Packaging Materials of the 21st Century

"Sustainable Nano-Marterials - Benefits to the industry"

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Agenda 2020

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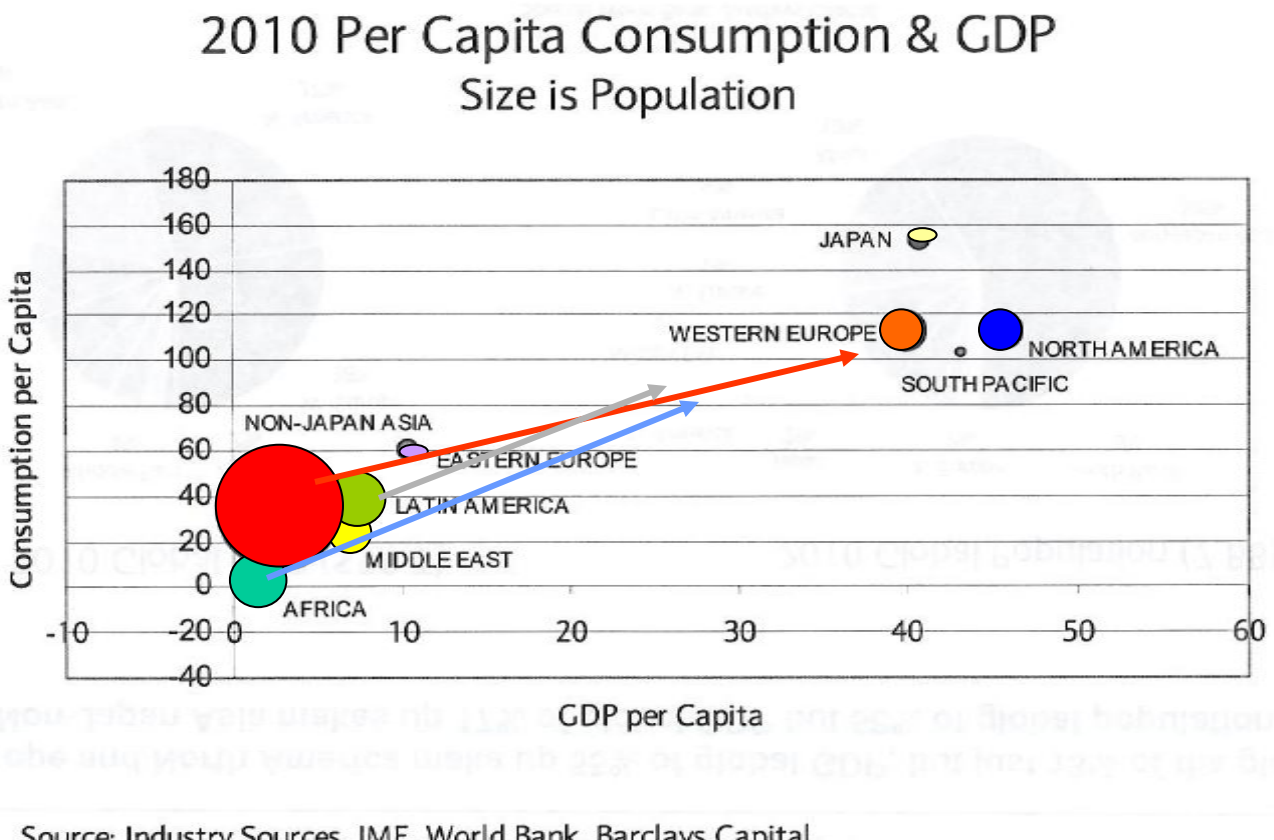
Packaging at Point of Sale

Packaging Materials of the 21st Century

- Appearance
- Low Cost
- High Strength
- Lighter weight
- Sustainable materials

Profound Changes will Drive Innovation



Source: Industry Sources, IMF, World Bank, Barclays Capital.

