



# AUSTRALIAN TECHNOLOGIES COMPETITION

## Carbon Nanotube Project

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Chairman  
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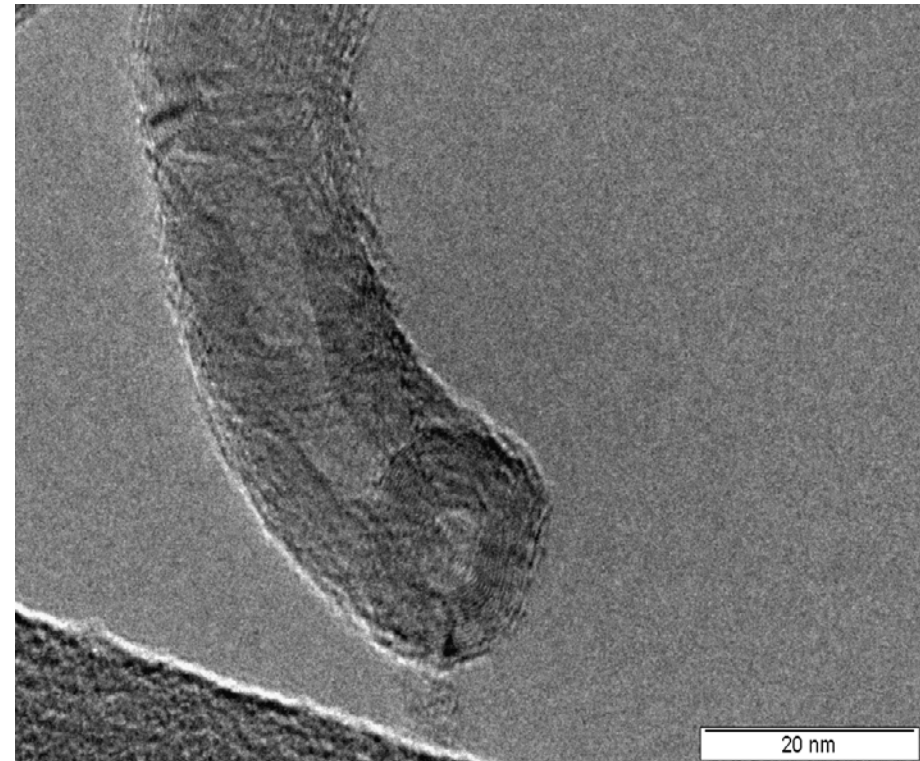
# Carbon Nanotube Project



## UQ/ Eden Developed Pyrolysis Production of CNT from Natural Gas (Eden 100%)



- Produces only CNT + H<sub>2</sub> - no CO<sub>2</sub>
- Multi-walled carbon nanotubes:
  - tensile strength -200-300 times steel
  - approx 17% the weight of steel
  - high conductivity (electrical/thermal)
  - bulk uses - concrete/plastics/polymers
- Patents in 8 countries



