Retroreflective films: constructions, history, and applications

Don McClure
Acuity Consulting and Training
AcuityCT@hotmail.com
31 La Villa Way
Ft. Pierce, FL 34951
651-470-6939
Retroreflective Films

• Several large volume suppliers – my 3M bias
• Classes of retroreflective films – overview
  • glass beads
  • cube corners
  • many variations in designs (and materials)
    • responses to problems
• Don’s interactions
  • Truck conspicuity films
  • A gold-medal-winning product
  • “Improved durability” work-zone-safety products
• Newer retroreflective products
• Transflector
Retroreflective Material
based on glass beads
beads need very high index
Retroreflective Material
based on glass beads – with spacer layer
Glass beads with metal reflector

Product Examples

highway signing
Glass beads with metal reflector

consumer high-visibility apparel
Glass beads with metal reflector

day

night

high-visibility work zone apparel
Glass beads with metal reflector

day

night

high-visibility work zone apparel
Retroreflective Material
based on glass beads

area selective removal of reflector layer
to add images of various kinds

Hidden images
  – viewer required
  – security documents

Floating or virtual images
  – 3D line drawings
Retroreflective Material
based on cube corners

Many cube corner structures use total internal reflection and do not need a metal reflector
Problems (！)

What about water droplets on the surface of these retroreflectors?
No retroreflection – signs/devices appear dark (black)!
Solutions

Images from:
John Lloyd, “A brief history of retroreflective sign face sheet materials”
Prelude to Don’s involvements

3M retroreflective sheeting business – quite large, based on large roll-to-roll, aluminum evaporators – with manufacturing plants on four continents.

All my contributions involved changes to that mfg. pattern.
Evaporated aluminum on cube corners

Flexible Truck Conspicuity Sheeting
Evaporated aluminum on cube corners

poor adhesion on molding-grade polycarbonate

We had “fairy dust” solution in-hand based on Mercury Sable lamp: Fresnel reflector – late 80s

It was quickly demonstrated for conspicuity sheeting (in the lab).

Near-zero budget to modify the manufacturing tool.

Cathode from storage plus unused power supply.

Process quickly optimized for environmental durability.
“Improved durability” work-zone-safety products

Industrial wash services moved to higher-pH detergents. Aluminum films slowly converted to transparent oxides. Many additions and variations to the aluminum process were attempted: all failed.

Solution: Use silver reflectors in place of aluminum

Transfer to manufacturing was successful!
Gold metallized cube corner sheeting

Michael Johnson’s gold medal running shoes
(2000 Sydney Australia Olympics: two races – two gold medals)
narrow width and short length: pilot coater
Other retroreflector variations

Transparent reflectors
Fluorescent material
DG³
Transparent reflectors

evaporated ZnS and cryolite
on glass beads

“Confirm” Brand Security Film

Confirm™ Security Laminate
Passports, ID Cards, Driver’s Licenses, etc.
Fluorescent reflectors

Concept: in sunlight, a sign with fluorescent color appears brighter than “expected.”

It stands out!
Problems (!)

Not all the light entering these retroreflectors is returned.

**Glass beads**
- Dead areas at the edges of each bead
- Dead space between beads
- Beads may fall out
- Less efficient than cube corners
- More light return at high angles

**Cube Corners**
- Dead areas at the edges of each cell
- No dead space between cells
- More efficient than glass beads
- Less light return at high angles
3M™ Diamond Grade™ DG³ Reflective Sign Sheeting

Conventional cube corner sheeting is brighter than glass bead sheeting but still presents a large amount on optically inactive area to the viewer.

Eliminates the dead areas

Images from:
John Lloyd, “A brief history of retroreflective sign face sheet materials”
Comparing three (of many) types

- Engineer Grade Beaded
- High Intensity Prismatic
- Diamond Grade™ DG³
Evaporated Silver on Microstructured Acrylate

Tilted Mirror Film: High-gain transflector for handheld LCDs
Questions??

Comments!!

Demo??

Act justly, love mercy, walk humbly.