BARCLAYS CAPITAL

W Europe & N America

15% population of world / 50% consumption world resources

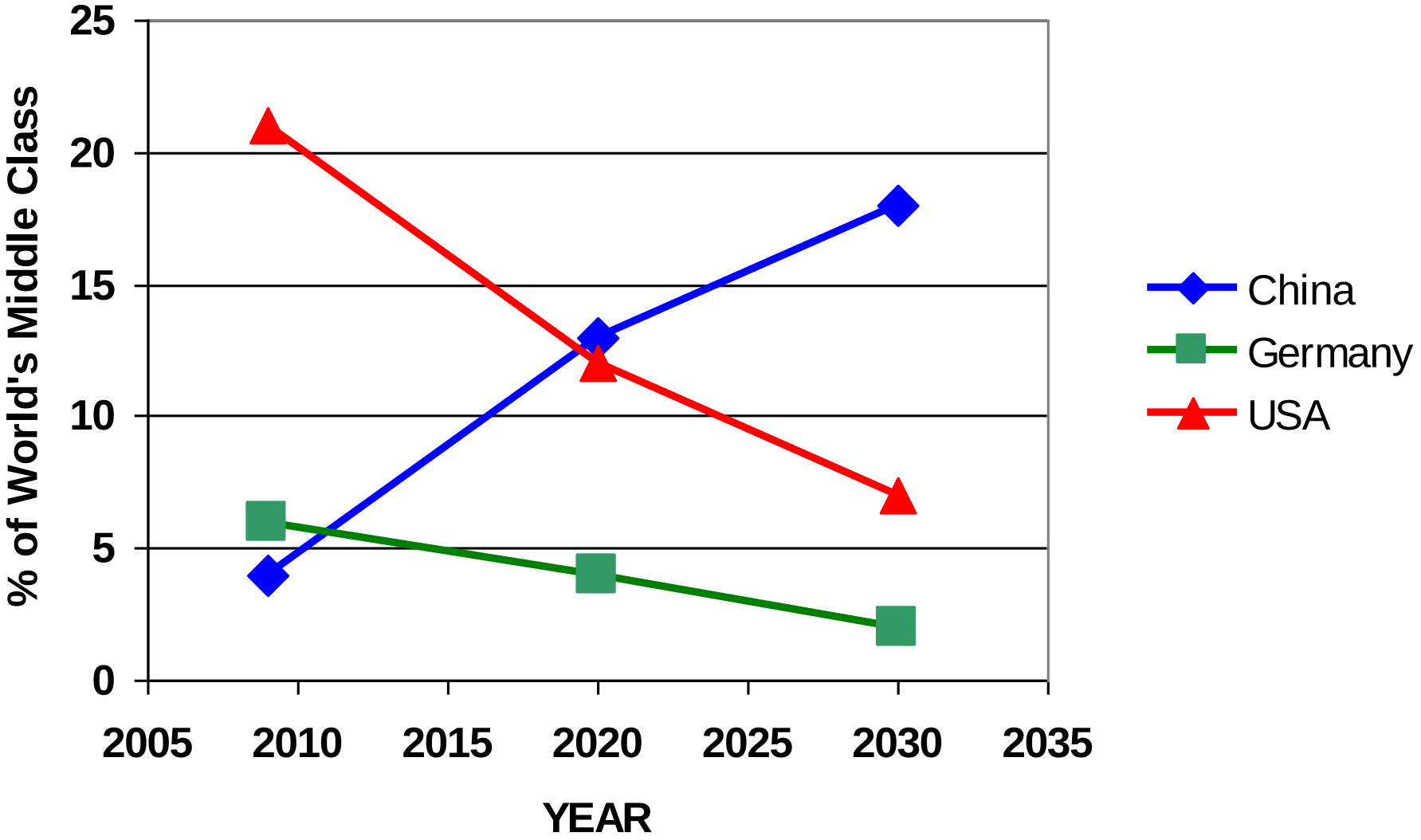
Demand in Asia accelerates: Commodity prices will explode

