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2009 Symposium on Nanomaterials for Flexible Packaging





2009 Symposium on Nanomaterials for Flexible Packaging



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2009 Symposium on Nanomaterials
for Flexible Packaging

Printed Intelligence in Packaging: Current and Potential Applications of Nanotechnology



**THE QUEBEC
INSTITUTE OF GRAPHIC
COMMUNICATIONS**

Islem A. Yezza
Project Manager
Smart and Sustainable Packaging

Few facts about food safety and counterfeiting

An estimated 76 million people in the United States get sick every year with foodborne illness and 5 000 die,

Source: The U.S. Center for Disease Control and Prevention

In the worldwide market, counterfeiting is estimated to account for \$700 billion in sales, or 8 to 10 percent of all global trade,

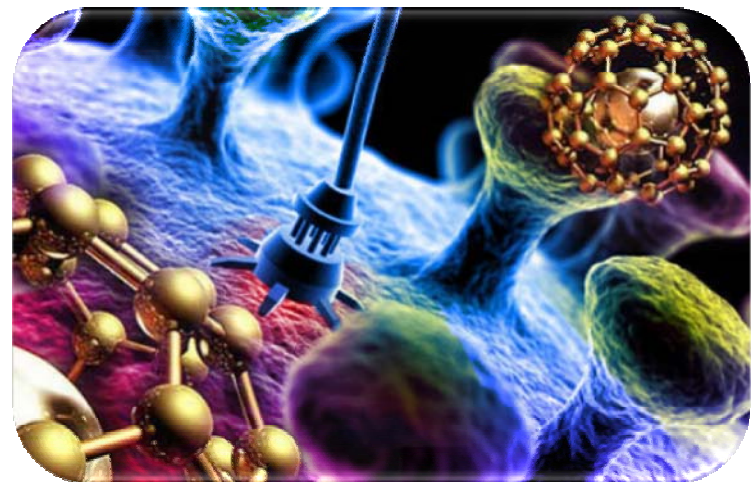
Source: The International Chamber of Commerce

Could **Nano-Printed Intelligent Packaging** be a Solution?



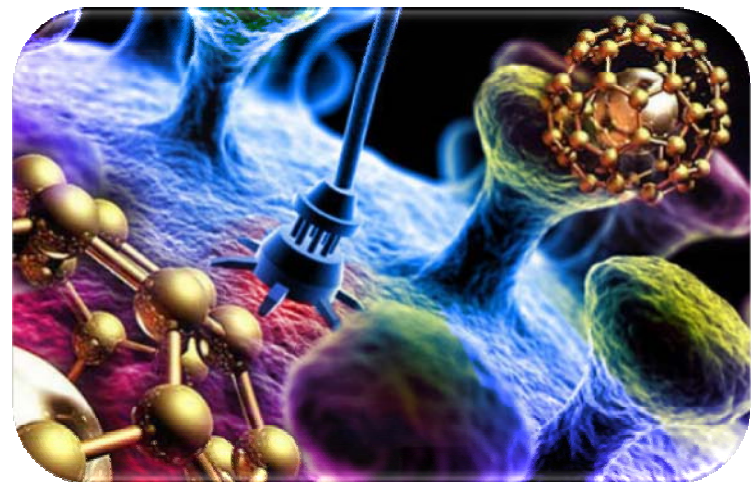
What we will talk about today

1. Intelligent packaging
2. Printed intelligence
3. Nanotechnology and packaging
4. Nano-printed intelligent packaging :
current and potential applications
5. Take Home...



