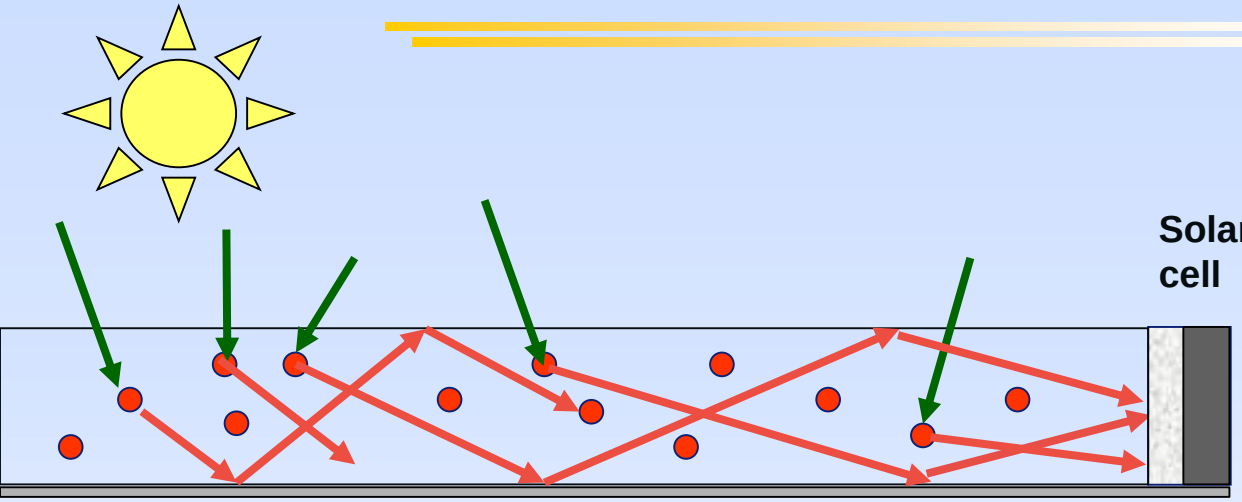
Sensors made so far:
time-temp. (vaccines)
acetone (diabetes)
humidity, CO_2, O_2
amines, methanol, ethanol,
strain

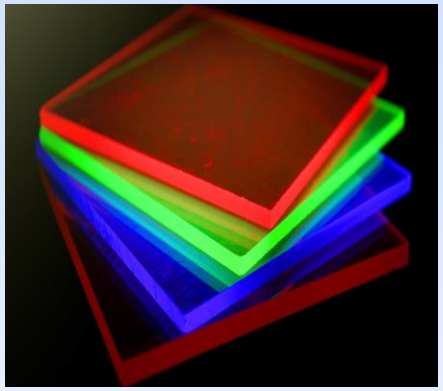




Smart materials for greenhouses

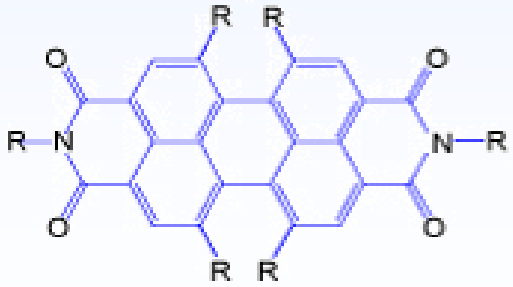
Luminescent Solar Concentrator

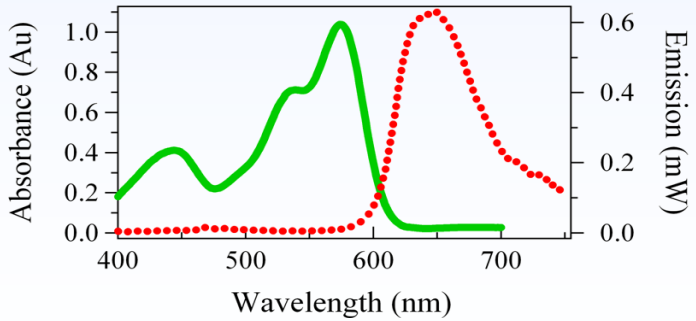




advantages:

- uses inexpensive materials and reduces solar cell size by > 90%
- flat or flexible modules: better integration into built environment
- requires no tracking of the sun/ functions in cloudy weather





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M. Debije, P. Verbunt, S. Tsoi, C. Bastiaansen

Sound Walls That Generate Electricity

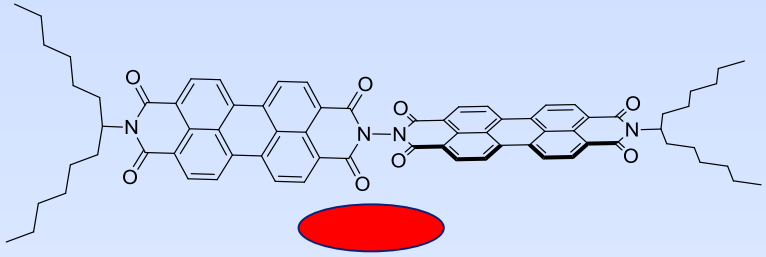

ECONOMIE 17

ZONNE-ENERGIE

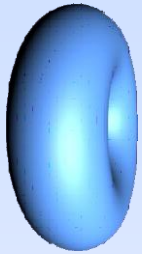
Rood levert de meeste energie

Michael Debije

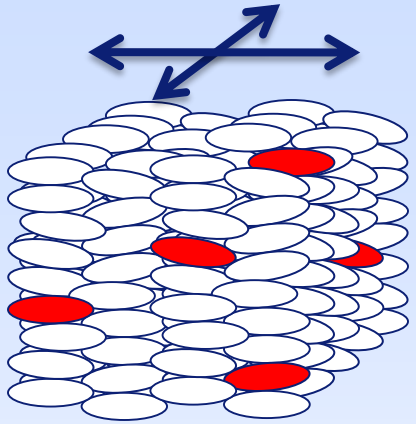
Aligned dyes improve light collection

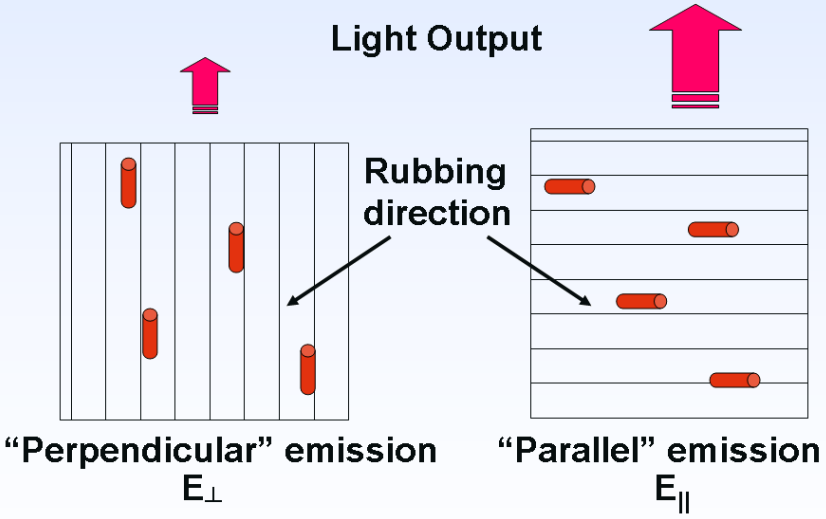


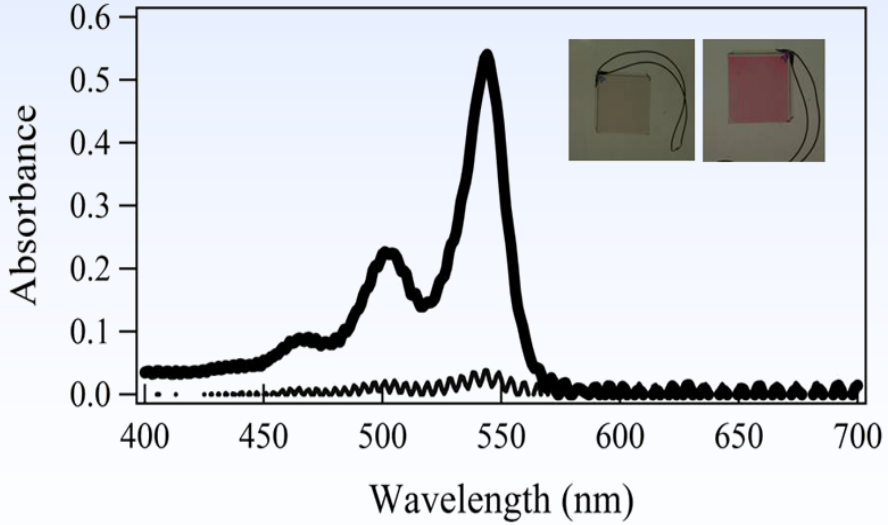
absorption



emission





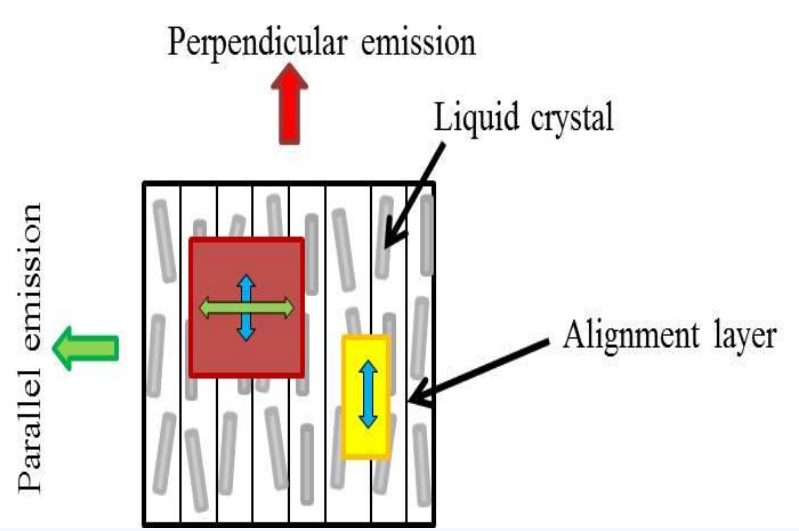


dye orientation determined by LC

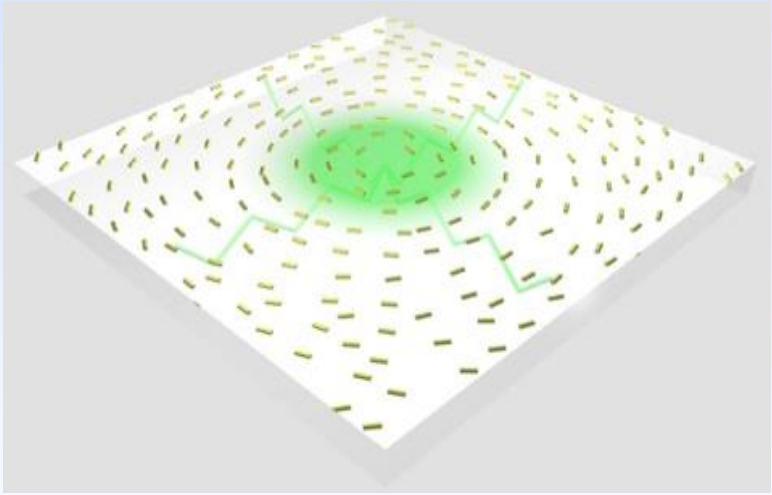
PCT Int. Appl. (2013), WO 2013004677

Light Management

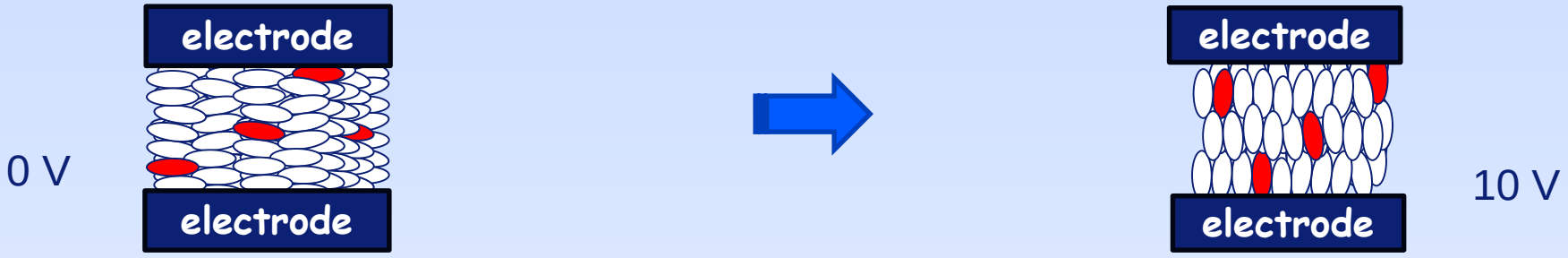
Different colors at different edges

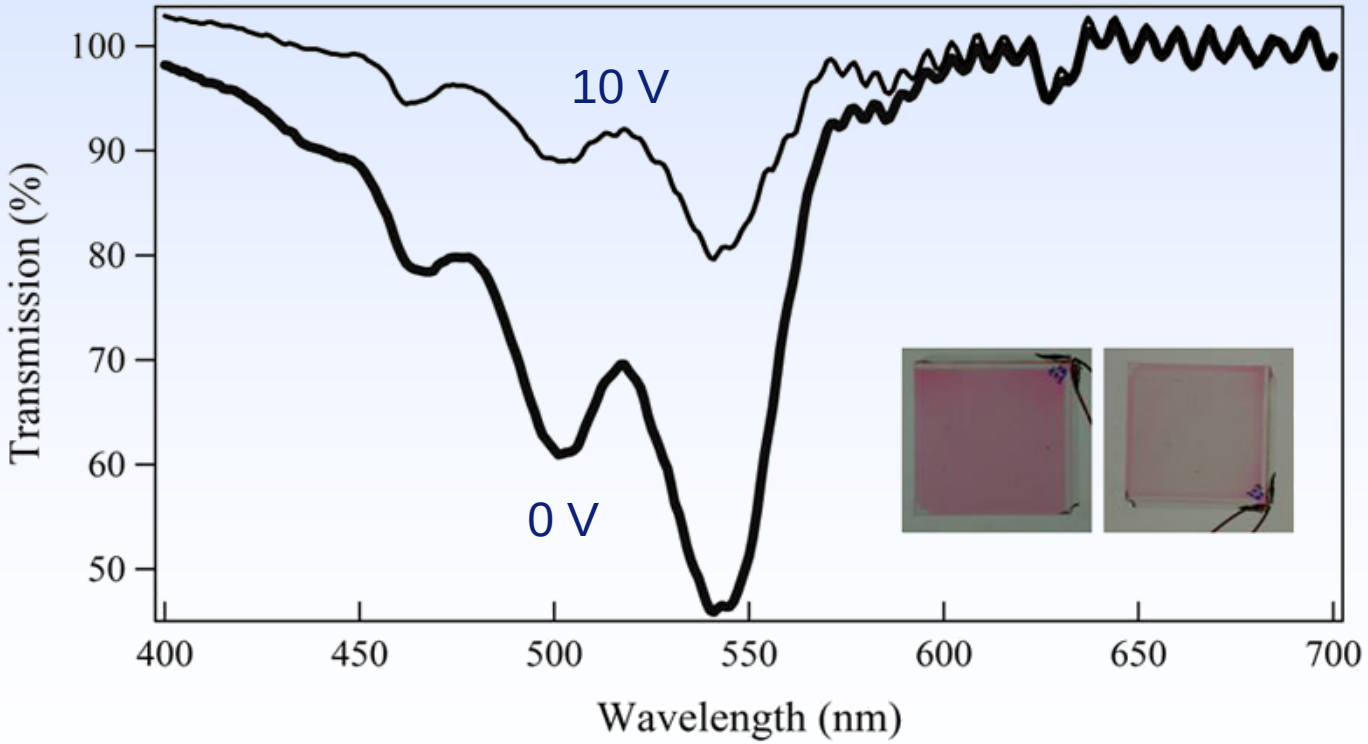


