



# Nanotechnology and Packaging

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# Nanotechnology applications

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- Current commercial uses of nanotechnology in packaging
- Emerging uses
- Future possibilities?



# PIRA – 2004 report

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- Longer shelf life
  - Improved barrier, absorbing compounds, UV absorbers
- Hot fill
  - Improved high temperature performance
- Flexible packaging – thin films
- Functionality
  - Anti-counterfeit, anti-tamper, anti-microbial, sensors (temperature, moisture, light, decay), integrated power (intelligent tags, self-healing containers)



# Pira – cont.

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- Increasing use for
  - Gas barrier
  - Oxygen barrier
  - Food packaging
  - Films



# Pira – cont.

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- Other uses
  - Nano barcodes – track & trace, sensing
  - Production process for paper
  - Nanoscale pigments for inks
  - Nanomaterials for color without use of dyes or conventional pigments
  - Nanomaterial electronic displays with quality of paper



# Types of applications

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- Barrier materials
- RFID
- Active/intelligent packaging
- Other



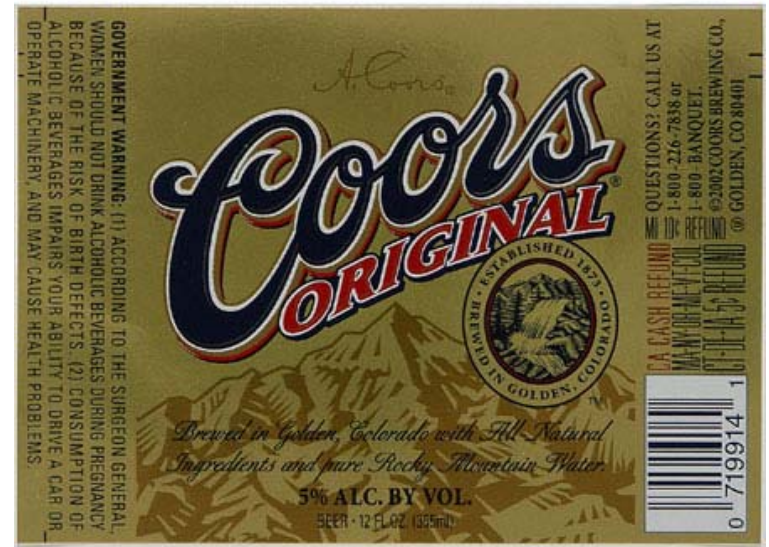
# Metalized film

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- Al thickness 400-500A = 40-50 nm
  - Replacement for aluminum foil laminations
  - Provides barrier, especially to oxygen
  - Permits downgauging of films
  - Limits disposal impact
  - Saves money

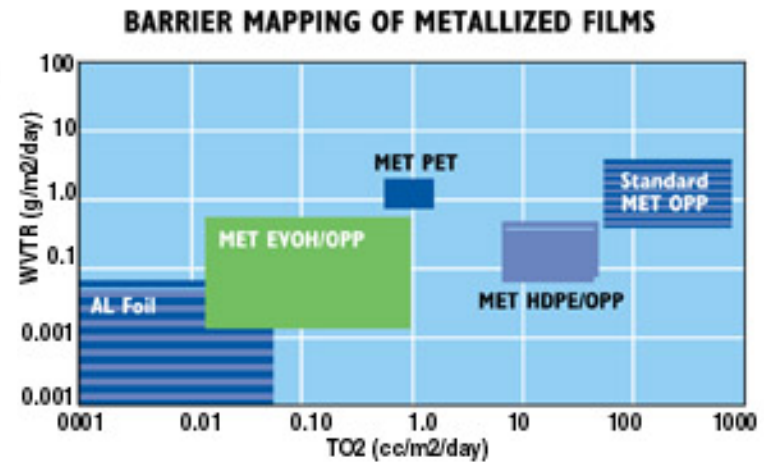
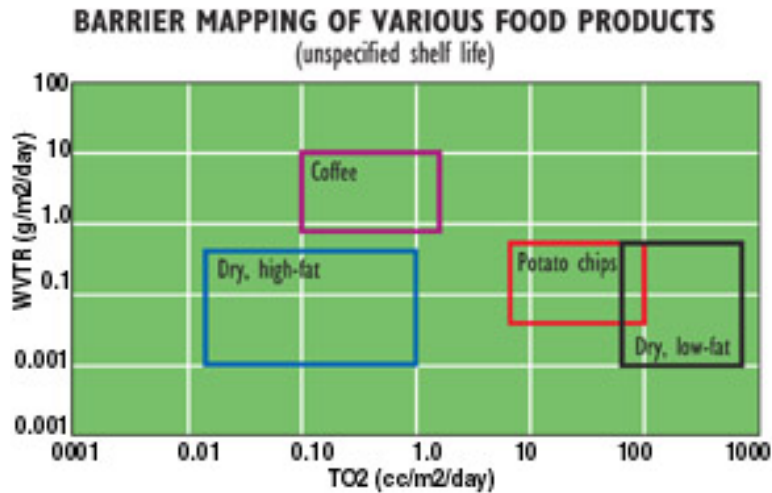
# Metallized films