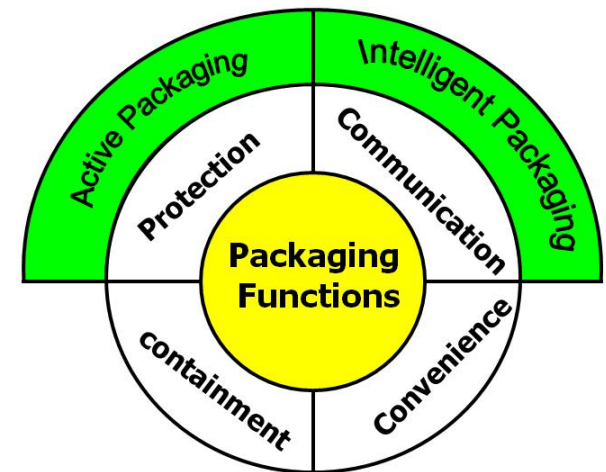
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IP: Track, Sense and Communicate

- **Intelligent packaging:** systems that monitor the condition of the packaged food to give information about the quality during transport and distribution
- IP is a packaging that has the ability to:
 1. **Track** the product
 2. **Sense** the environment inside or outside the package
 3. **Inform** the manufacturer, retailer and consumer



Model of packaging functions (Yam et al. 2005)

Intelligent Packaging Applications

- The global smart packaging market will grow to **\$4.8 billion** in 2011 and reach **\$14.1 billion** in 2013

Source: NanoMarkets, 2006

1. Tamper evidence/pack integrity
2. Safety/quality
3. Traceability/anti-theft
4. Product authenticity



Intelligent Packaging

Sensors

Gas sensors

Fluorescence based oxygen sensors

Biosensors

Indicators

Integrity indicators

Freshness indicators

Time Temperature Indicators

RFID Tags





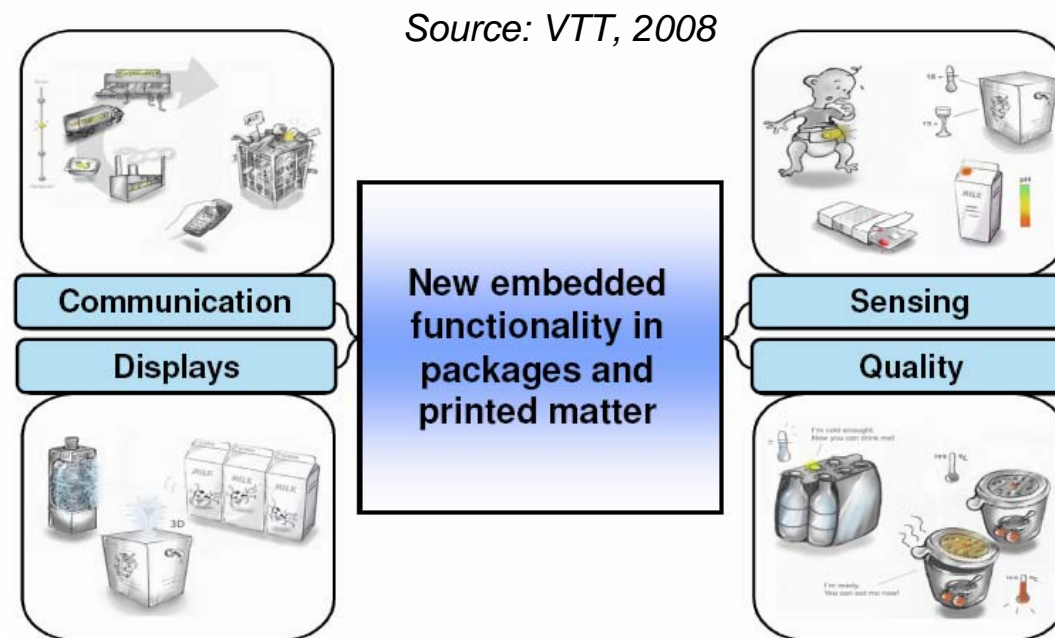
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What is printed intelligence?