TEM image of Eden's MWCNT

# Eden's CNT Commercial Production Capacity



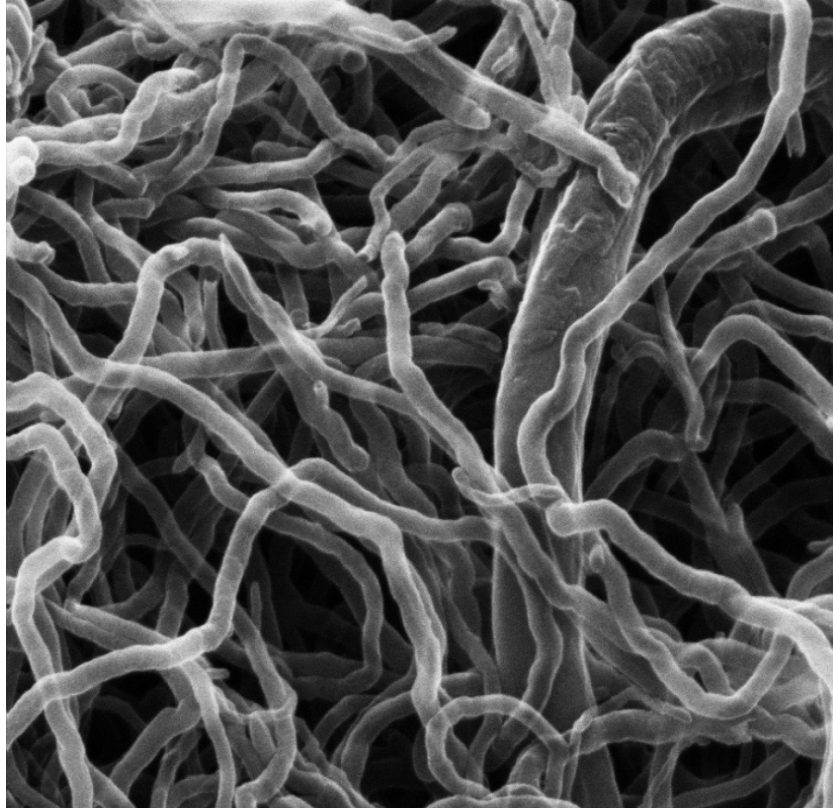
- **Eden's Commercial Scale Reactors in Denver, USA**
- **Capable of producing <40 tonnes of CNT/ year**
- **Low cost catalyst production**
- **High quality / low cost CNT**

# Primary Market – CNT in Concrete



- **CNT Concrete - 0.5 % CNT : 99.5% cement /tonne concrete**
  - **< 30% increase in compressive strength of cement**
  - **< 14% increase in tensile strength of cement**
- **Product - CNT enriched liquid admixture-** added during batching
- **Benefits - stronger, tougher concrete**
  - **less concrete / steel re-enforcing needed**
  - **reduced building costs/ greater design flexibility**
- **Global Application - road and bridges, high rise buildings**

# CNT in Fresh Cement Paste



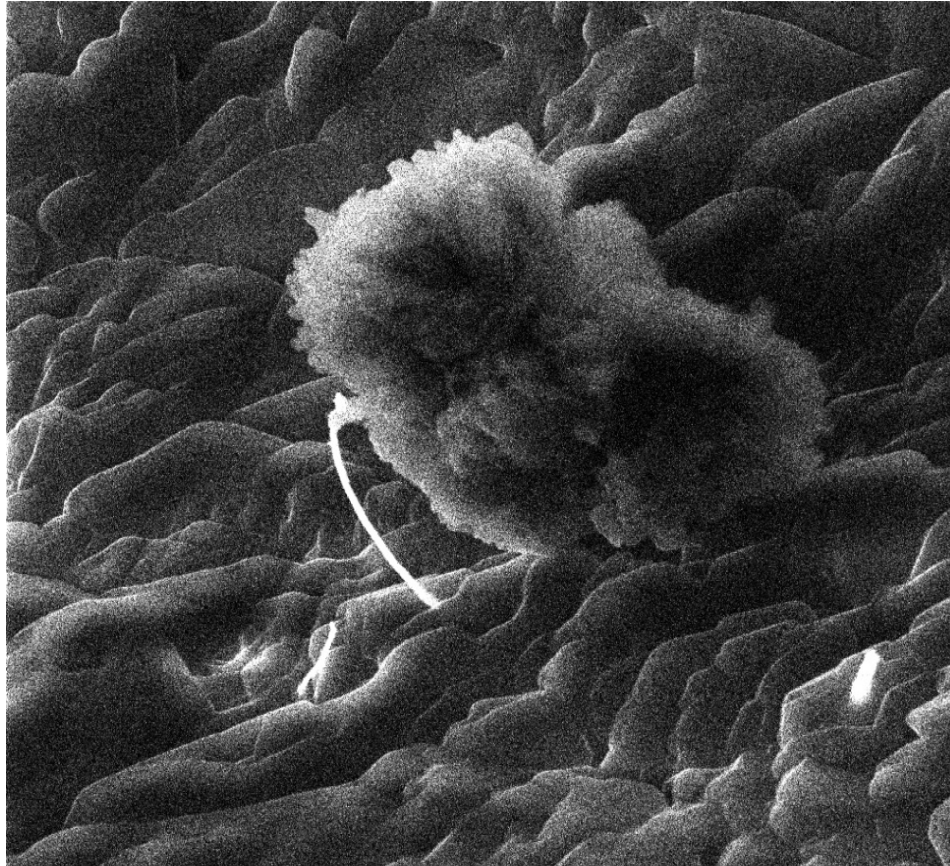
ZEISS CARL ZEISS SMT	Field Of View 1.50 um	200.00 nm	Dwell Time 3.0 us	Date: 2/16/2012 Time: 3:10 PM
	Working Dist 11.9 mm	Acceleration V 29.8 kV	Mag (4x5 Polaroid) 76,200.00 X	Blanker Current 0.5 pA