Forest Based, Materials of 21st Century

PJ 2012

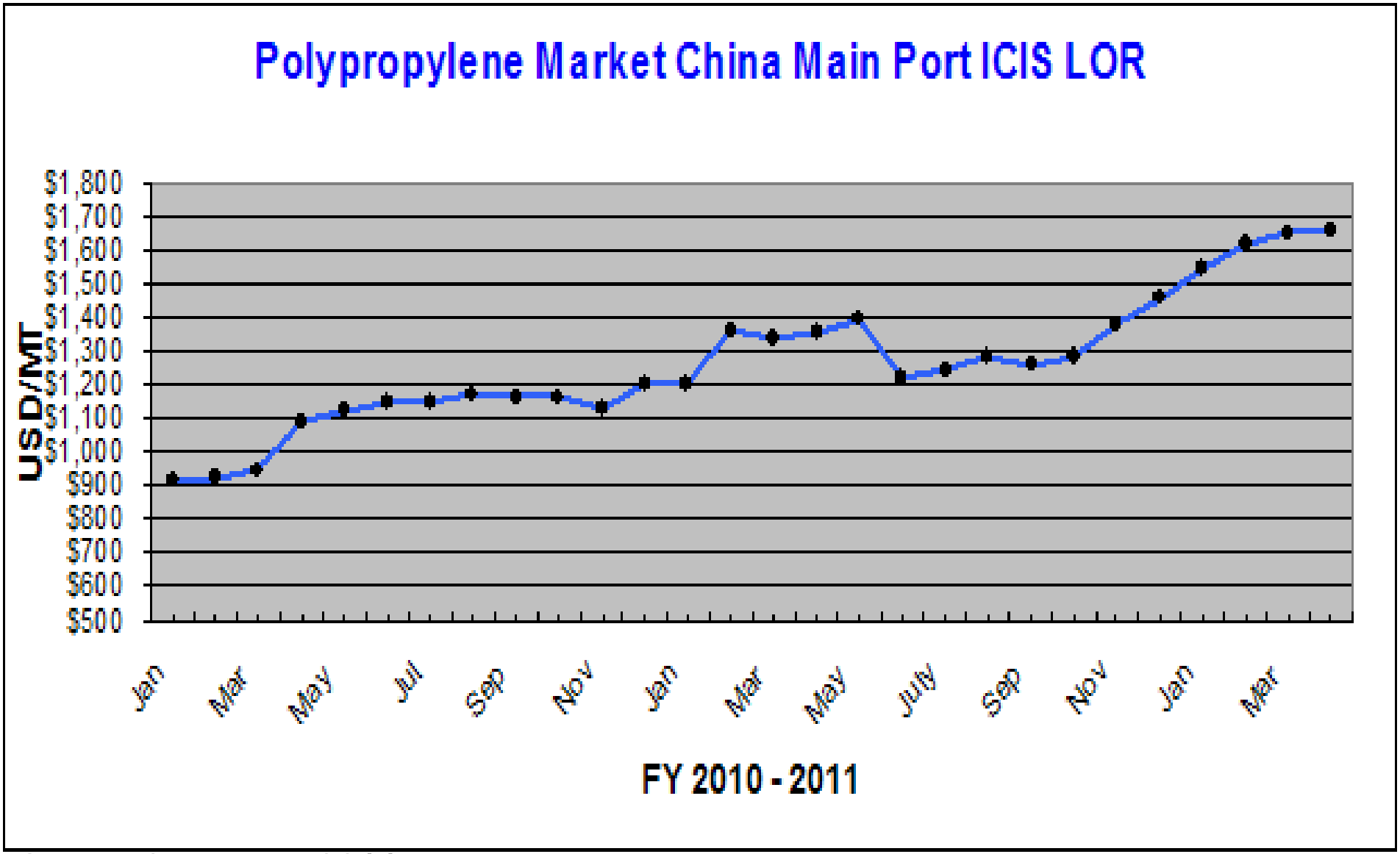
The consumption potential of China becomes very large