Printed intelligence are components and systems, which:

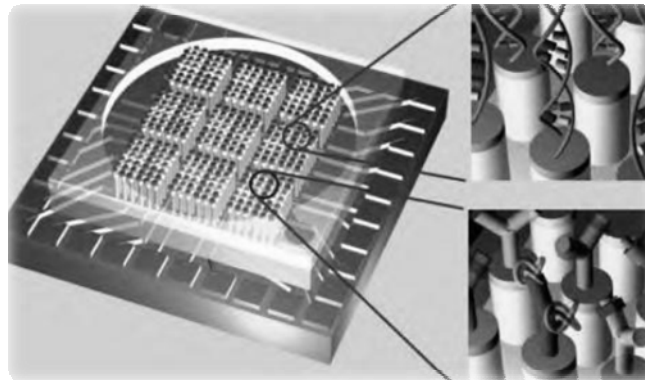
1. Extend the functions of printed matter beyond traditional visually interpreted textual and graphical communications
2. Perform actions as a part of functional products or information systems



Printed Intelligence

Printed intelligence is based on innovative multidisciplinary technology integration of:

- Printing like mass-manufacturing methods, ink-like innovative material technology, and
- Functionalities created from electronics, biotechnology, chemistry, optics, optoelectronics or their combinations

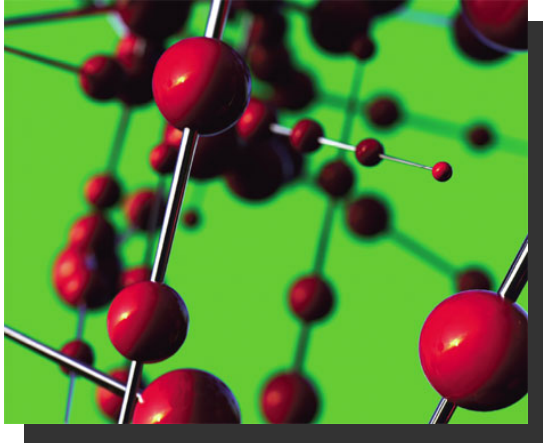




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Nanotechnology and intelligent packaging: market and forecast



Nano food and beverage packaging market was \$1.1 billion in 2005, and forecast to reach \$3.7 billion by 2010

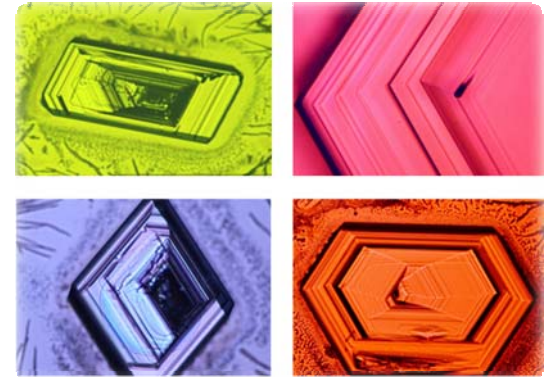
Source: Helmut Kaiser Consultancy, 2007

- Commercial use now : between 400 and 500 nanopackaging products
- Nanotechnology to be use within the next decade : manufacture of **25% of all food packaging**

Source: Helmut Kaiser Consultancy, 2007

The packaging benefits of Nanotechnology

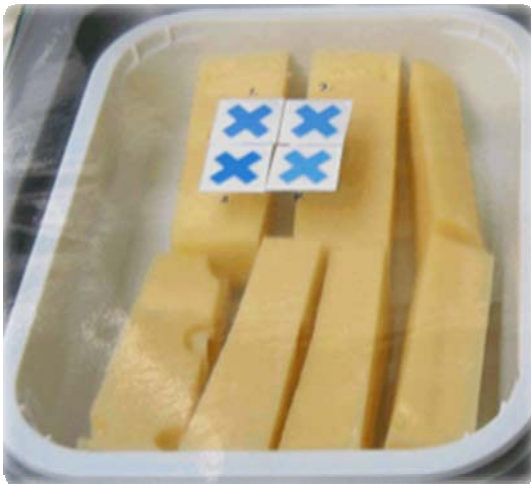
Nanotechnology is expected to have an important influence in packaging. The major market trends include:



