SAND2009-2968P

Energy Efficient Materials:
Application to
Energy Production and Conservation

Kate Helean, 6786
Allen Ricks, 1532
Alicia Aragon, 6315
Tom Laub, 1341

ENG 300

Presentation Outline

- Building Materials
  - Roofing
  - Smart windows
- Smart‘er’ Materials
  - Photovoltaic windows
  - Color changing paints
- Phase Change Materials (PCM)
- Sandia’s Potential Role

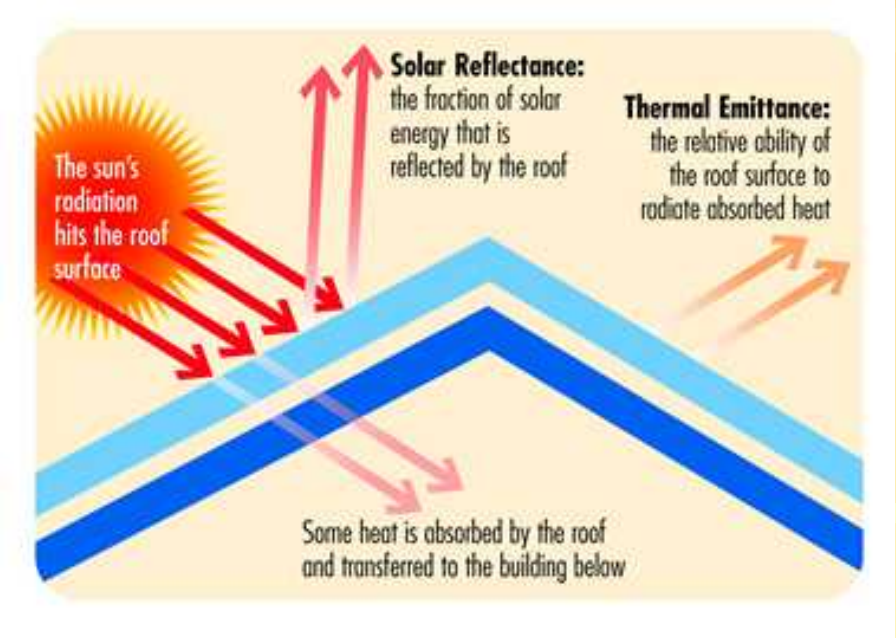
Energy Efficient Building Materials

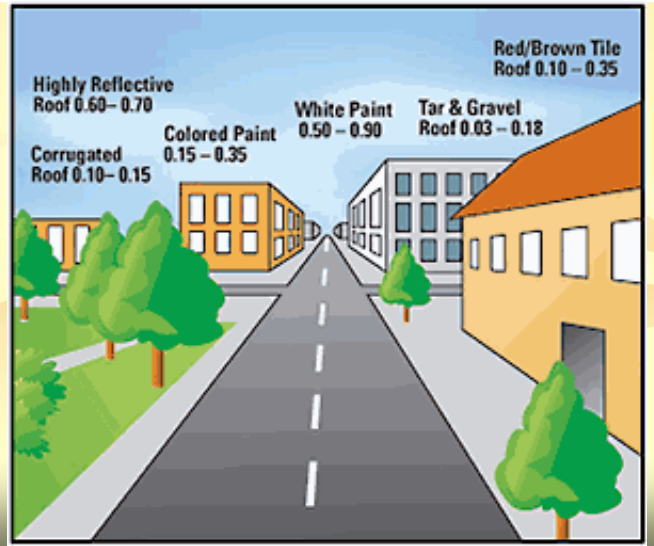
Cool!

Smart!

‘Cool' Roofs

- Cool roofs reflect sunlight and reradiate absorbed heat as light energy back to the atmosphere, rather than transferring absorbed heat to the building below
- **Materials**
  - Shingles
  - Coatings
  - Membranes
  - Metal
  - Tiles
- **Properties of Interest**
  - Solar reflectance
  - Thermal emittance
  - Solar reflectance index
  - Temparature rise