Add barrier



Enhance appearance

# Barrier requirements



# Other barrier materials

- SiO<sub>x</sub> coatings
  - Transparent, unlike metallized
- Al oxide coatings



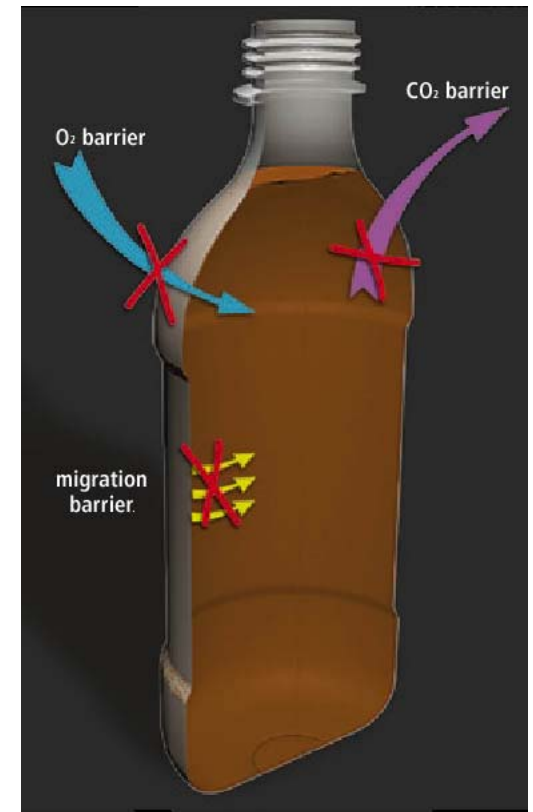
# Silicon oxide barrier coating

- Silicon oxide
  - 40-60 nm thickness
  - Glaskin one major brand
  - BestPET another
  - Inside, usually, but can be outside



# Amorphous carbon

- Sidel – tradename Actis
  - About 200 nm thick
- Coating on inside of bottle
- Plasma Nano Shield
  - Ionizes gas
  - 20-40 nm thick





# Sidel system

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- Uses acetylene gas
- Introduced into bottle
- Excited to plasma state
- Bonds to PET bottle wall on contact
- Actis Lite
  - Thinner layer for less sensitive foods



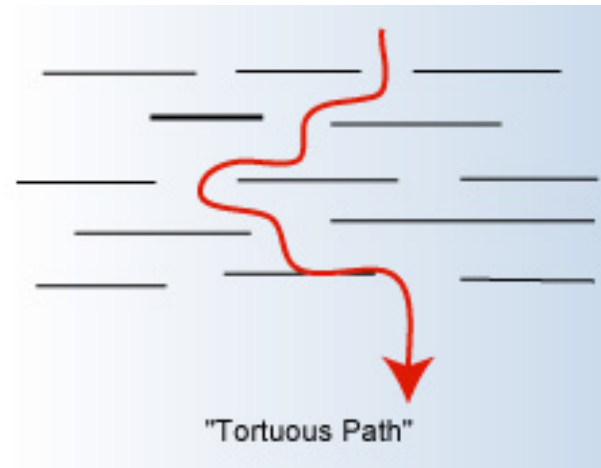
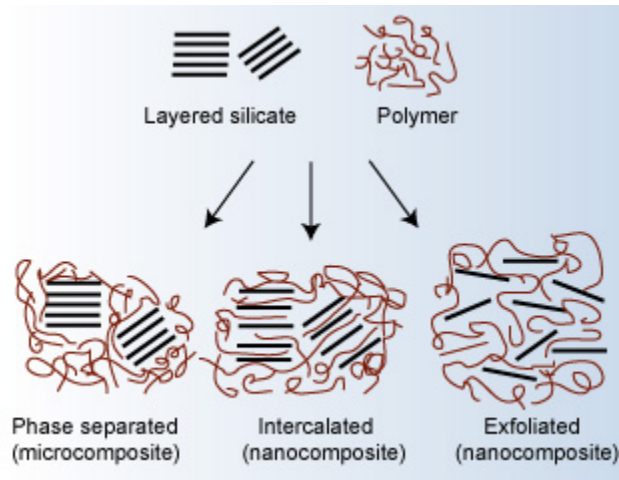
# Combustion chemical vapor deposition (CCVD)