- Improve polymer properties to extend shelf life
- Incorporate antibacterial functions
- Make packaging interactive
- Create new functional coatings, sensors and smart inks
- Fabricate printed intelligent sensor and indicator for flexible packaging

Nanoprinted Intelligent packaging

- Visual and/or optically readable, low cost indicators attached or printed on packaging material
- Components are manufactured into the products using already existing printing techniques



New functionalities:

- Advisable, entertaining and impressive
- Increased informativity
- Link between the product and the intelligent environment

Source: VTT, 2008

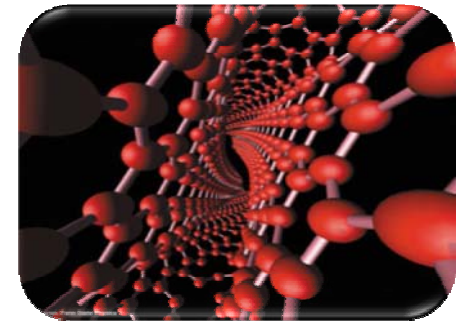
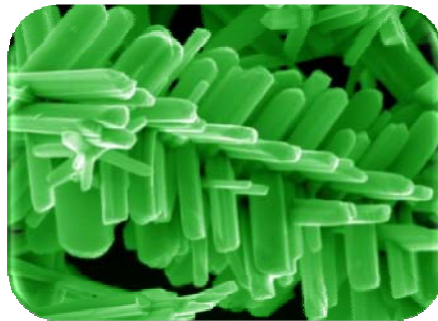
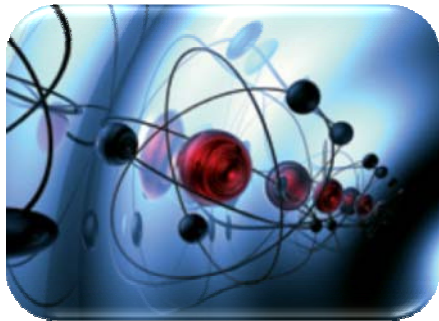


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Current and Potential Applications of Nanotechnology

1. Nano-sensors for pathogen and contaminant detection
2. Nano-scale freshness indicators
3. Nano-particles based intelligent inks
4. Ink-based RFID circuits
5. Nano-barcodes for track and trace



Nanosensors

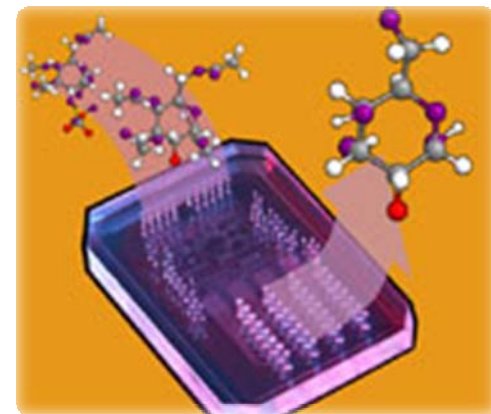
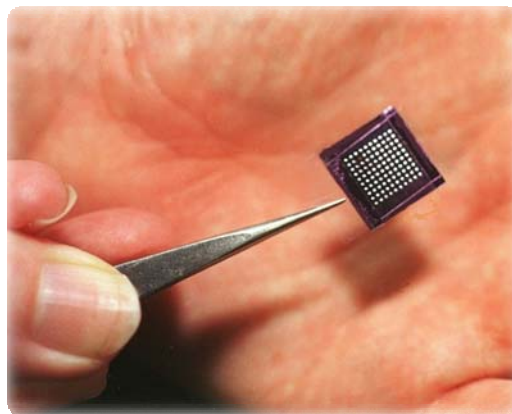
Nanoscale sensors have been emerging as a feature of recent nanotechnology applications for food safety and quality measurement