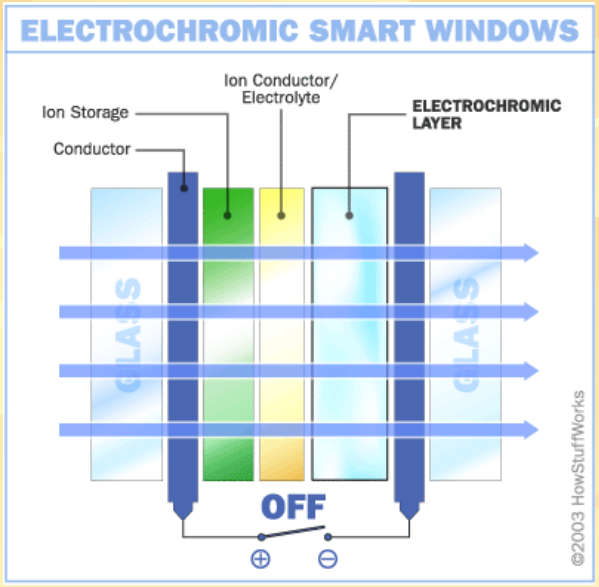


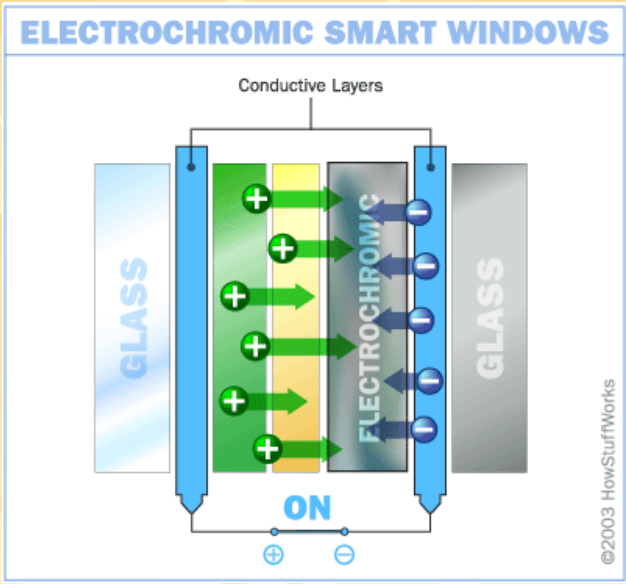


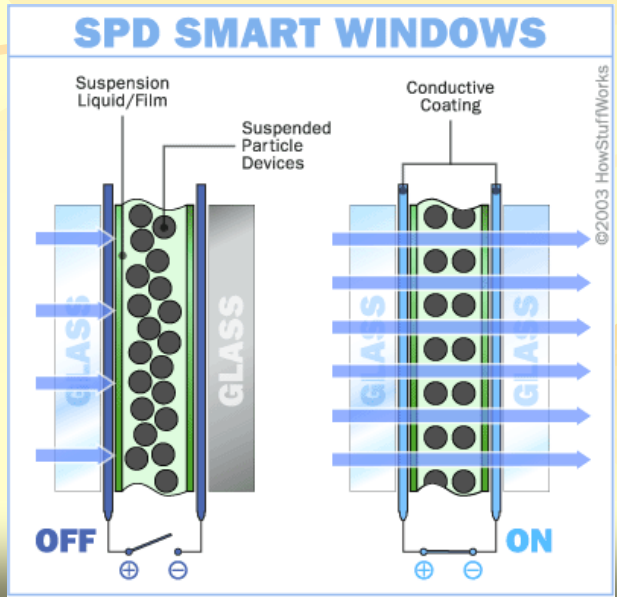
www.coolroofs.org http://eetd.lbl.gov/coolroof