**Build-up of dense, hydrated cement on surface of CNT** (top right)

- **CNT provide:**
  - nucleation points for cement hydration
  - nano-scale fibre re-enforcement.
- **CNT facilitate denser, stronger and potentially more durable concrete.**
- **Other larger-scale fibres provide only nano-scale fibre reinforcement.**

**Monash University Helium Ion Microscope Image**

# CNT in Fractured Hardened Cement Paste



**CNT bonded in hardened cement paste after fracturing**

Note: ends of CNTs are well-bonded within cement gel and provide anchorage

ZEISS CARL ZEISS SMT	Field Of View 3.50 um	500.00 nm	Dwell Time 10.0 us	Date: 2/20/2012 Time: 3:57 PM
	Working Dist 11.1 mm	Acceleration V 29.8 kV	Mag (4x5 Polaroid) 32,161.91 X	Blanker Current 0.4 pA

**Monash University Helium Ion Microscope Image**

# Primary Market - CNT in Concrete



- **Global concrete/ cement market- US\$450 billion/year**
  - **Approx. 1 tonne of concrete** produced annually for every person on Earth
  - **Cement production creates 5% of annual global GHG emissions**
  - **CNT concrete could reduce cement requirements by >15-30%**
- **USA - initial target market**
  - **700 million tonnes/year** of concrete
  - **89,000kms of concrete** paved roads and bridge
  - **US\$40 billion annual** infrastructure maintenance cost

# Future Large Scale CNT Production



- **1,000 tonnes p.a. CNT capacity reactor- \$50million capital cost**
  - **sufficient for > 1.7 million tonnes concrete** -7% of Australian market
- **10,000 tonnes p.a. CNT capacity -Natural Gas Fired Power Stations**
  - **500MW station** uses >100,000 tpa of natural gas (NG)
  - **10,000 tonnes CNT:** needs 5% of total NG; enough for 70% of Aust. concrete
  - **H2 by-product -3,333 tonnes-** used in power production
- **10,000 tonnes p.a. CNT capacity -Fertiliser Plants**
  - **CH4 used to produce H2** for ammonia production- CO2 by product
  - **10,000 tonnes CNT produces 3,333 tonnes H2**
- **CO2 reduction < 36,000 tpa** in both cases



# Challenges and Marketing Plans



## Challenges

- **Extension of shelf life of admixture** development underway
- **OH&S concerns resolved**
  - CNT in low concentrations (< 0.5%) in liquid admixture
  - CNT used in low concentrations and is firmly bonded with cement

## Marketing Plans

- **Global manufacturers planned for CNT admixture** production /marketing
- **Global concrete company interest-** initial Australian trials planned in 2014
- **US Trials to commence in 2014** -initial target roads/ bridges
- **Planned US commercial rollout in 2016**



**ASX: EDE**

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