element™

Non-metallic materials in energy applications

Peter Hansen – Element Hitchin Ltd

Overview of presentation

- Introduction to Element Materials Technology
- Overview of energy applications
- Non-metallic materials used in O&G, renewables etc
- Example research projects
- KMM VIN activities in energy
- Example project from ‘Materials for energy’ group

Where We Are – What We Are

element™

Element - What We Do...

Advanced Industrial Products

Aerospace & Defence

Oil & Gas

element™

Transportation & Industrials

Materials testing, product qualification, failure analysis, R&D

Element Hitchin (formerly MERL) – what we do...

Applied engineering with composites, elastomers, thermoplastics, joining technologies…

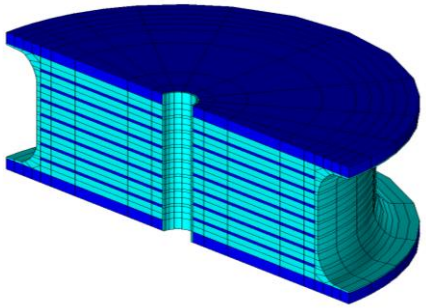
element™

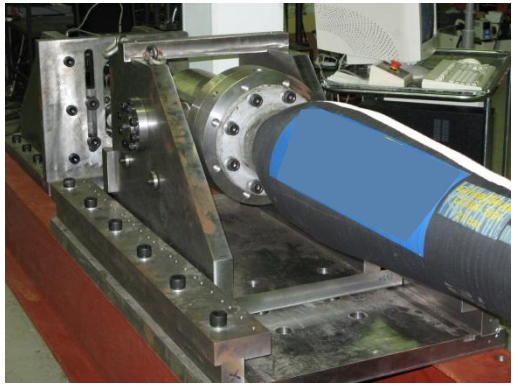
Energy applications

- Oil and Gas - exploration, production, processing…
- Renewable - Wind, wave, tidal energy
- Power generation – coal, gas, nuclear…
- Energy storage – batteries, fuel cells, hydrogen storage…
- Photo-voltaics…
- Bioenergy…

Elastomers in O&G applications

- ‘ENGINEERING’ ELASTOMERS
  - NR (hose wall, laminated components - flexelements, bearings)
- MODERATE DUTY
  - EPDM (seals for non-hydrocarbon fluids)
  - NBR, HNBR (liners, seals, packers,…)
- HOSTILE ENVIRONMENTS - FLUORO-ELASTOMERS
  - FKM, FEPM (seals)
  - FFKM (fully fluorinated; seals)





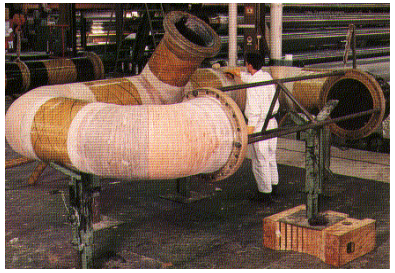
element™

Thermoplastics in energy applications

- SEALING
  - PTFE (primary [energized]; back-up)
  - PCTFE (ball valve seat)
  - PEEK, PPS (anti-extrusion duty in HP sealing systems; valve seat, risers, intervention lines)
- BARRIER
  - PVDF, PA 11/12 MDPE, HDPE, PEX (flexible pipe sheath, liners)
  - PA 11, PVDF (umbilicals)
- INSULATION
  - PP, PU, SILICONE
- Less widely used
  - UHMWPE, POM, ETFE, PFA, MFA, FEP, PAEK, PI…

Composites in energy applications

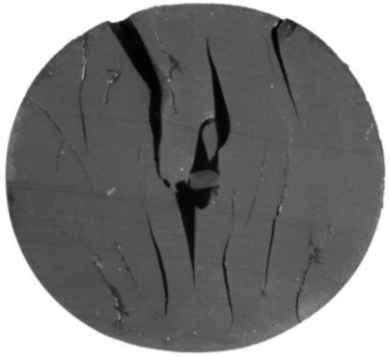
- EXAMPLE SYSTEMS
  - epoxy, vinyl ester, phenolic, thermoplastic…
  - carbon, glass, aramid…
  - sandwich, …
- APPLICATIONS
  - Gratings, liners, tubulars, water injection, plugs, wire lines, risers, fire/blast protection, sub-sea covers, bridge plugs, drill pipes, load bearing applications, CCT, …
  - Wind and tidal turbine blades – CF blades to improve economics
  - Storage tanks for high pressure gases…