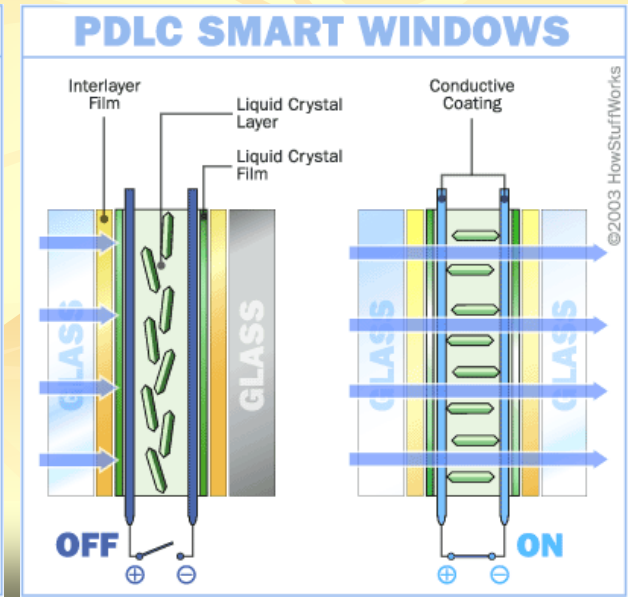
‘Smart’ Windows & Skylights

- Change opacity with applied voltage, heat, or UV light
- Electrochromic
- Suspended particle devices (SPD)
- Polymer dispersed liquid crystal devices (PDLC)
- Thermochromic
- Photochromic









www.consumerenergycenter.org

www.howstuffworks.com

How can we improve these materials?

- Engineer the material properties of interest
- Properties are tailored ‘one way’, can we make them efficient ‘both ways’ – cool in the summer AND heat in the winter
- Expose the right material at the right time – summer roof/winter roof, summer window/winter window
- Layers of materials to optimize properties
- Engineer window glass to switch between reflective and transmissive, rather than just transparent/opaque

What are Smart‘er’ Materials?

Materials that have one or more properties that can be significantly changed in a controlled fashion by external stimuli, such as stress, temperature, moisture, pH, electric or magnetic fields.

Smart Materials Definition from Wikipedia

Examples of Smart‘er’ Materials

- Piezoelectric materials
- Shape memory alloys and shape memory polymers
- Magnetic shape memory alloys
- pH-sensitive polymers
- Temperature-responsive polymers
- Halochromic materials
- Chromogenic systems
- Non-Newtonian fluid
- Ferrofluid

RSi Solar Windows

- A company called **RSi Solar** has announced that they've created **transparent, photovoltaic glass window**.
- RSi claims that these solar windows could generate **80 - 250 watts each**, depending on the size.
- Another important feature is that they **reduce heat**, which reduces cooling costs and they provide a 100 percent reduction in infrared an UV radiation .
- RSi Solar further claims that this new design could result in energy savings greater than 50 percent.

http://www.businesswire.com/portal/site/home/permalink/?ndmViewId=news_view&newsId=20081210006113&newsLang=en

Color Changing Paint

- Scientists have developed a new form of paint that changes color with the touch of a button.
- Hyped as an automotive technology, but could be used for building roofs and siding.
- The color could be changed by a thermostat or light sensor from white to black depending on the desire to absorb or reflect light energy.
- The color could even be adjusted to absorb just the right amount of light energy.

