Electro-Responsive Polymer Glazings For Smart Windows With Dynamic Daylighting Control

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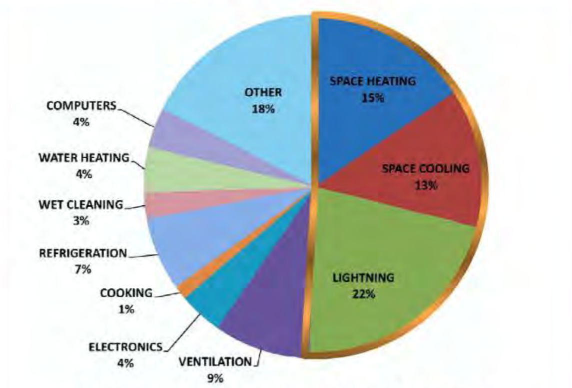
Introduction

In the context of alarming phenomenon of global warming as a consequence of increasing greenhouse gases beyond predictions, the development of energy efficient technologies is nowadays of a primary importance. Since the building sector accounts for 39% of total US primary energy consumption, fenestration can significantly contribute to lowering the energy use for heating, cooling, and lighting. In spite of the great research and engineering efforts in the fast growing area of smart windows, development of glazing devices able to provide efficient, durable, and inexpensive products for dynamic daylight control is in infancy. Here we report on the development of novel technology for switchable daylight-redirecting glazing with great potential to respond to the current market needs. Our research directions aimed the development of a prismatic optical element capable to change their geometry in response to an applied potential so that a control system could adjust the structure and thereby its optical properties in response to changes in the angle of incident light.

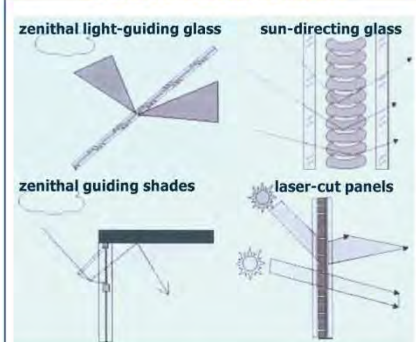
opportunity for more energy efficient building envelope and windows



forcast savings for energy efficient windows :
~1 quad/yr from daylighting
~ 3.6 quads/yr from conductive losses and unwanted solar heat

Buildings Energy Data Book, 2010 **http://buildingsdatabook.eere.energy.gov;**
D. K. Arasteh, S. Selkowitz, J .Apte, M .LaFrance. *Proc. ACEEE Summ. Study Ener. Eff. Bldg* **2006**

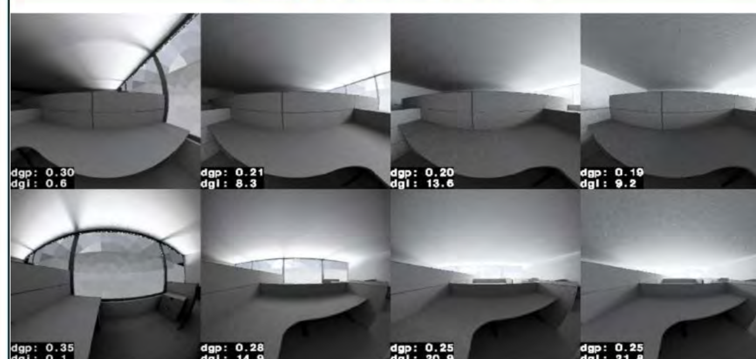
state-of-art of redirecting daylighting systems: brief overview



Current technologies fail to provide illumination into the depth of the room, glare control and sun-tracking at affordable prices

Daylight in Buildings:
A Source Book on Daylighting Systems and Components

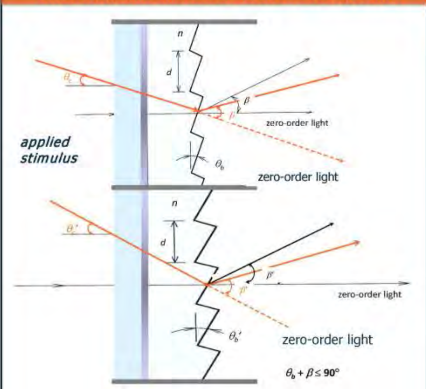
daylighting performance assessment and systems design using ray-tracing programme RADIANCE



Functional dPOE coatings have the potential to reduce U.S. commercial building lighting energy use by as much as 930 TBtu per year when coupled with dimmable lighting controls.

Shehabi, A. et al., Energy and Buildings 66 (2013): 415-423.

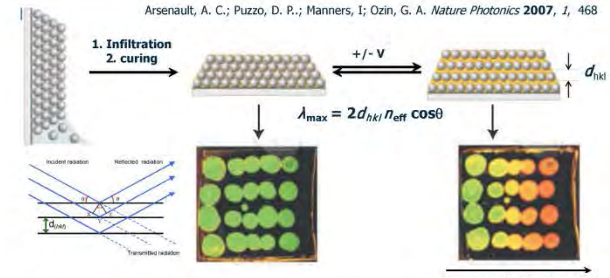
a new concept: smart materials for smart windows