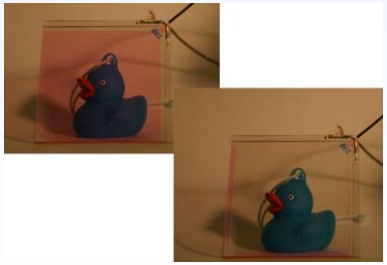
Directing light to one point



Switching Orientation by E field







J. Mater. Chem. A, 2013, 1, 229- 232

M. Debije, A. Kendale

Smart Windows: Smart energy glass

Dark

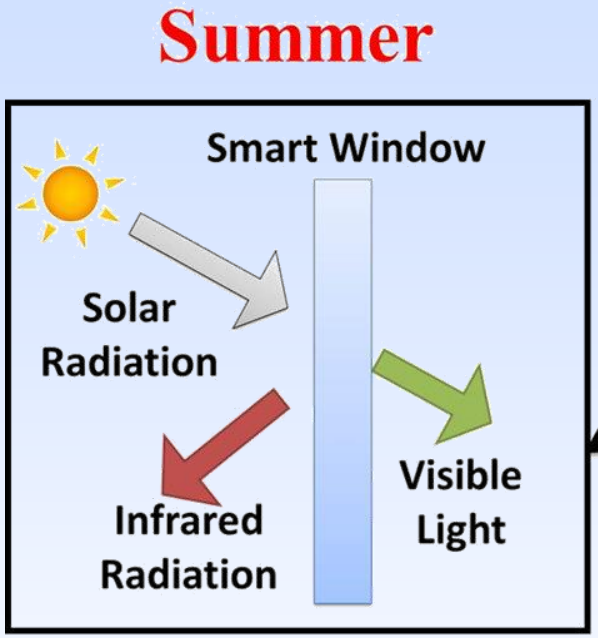
Light

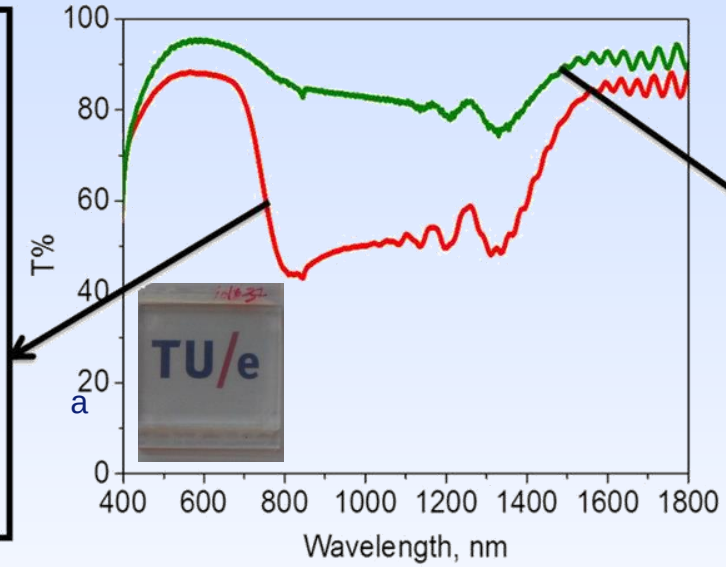
peer+
Smart Energy Glass

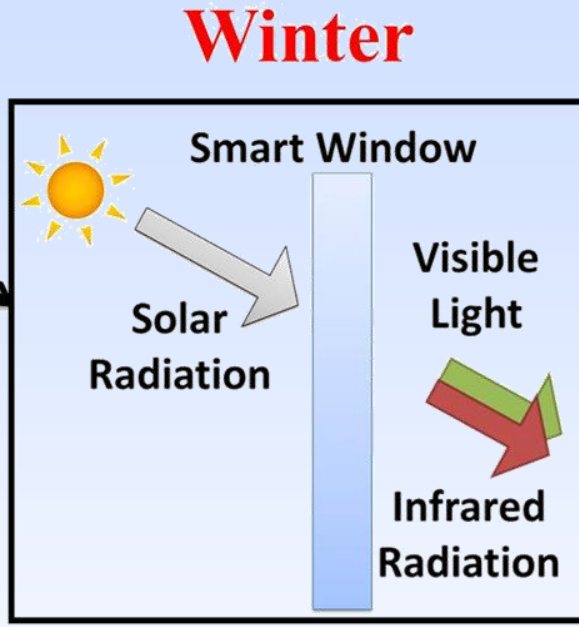
MERCK

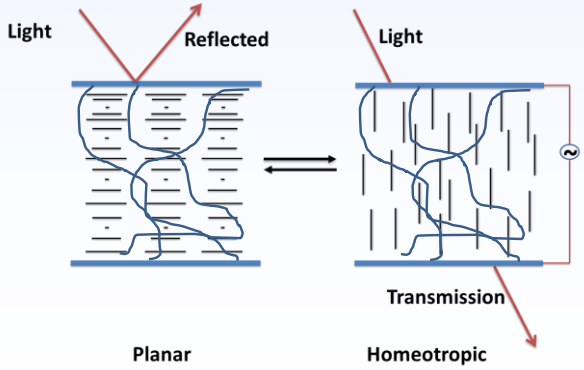
Casper van Oosten
Teun Wagenaar

Smart windows: Responsive IR reflectors