With substantial implications on demand for and cost of materials



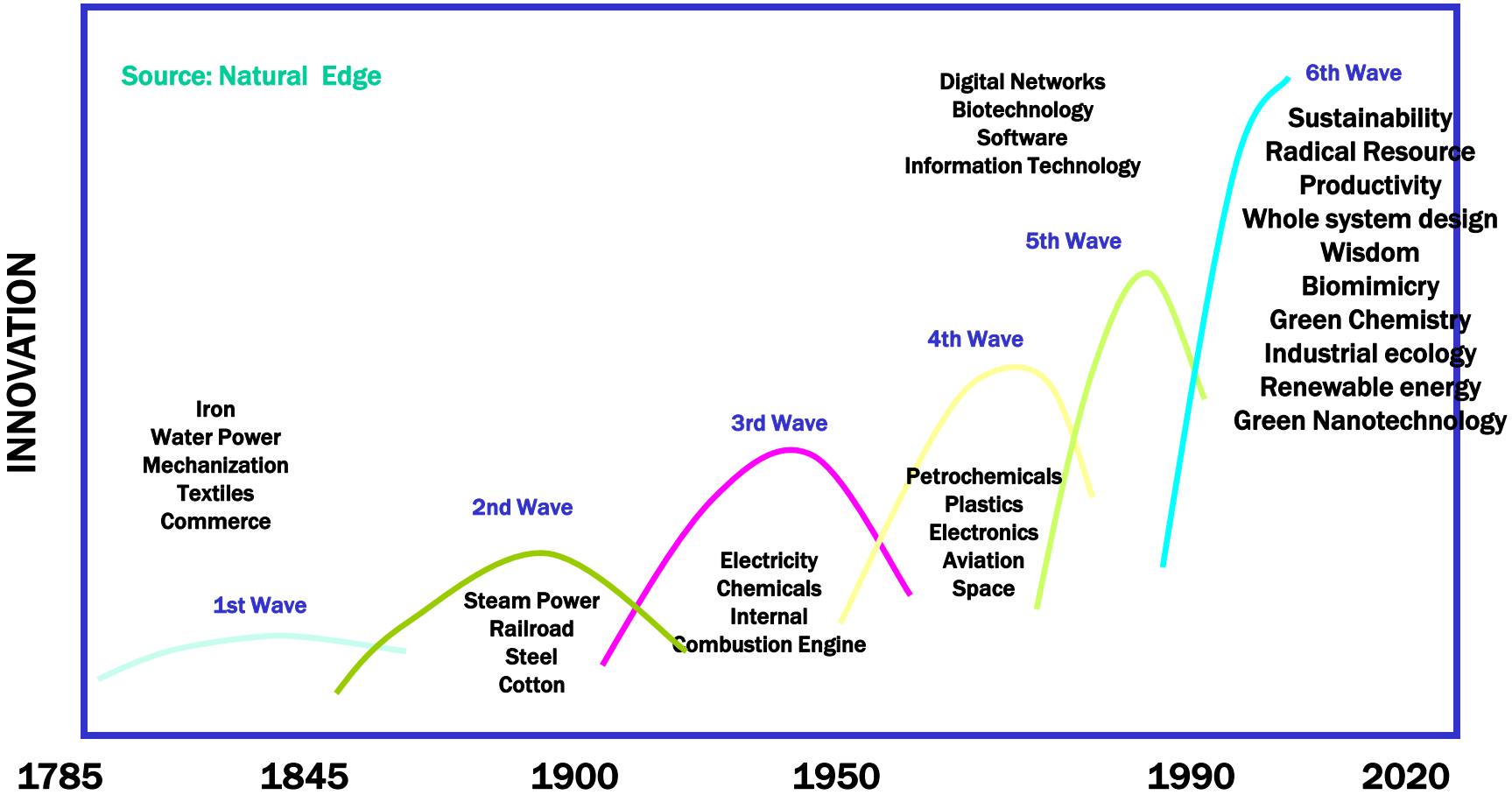
Source: London Times 2011

Oil price and refinery balances are re-setting the opportunities for paper-based materials