- When integrated with food packaging, nanosensors can detect chemicals, pathogens, and toxins in food
- Nanosensors can also detect allergen proteins to prevent adverse reactions to foods such as peanuts, tree nuts, and gluten
- Nanoscale sensors can be printed onto the packaging

Nanosensors as 'electronic tongue' or 'noses'

- Such nanosensors could be placed directly into the packaging material, where they would serve as 'electronic tongue' or 'noses' by detecting chemicals released during food spoilage
- Sensors can detect substances in parts per trillion and would trigger a colour change in the packaging to alert the consumer if a food has become contaminated or if it has begun to spoil



The Food Sentinel System™

- FSS is a biosensor system capable of continuous detection of pathogens in food packages
- A specific-pathogen antibody is attached to a membrane-forming part of the barcode
- Presence of contaminating bacteria will cause the formation of a localized dark bar, rendering the barcode unreadable upon scanning



SAFE PRODUCT

Bar Code Food Safety Label

Safe Food Handling Instructions

- Keep refrigerated or frozen.
- Wash working surfaces (including cutting boards), utensils, and hands after touching raw meat or poultry.
- Cook thoroughly.
- Keep hot foods hot. Refrigerate leftovers immediately or discard.

FOOD SENTINEL SYSTEM: To assure safe handling, this package is being automatically monitored for proper refrigeration and shelf life by time and temperature-sensitive barcodes. Abused product can also be visually identified by an extra wide, colored bar in the lower bar code.

Sure  Pure

Tare	Store No.	Sell By
Net wt/ct	Unit Price	Total Price

Nanosensor packaging under development

Company/ Institution	Nano content	Purpose
Georgia Tech in the United States	Multi-walled carbon nanotube- based biosensor	Detects micro- organisms, toxic proteins, or spoilage of foods and some beverages (Nachay 2007).
University of Southampton UK & Deutsches Kunststoff- Institut, Germany	"Opal" film, incorporating 50nm carbon black nanoparticles	Changes color in response to food spoilage (El Amin 2007d).
University of Strathclyde, Scotland	UV-light activated, nano titanium- dioxide based, oxygen-sensing ink	Tamper proofing (El Amin 2006a).
Australian company MiniFAB	Nanotechnology- based biosensors	Detect biological contamination (Invest Australia 2007).

Source: Friends of the earth, 2008

Nanosensors to detect *Salmonella*

The main aim of nanosensors is to reduce the time for pathogen detection from days to hours or even minutes

1. Dutch Bionanotechnology Centre for Food and Health Innovations used nanoparticles to build devices that sense the DNA of microbes such as *Salmonella* or *Listeria* (CBC, March 2009)
2. US Department of Agriculture's Research Service (ARS) and University of Georgia developed a nanorod-based biosensor that enables rapid detection of the *Salmonella* pathogen with high sensitivity. The sensor include fluorescent organic dye particles attached to *Salmonella* antibodies; the antibodies latch onto *Salmonella* bacteria and the dye lights up like a beacon, making the bacteria easier to see. (Food Production Daily, January 2009)



Freshness indicators

Visual Freshness indicator for Poultry

- Nanolayer of silver reacts with hydrogen sulphide and forms silver sulphide
- Difference in optical : a visually detectable colour change From light brown to White



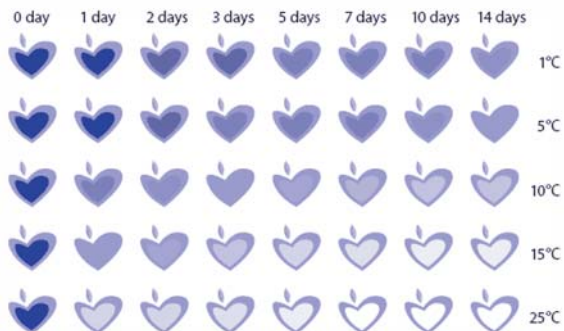
*Source: Smolander et al. (2004);
Freshness Guard, UPM Raflatac*