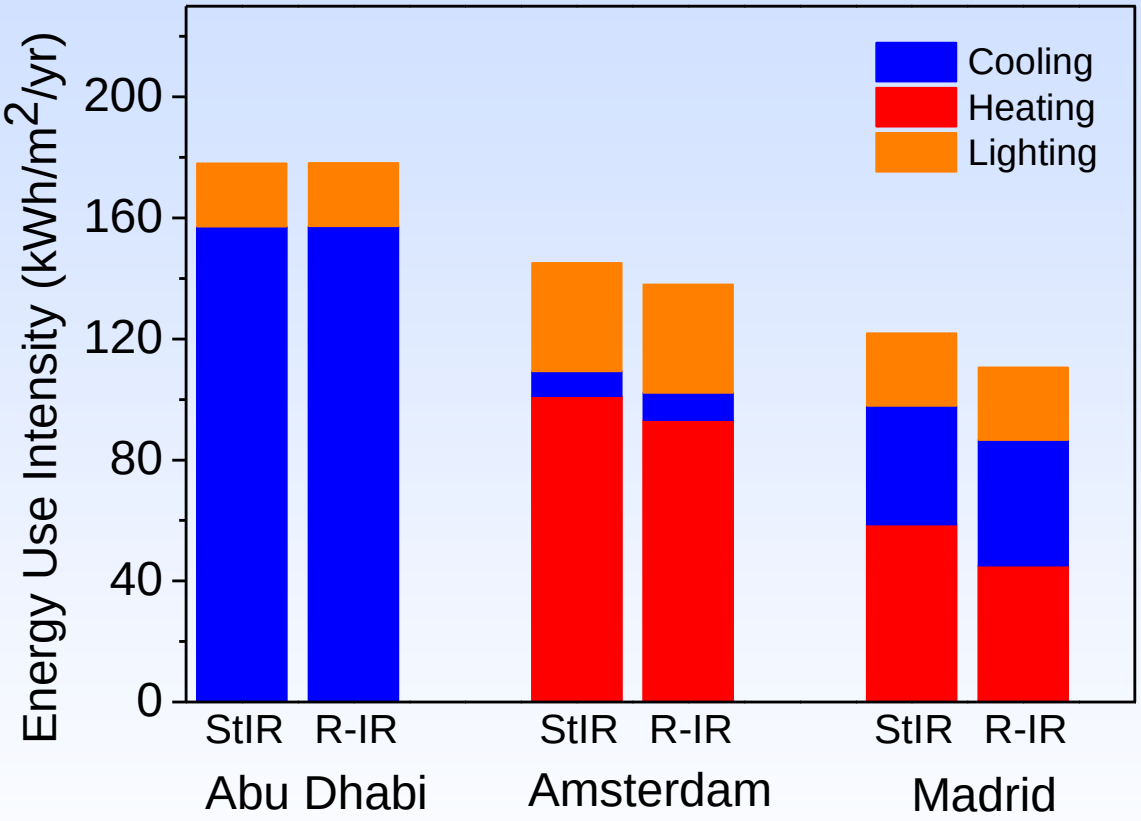






Hitesh Khandewal

Impact of Switchable IR Reflector on Energy Savings



Simulations

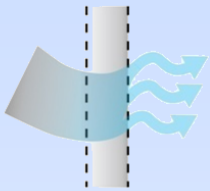
StIR: Static IR reflector
R-IR: Electrically switchable IR reflector

We have **NOT** considered the switching energy in these simulations!!

Smart Materials for Architectural Challenges

Air/Sound filter

Air and sound is selectively filtered through the surface. Unwanted smells and sounds are kept out.

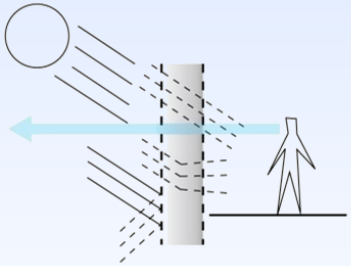