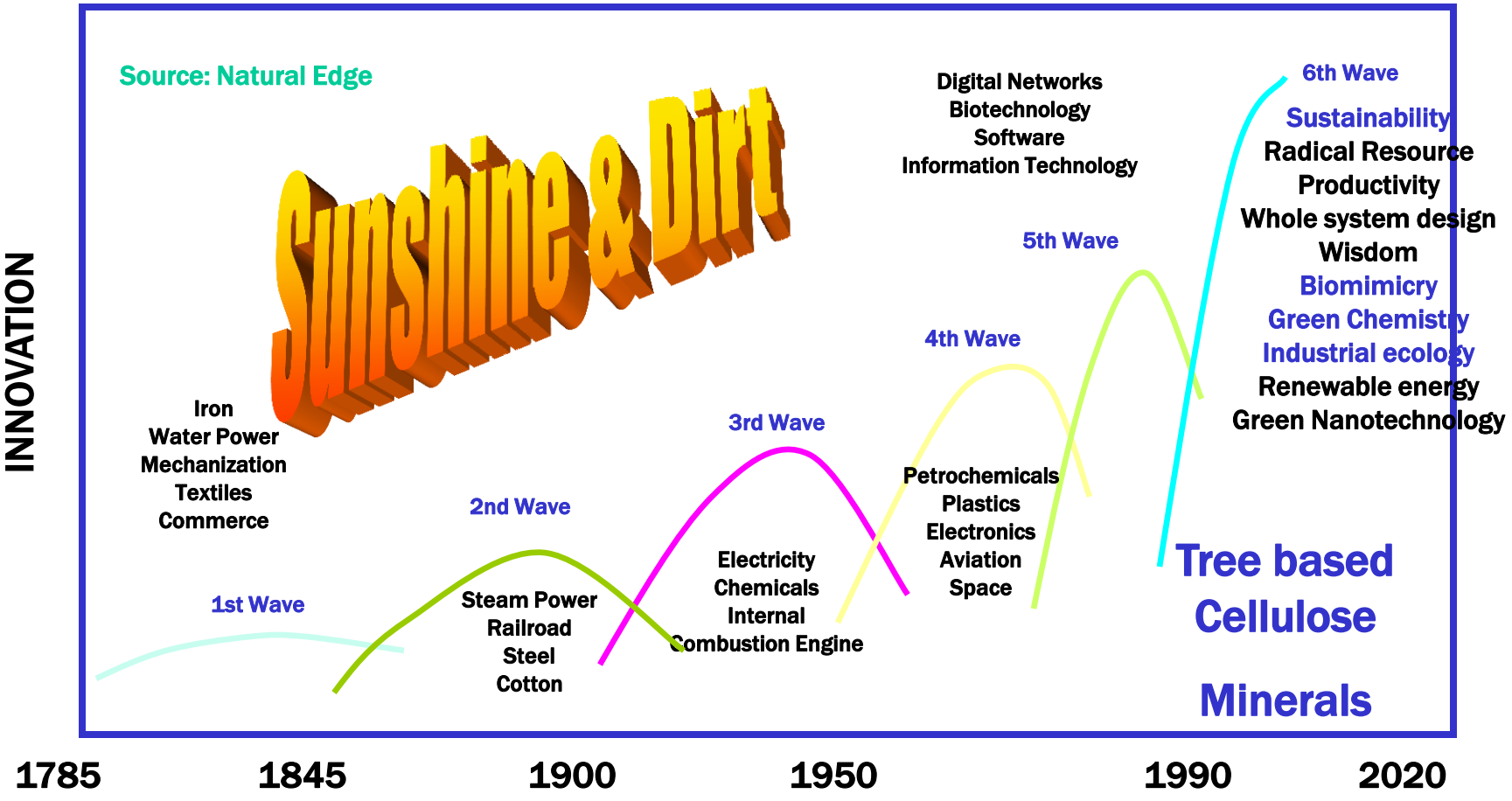
Source: G Thornton 2011

Waves of Innovation



Adapted from L Hunter Lovins 2008

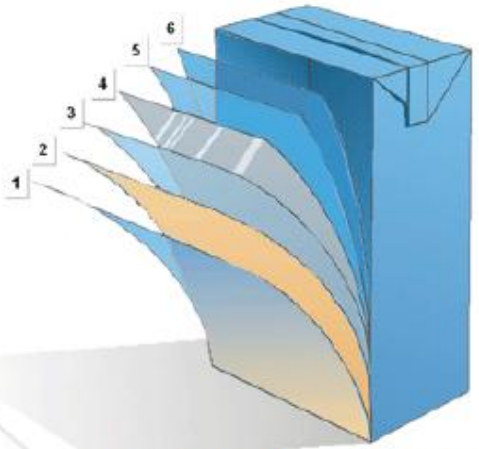
Waves of Innovation



Adapted from L Hunter Lovins 2008

www.nanotechforest.org

Motivations



Layer 4: Aluminium foil

www.longflat.com.au

Multi-layer packaging

Source Thao: EMPA 2011

Needs

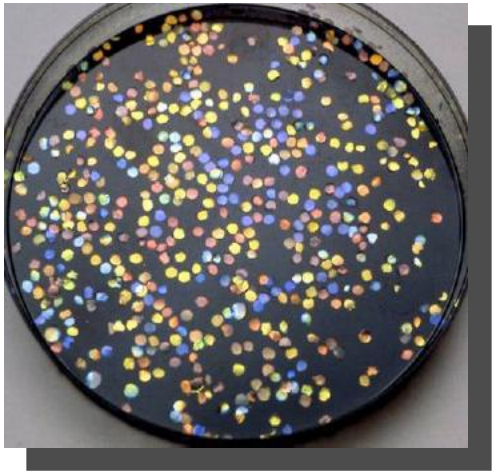
Replace non-renewable & Non compostable packaging

Reduce food wastage

Source:Conservation, Summer 2012

Bio-mimetic Processes Leveraging Bio-Technology

Hierarchical structures
Of nanocellulose in wood
Provides strength



Source: D Grey 2003, Canada

Source: Yano 2007, Japan

Photonics Developing New
Materials to interact
with Light in Precise
Ways

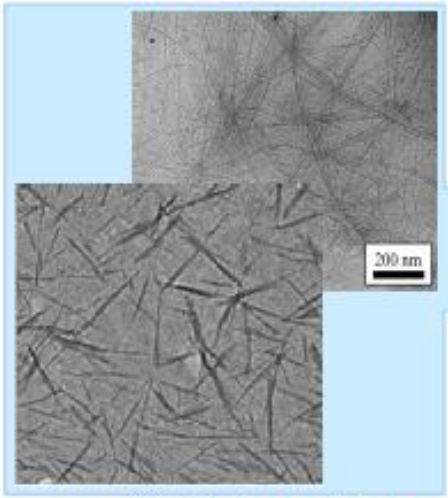
Source: Sambles 2001 UK

Nature constructs valuable materials from
Low coast low materials assemble with low energy

THE FINNISH CENTRE FOR NANOCELLULOSIC TECHNOLOGIES

Towards novel nanocellulose materials

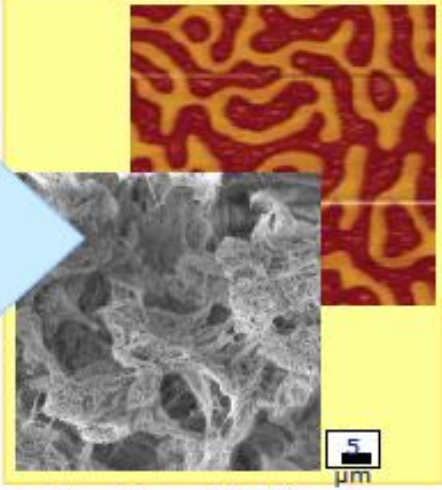
Cellulose nanomaterials



- ✓ nanofibrillated cellulose, NFC
- ✓ nanowhiskers
- ✓ nanospheres

Upper TEM-image:
TKK, Nykänen, 2007
Lower image: Fleming et al
Chem. Eur. J., (2001)7