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- “Nanomiser” atomiser vaporizes coating precursor
- Delivered to a flame to generate coating
- Organic coatings polymerized by heat
- Submicron thick layers – nano??
- Company: MicroCoating Technologies

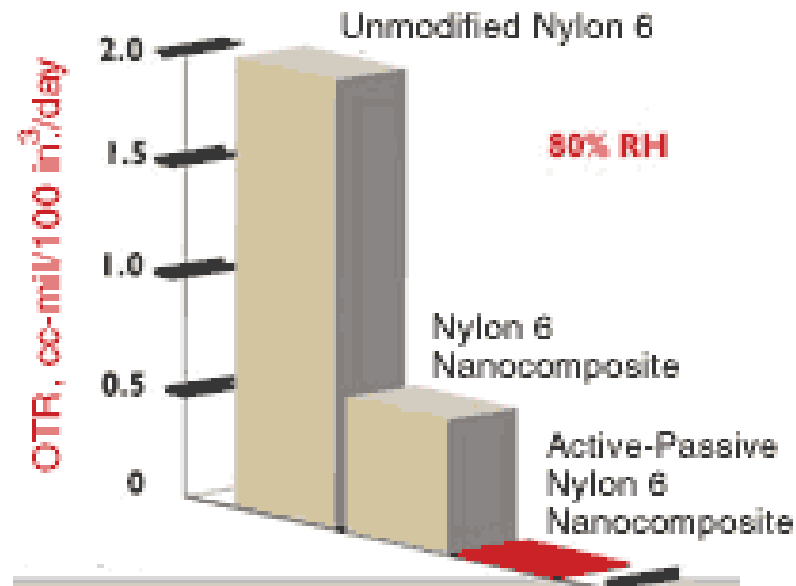
# Nanocomposites

- Most based on clay
  - Montmorillonite, usually
- Barrier improvement primary



# Nanoclay Composites

- 10% clay can cut permeation as much as 75%



# Nanocor

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- Nanoclay with MXD6 nylon as component in barrier layer in beer bottles
  - Plates are nanometers thick, aspect ratio above 200:1





# Other companies

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- Honeywell
  - Nanoclay in nylon 6 blends
  - Brand name Aegis
- Others
- Film as well as container
- Improve stiffness as well as barrier

# Nanocomposite barrier coatings

- Solplas



- Organic/inorganic coatings
- Plasma-assisted deposition
- Barrier and antimicrobial layers



# RFID

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- Track, trace, record history
  - Active – have battery, send signal
    - Very expensive
  - Passive – get energy from probing signal
    - Much less expensive; can be read-only or read-write
- Nanotechnology used in manufacture
- Smaller chips in future?



## RFID - cont

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- Wal-Mart, Defense Dept. the current drivers
- Case scale for now
- Tagging of individual items the goal
- Potentially query by satellite & locate
- May add environmental sensing



# RFID Future

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- RFID tags can trigger action
  - Tesco
    - Tag in razor blades, triggers camera when packet removed from shelf
    - Second camera takes picture at checkout
    - Security can compare the two for theft prevention
  - Gillette
    - Smart Shelf technology – alert when stocks low or products stolen



# RFID Alternatives

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- Smarter bar codes
  - Less expensive alternative to RFID
- Nanosensors



# Active Packaging

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- Antimicrobials
  - Silver-based
    - AgION
  - Other inorganic
  - Organic



# Sensors

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- Sensors
  - Environmental conditions
    - Temperature
  - Contaminants
    - Bacteria
    - Toxins

The logo for Strathclyde University, featuring a stylized 'S' composed of overlapping yellow, red, and blue squares, with a black crosshair.