Self healing

Surface or other fractions of the material are self healing

Sun/View

Direct, difuse or none light is let inside, while the view is not obstructed



Structural Integrity

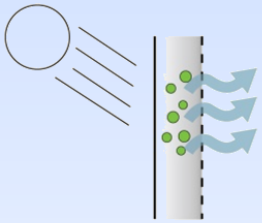
The surface is able to allocate different degrees of stiffness locally

Colour

Surfaces changes colour in order to maximize or minimize energy gain

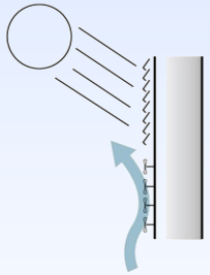
Oxygen

Surface turns CO_2 into Oxygen



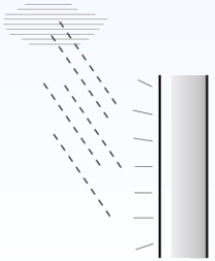
Electricity

The surface utilizes Sun and air currents in order to produce electricity



Clean/Protected

The surface stays always clean and is protected from pollution.



Architecture's wish list from brainstorm discussions with Tillmann Klein and colleagues (TU Delft, Building Technology & the Energy Club team)

Acknowledgement

NWO
Netherlands Organisation for Scientific Research

STW

DPI
DUTCH POLYMER INSTITUTE

SEVENTH FRAMEWORK PROGRAMME

DSM
BRIGHT SCIENCE. BRIGHTER LIVING.

sabic