Tailored properties



- ✓ functionalization
- ✓ self-assembly
- ✓ multicomponent systems

TKK, Kontturi

Cellulose nanomaterials in applications

- ✓ low grammage, high strength products
- ✓ new cellulose structures
- ✓ coatings, films, foams
- ✓ composites
- ✓ adhesives

TKK, Pääkkö et al., 2007

VTT TKK UPM

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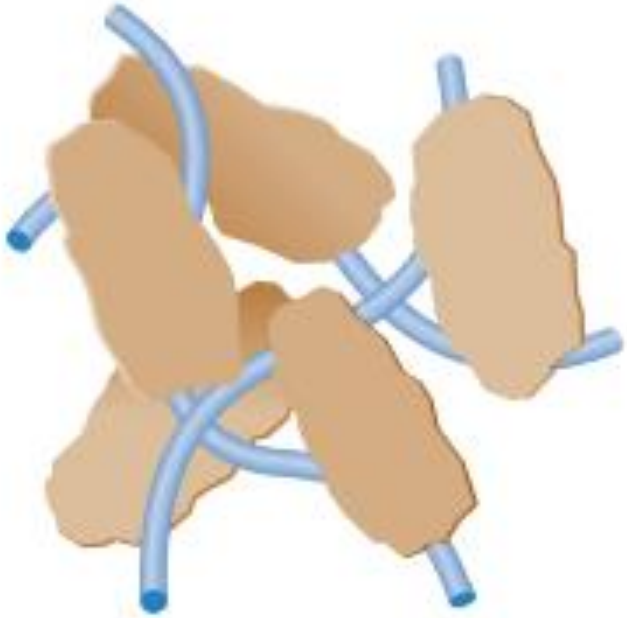
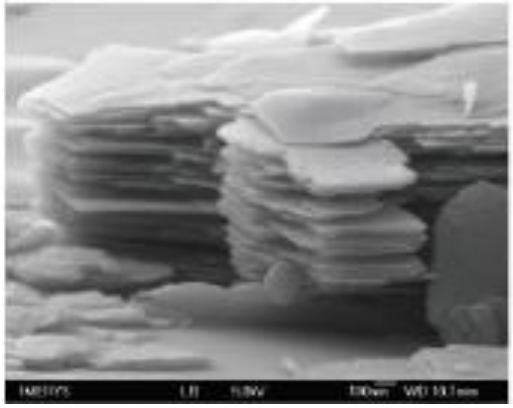
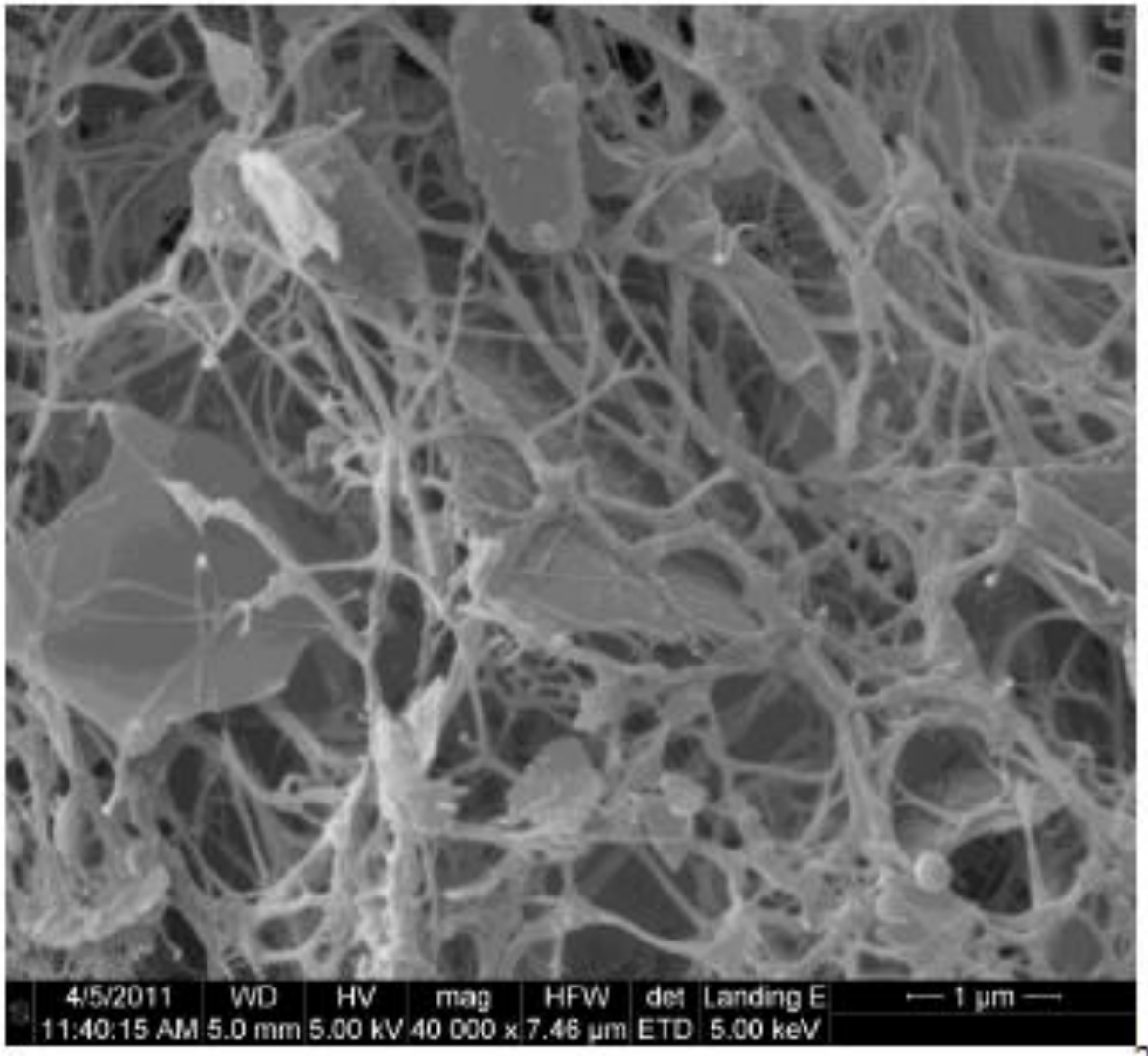
Source Qvintas et al VTT, Finland, 2010