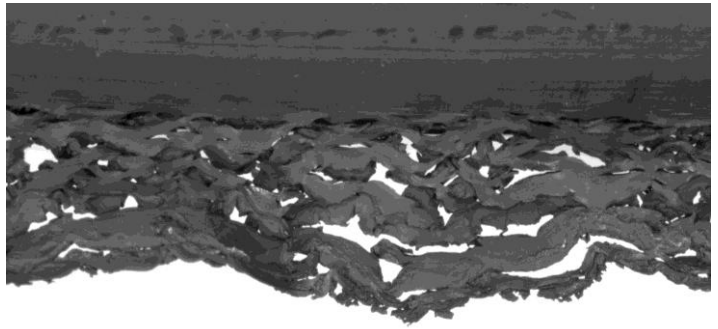


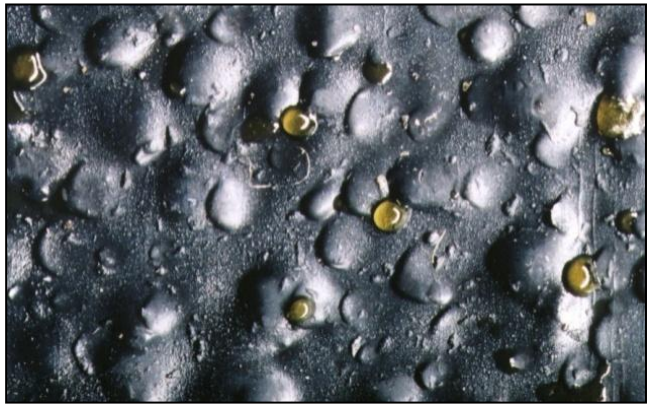
"Wind and energy is the fastest growing end market for composite materials. Wind blades, oil rig tubulars, solar panel frames and other structures are forecast to consume more composite materials than any other market over the next decade"

element™

Material failures







Other materials

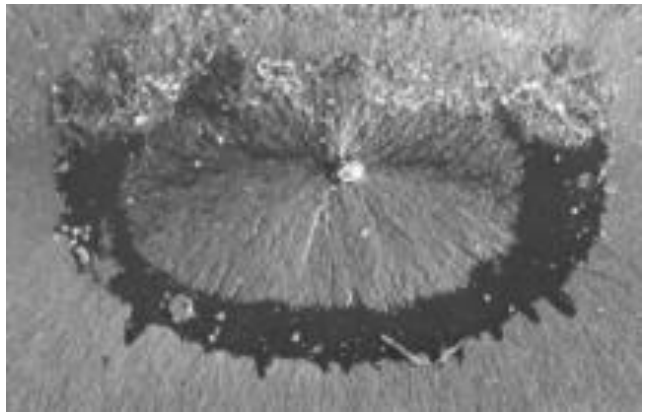
Graphene - has wide potential applications in energy-related systems, mainly because of its high electrical or thermal conductivity, optical transparency, mechanical strength, inherent flexibility, and large specific surface area....

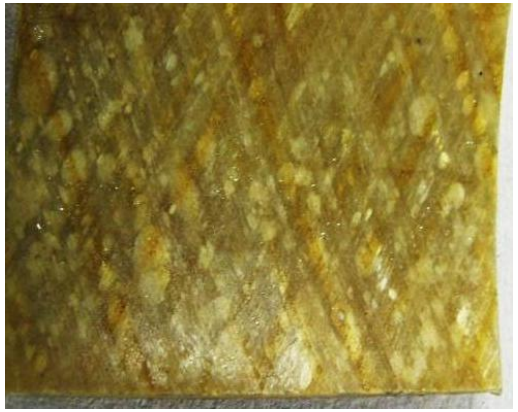
Self-healing materials – nanocapsules to release resins in composite....

Nano-reinforcement – CNT etc for reinforcement...scaling up challenges...

Gas decompression testing

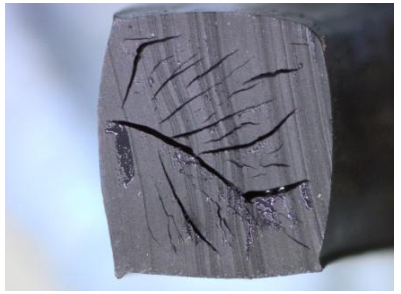
- NORSOK M710/ISO 23936-2
- NACE TM0192, TM0297
- Shell/Cox RGD rig
- TOTALFINA SP-TCS-142
- Service replication

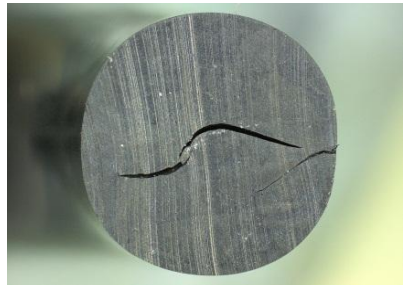


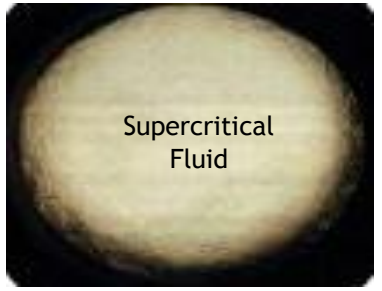


Supercritical CO_2 testing

- Some new O&G fields are producing large amounts of CO_2
- Used to increase oil recovery by re-injection (EOR)
- Disposed of in depleted reservoirs (CCS)
- Many of these applications involve supercritical (sc)CO_2
- scCO_2 acts as a liquid
  - swelling
  - softening
- scCO_2 acts as a gas
  - diffuses/permeates quickly
- RGD damage
- Excessive swelling
- Plasticizer removal
- Delamination of composites