OnVu™ Time-Temperature Indicators

- OnVu TTI technology relies on the properties of nano-pigments that change color over time and if temperatures fluctuate



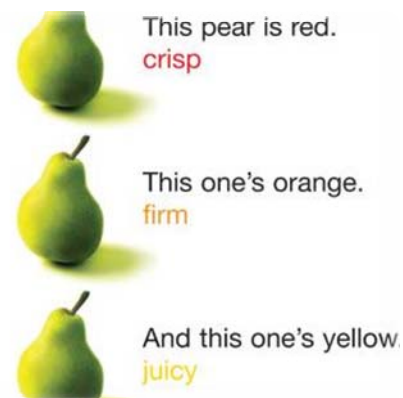
- Allow producers, retailers and consumers to check at a glance whether perishable products have been correctly transported and stored



- Help to enhance consumer convenience and confidence, strengthen the reputation of brands using them and optimize shelf life

Ripeness indicator label

- RipeSense, the world's first ripeness indicator label developed in New Zealand
- The intelligent ripeness indicator responds to the aroma released as fruit ripens, giving consumers a better way to determine the shelf life of the fruit before they take it home
- Help shoppers to reduce wastage



Printed oxygen Indicator

- Many foods are packed or under MAP
- An oxygen-sensitive ink could be used to show if the MAP remains intact, throughout the whole distribution chain
- "Intelligent ink" was created using light-sensitive nanoparticles such as titania nanoparticles

The ink is blue in air and ambient room light. When it is irradiated with a pulse of UV light, the colour changes to white but reverts to blue under normal room light. In an oxygen-free atmosphere the ink remains colorless after the UV pulse



Source: Mills and Hazafy, 2008

Inkjet printed oxygen indicator



- With inkjet printing, the indicator can be attached directly to the packaging material during packaging
- Enables the manufacture of an individual, product-specific indicator on the packaging line without the disadvantages associated with handling and storing pre-made oxygen indicators that must be kept in an anaerobic state

RFID: printed antennas

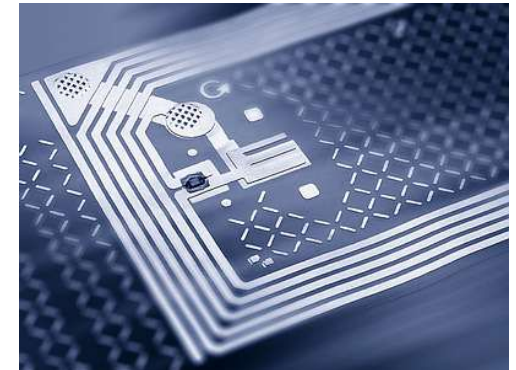
Radio Frequency Identification (RFID) offers a number of potential benefits: **traceability, inventory management, labour saving costs, security and promotion of quality and safety**

- RFID chips are too expensive: the cheapest tags cost about **50 cents (US\$)**
- RFID tags can be printed on packaging like bar codes



Nano Will Boost RFID Tags

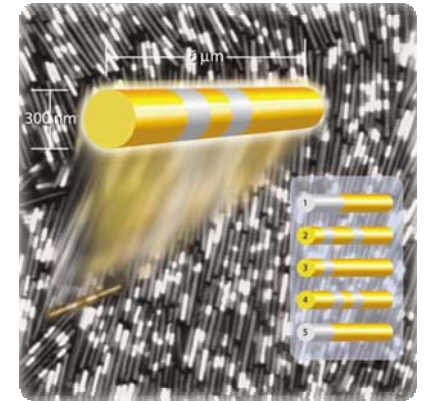
Nanotech could eliminate the need for silicon chips entirely with ink-based RFID circuits