CNC / Clay Composite



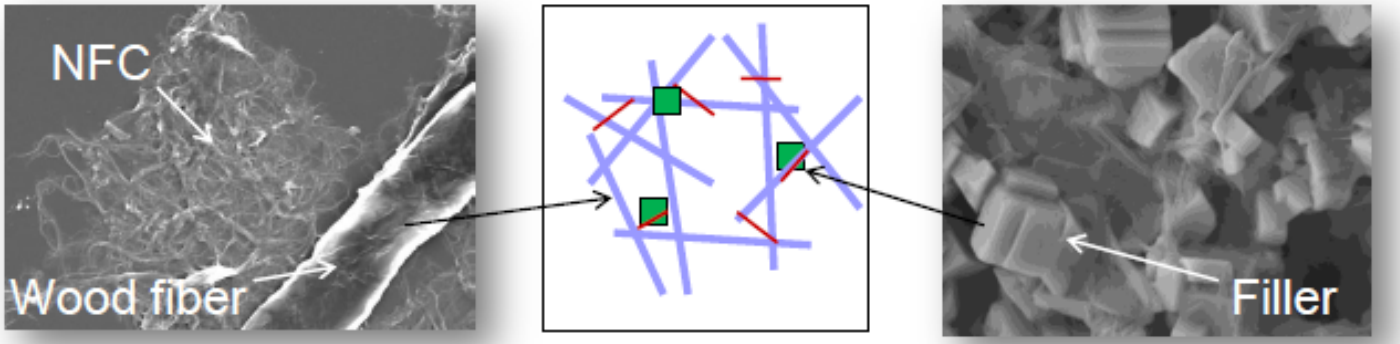




Source Thao: EMPA, Switzerland, 2011

Porous Materials & Fiber Web Structures

- **Paper & Board Strength Enhancement**
  - Wood fiber web structures – Paper as a porous nanocomposite
    (*e.g.* Gardner *et. al*, J. Adhesion Sci. and Tech. (2008) 545–567,
    Eriksen *et. al*, Nordic Pulp & Paper Research Journal, 299-304 (2008))



NFC increased both:
binding area and binding strength ($S_{tot} \sim A_B \cdot S_B$)

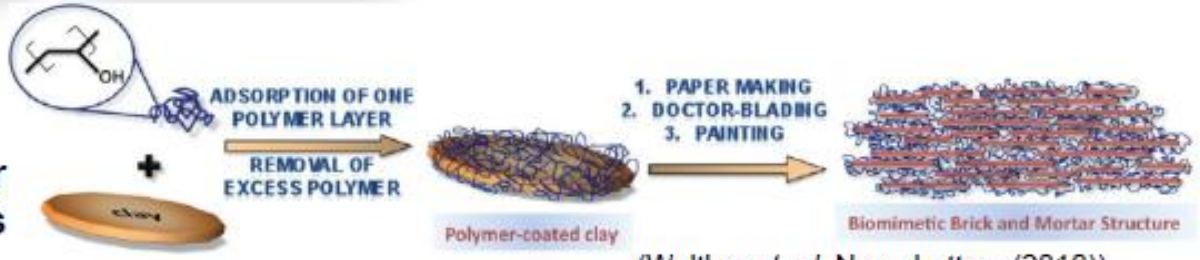
  - Applications:
    High strength / high bulk / high filler content paper & board