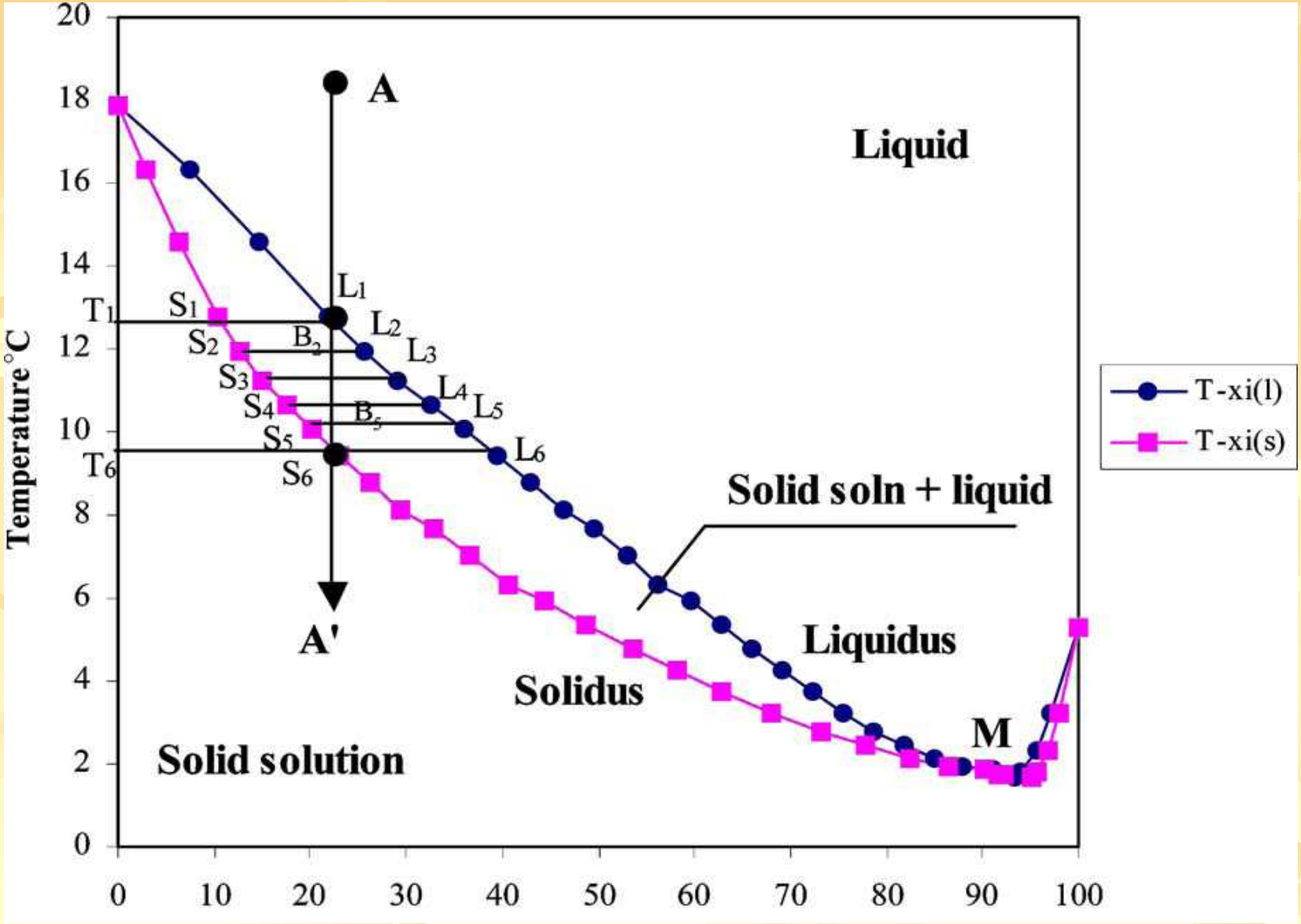
http://www.nextenergynews.com/news1/next-energy-news-paramagnetic-paint.html

Phase Change Materials (PCM)

Materials that change phase based on temperature, rather than requiring external energy inputs. They absorb and store heat during one phase change and radiate heat during another

Heat Storage in PCM

- Thermochemical property, latent heat is the amount of energy absorbed (endothermic) or released (exothermic) by a substance during a change of state.
- PCMs investigated for cooling electronic components, also for heating/cooling applications in the home. These systems are scalable.
- Q = mL energy divided by mass gives the latent heat in J/kg
- Equilibrium phase diagrams are a fundamental tool for determining thermal storage properties of substances or mixtures and are typically derived using theoretical models, DSC measurements and the thermal sensor method.
- PCM: paraffin wax, eutectic salts such as sodium sulfate hydrates and calcium chloride hydrates and water. PCM selected for their high latent heats of transition, high thermal storage densities, small volume change upon fusion/solidification.


Temperature °C
X (mole %)
A
A'
Liquid
Solid soln + liquid
Liquidus
Solidus
Solid solution
M
L1
L2
L3
L4
L5
L6
S1
S2
S3
S4
S5
S6
T1
T6
B2
B5
T-xi(l)
T-xi(s)
0
2
4
6
8
10
12
14
16
18
20
0
10
20
30
40
50
60
70
80
90
100

Optimization of PCM

- Storage density = length B_2L_2 / length S_2L_2 multiplied by ΔH_{pt}
- Adding thermochromic chemicals to alter reflection/transmission properties of PCM
- Additives to increase thermal conductivity
- Adding nucleation enhancers to modify heat flow characteristics
- Thermochemical modeling and measurements to inform engineering designs

Sandia's Role

- The future of smart materials is to engineer them at the atomic scale.
- Sandia's Center for Integrated Nanotechnology can play, or may already be playing, a leading role.
- Once the physical laws governing materials at the nanometer scale have been discovered at CINT and elsewhere, Sandia's Modeling and Simulation capabilities are well-suited to carry on research of novel new smart materials.