- RFID tags incorporating nanoscale components are much smaller, can be flexible and are printed on thin labels
- Increases the tags versatility and thus enables much cheaper production
- Nanotech could really help accomplish the goal of **5 cents (US\$)**
- Nanotech can help improve tag reliability

Nanobarcodes: Tracking, Tracing, Brand Protection

- The nanobarcodes fluoresce under ultraviolet light when target compounds are detected
- Improve packaging's security: assure brand and authenticity
- This technology has a number of competitive advantages:
 - Unlimited numbers of unique, machine-readable codes;
 - Low cost of manufacture and implementation;
 - Extraordinary compatibility/durability;
 - Difficult to counterfeit.





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Take home...Think outside the box



- Demands on packaging are continually changing: increases in functionality, improvements in economics and meeting environmental and legislative measures
- Nano-printed intelligent packaging is the results of **“Thinking Outside the Box”**
- Nano printed intelligence has potential to influence the packaging sector greatly, as it fits perfectly with the food safety strategy and brand protection

Take home...Nano-Printed Intelligence

- Printing technologies enable cost-effective, mass production of smart labels integrated in flexible packaging
- Much of the technology is still confined to the lab
- Consumer acceptance of the use of printed nano-materials in packaging is very important and will be greatly dependent on the demonstrated benefits and safety of the new packaging products



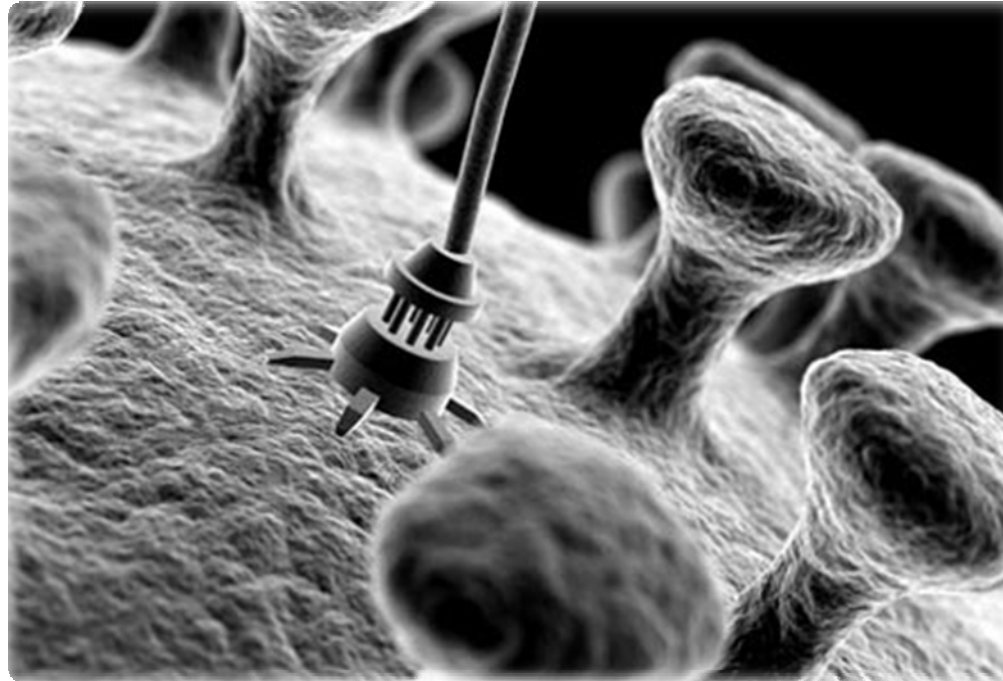
Nano-Packaging and regulatory challenges



“Nanotechnology offers tremendous opportunities for innovative developments in food packaging that can benefit both consumers and industry. However, before these packaging innovations can be brought to market, we must ensure that the food-packaging industry, through working closely with government, understands the regulatory framework currently in place along with its many requirements”

Robert Brackett, GMA’s chief science officer

Think Big...Think Nano!!!



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