Composite & Construction Materials

- **Concrete and Cementicious Materials**
  - Strength enhancement of cellular concrete (*e.g.* 'Nanocrete Technologies')

Foamed, cellular NFC-concrete hybrid materials

Dense, silica-polymer hybrid materials

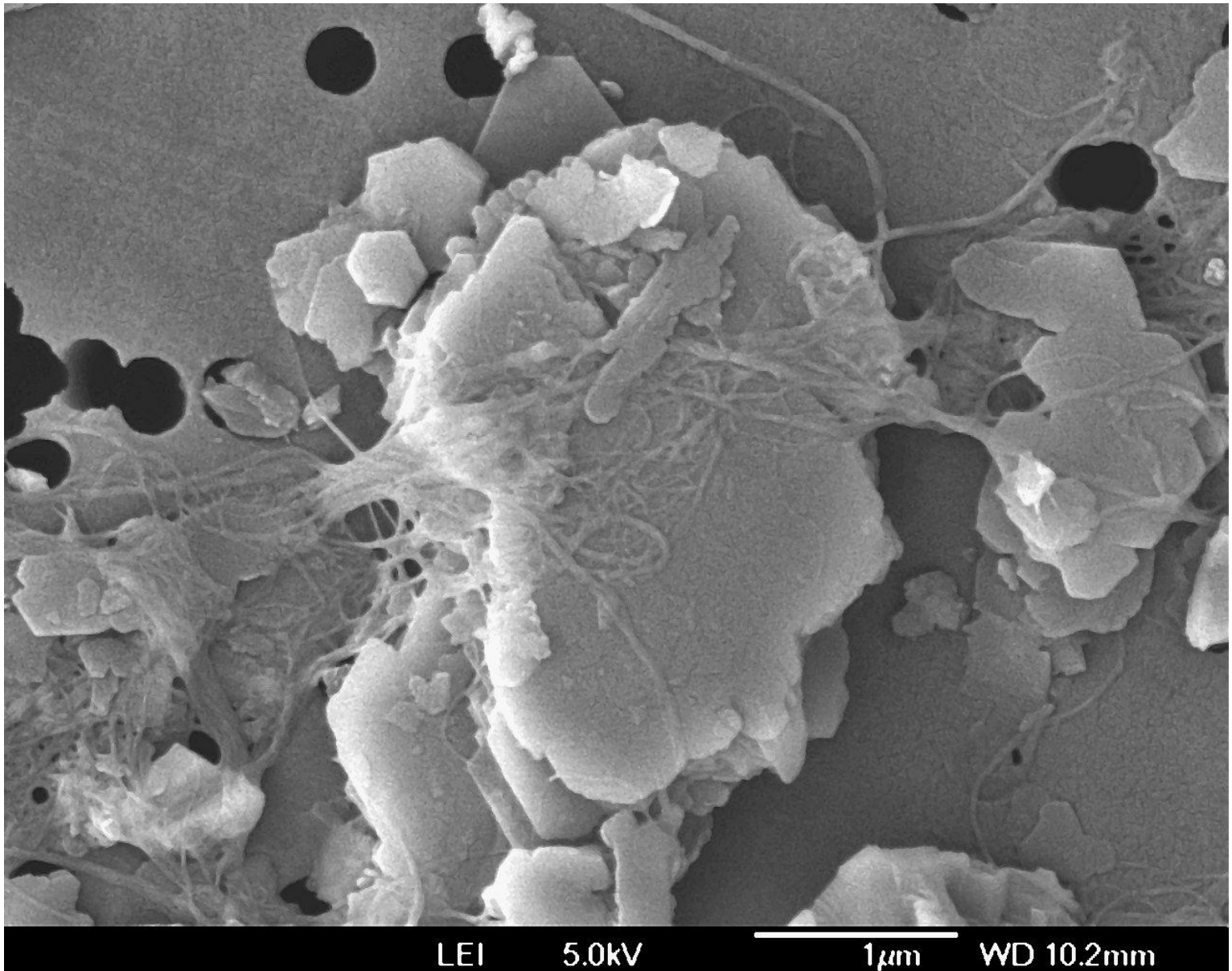


(Walther *et. al*, Nano Letters (2010))

  - Application: - Light-weight, foamed, cellular concrete structures
    - Crack reduction, combining toughness & strength

Nano-fibrillated Cellulose with Kaolin

Next Generation Composites



Packaging at Point of Sale

Packaging Materials of the 21st Century

- Abundant resources
- Renewable resources
- Sustainable Packaging

Source:Conservation, Summer 2012