# Strathclyde University

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- Film that changes color with oxidation of food inside package
  - Based on nanocrystalline semiconductor technology
  - Printable on paper, plastic, or metal
  - Easily handled
  - Color, sensitivity can be changed



# Others

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- Dublin University
  - Printable oxygen and carbon dioxide sensors
- University of Leeds
  - Incorporation of oils and oil-soluble sensors
    - Fragrance release
    - Color change
    - Anti-counterfeiting



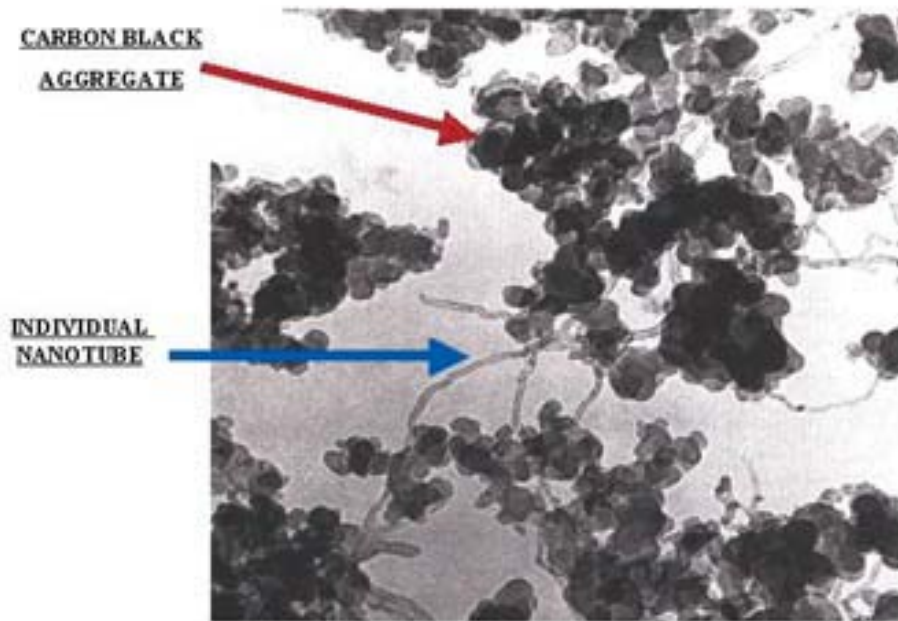
# Other applications

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- Appearance
- Physical properties
  - Increase stiffness but maintain flexibility, impact strength
  - Reduce elongation
  - Improve thermal properties

# Carbon nanotubes

- Stiffness improvement
- Electrical conductivity



# Metalized paper

- Primarily for appearance
  - Glossy look of metal
  
- Metallized film can also be used for appearance





# Pigments

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- Nano-dispersed water-based pigments
  - Degussa, Clariant, designed for ink-jet printing
- Colors generated by dispersions of uniformly sized particles



# Papermaking

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- Retention and drainage systems
  - Colloidal silica sols and cationic polymers
  - Highly active surface, high charge density
  - Enhanced flocculation and improved fiber retention and water drainage



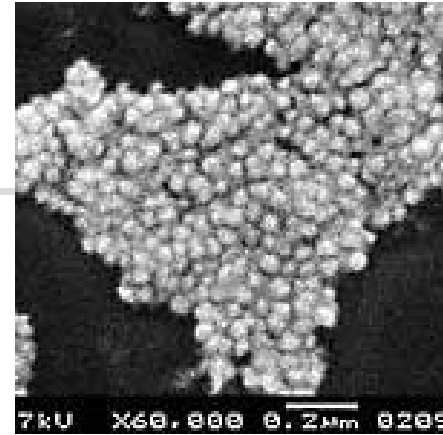
# Paper Coatings

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- Inorganic/organic hybrids
- Mineral-based coatings
- Polymer-encapsulated nanoclay hybrids

# Adhesives

- EcoSynthetix Inc.
  - Lansing, MI
  - EcoSphere nanoscale starch adhesive
    - Corrugated board adhesive
    - Particles 50-100 nm
    - Higher solids content, so dries faster
    - Remains stable in liquid form longer than conventional





# Others

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- Ultrathin films
  - Films or monolayers 1-5 nm thick
    - Organic or inorganic
- Single layer clays
- Microtaggants
  - Encoded particles act as “fingerprints”



# Others

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- Biosensors
- Carbon nanofibers
- Carbon dioxide to biodegradable plastics using nanotechnology
- Nano-size capsules to store antioxidants or flavors inside foods until eaten, or nutraceuticals until reach intestine
- Nano-filters to remove undesirable food components