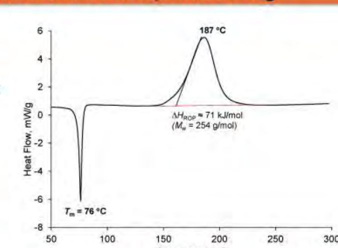


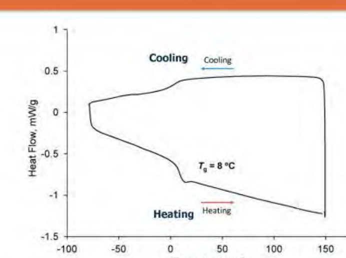
what materials can do the job?
stimuli responsive polymers:
electric current
temperature
light

polyferrocenylsilane (PFS) – a redox-active polymer: synthesis, characterization, and curing

Arsenault, A. C.; Puzzo, D. P.; Manners, I; Ozin, G. A. *Nature Photonics* **2007**, *1*, 468



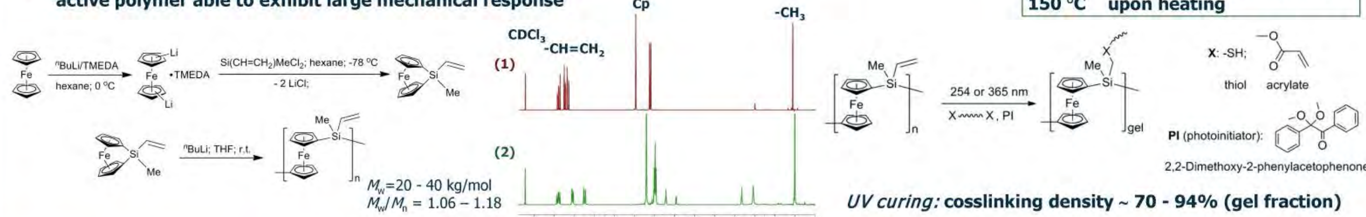




a demonstration of tuning colloidal photonic crystals color with redox cycling and degree of crosslinking using PFS as an electro-active polymer able to exhibit large mechanical response

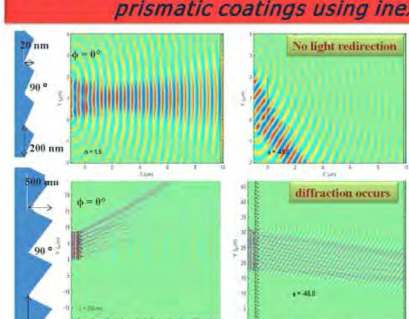
T_m: 76 °C	liquid monomer: polymerizes and crosslinkes upon heating

T_g: 8-12 °C	processable by mechanical embossing /imprinting at low temperatures
T_{XL}: 150 °C	thermal curing is achieved upon heating



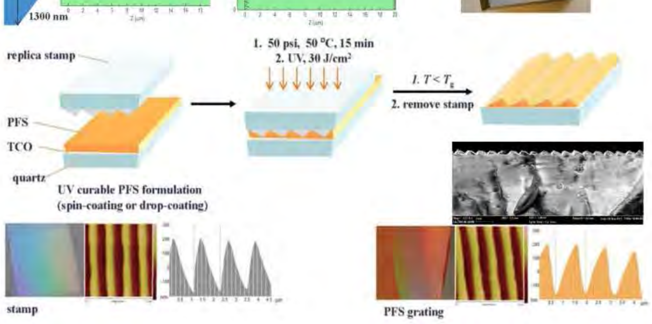
UV curing: **cosslinking density ~ 70 - 94% (gel fraction)**

simulated-driven designed and fabrication of electro-active prismatic coatings using inexpensive stamps

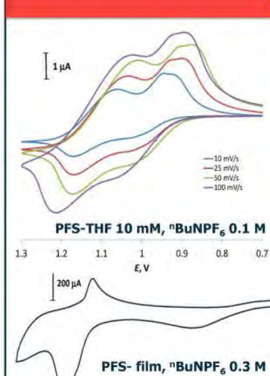


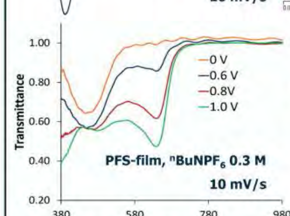
FDTD simulations are used to identify the geometries for which light redirection is achieved

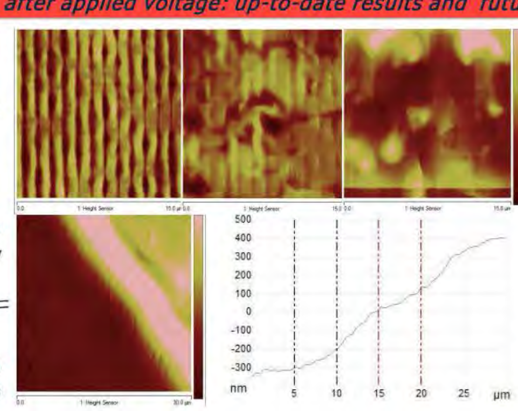
blaze λ (μm)	1.20
blaze angle	29.9°

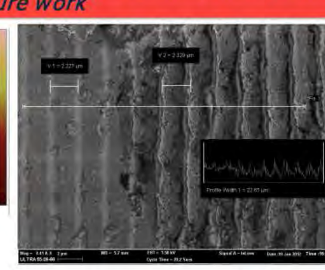


spectro-electrochemical characterization and surface analysis of the electro-actuated grating before and after applied voltage: up-to-date results and future work









surface analysis at the interface pristine-oxidized PFS films for a total film of 2 μm (AFM, left) and 40 μm (SEM, above)

***next challenges to be addressed*:**
controlled film response with applied voltage as a function of croslinking density and film thickness • charge transport • reversibility and life cycle

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