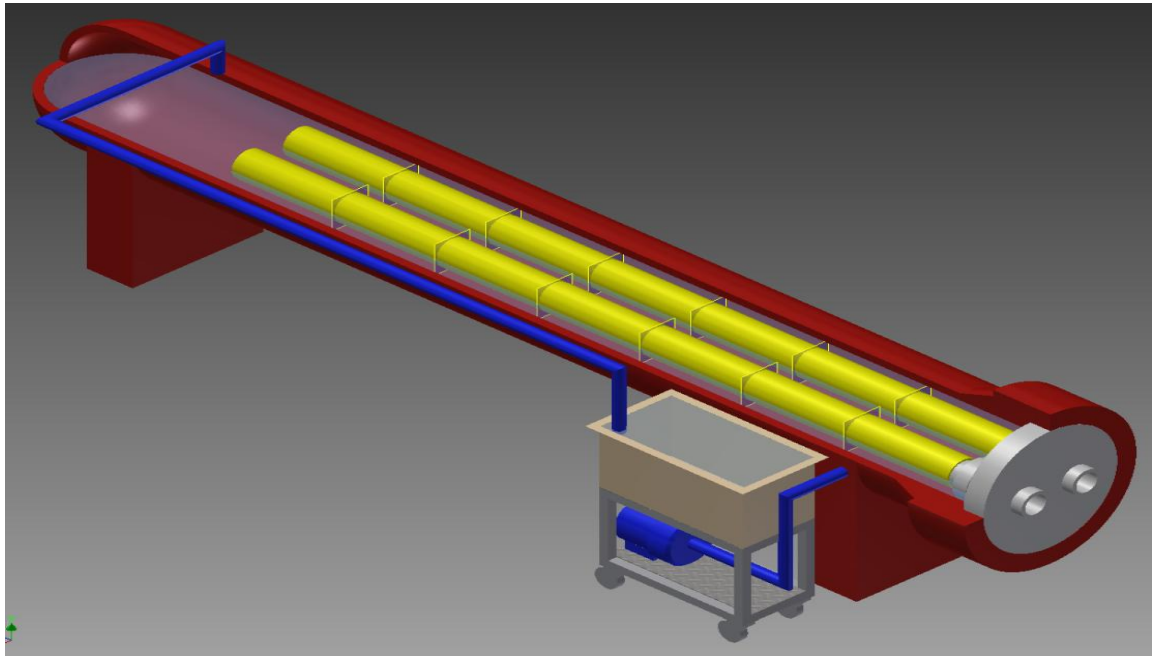




element™

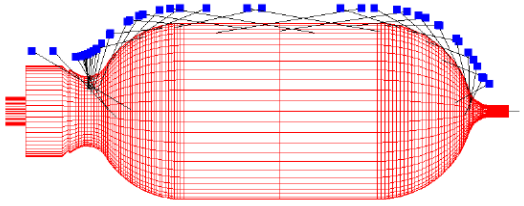
Simulated Service Tests – subsea pipe insulation

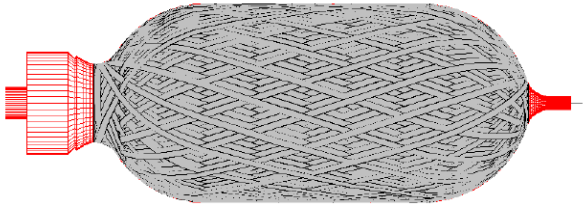
Dual pipe; >100 °C internal
External 4 °C, 250 bar
Fully instrumented; continuous logging
DAQ developed in-house

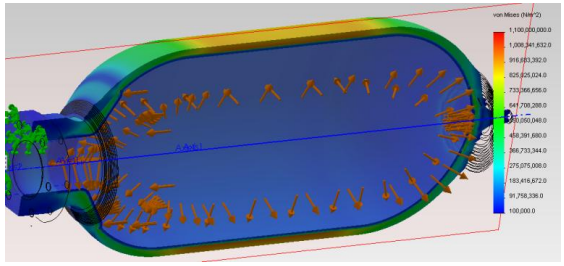


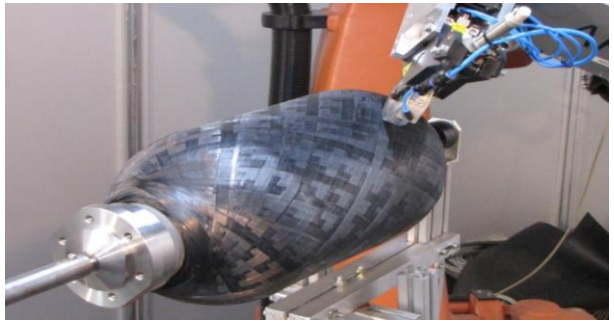
Example project - Hydrogen storage - Vessel concept and materials

- Collaborative R&D project with 7 UK partners
- Monolithic vessel design – liner and reinforcement matrix use same material
- Aim to reduce weight and increase recyclability – for auto market
- Liners made separately using roto-mouding then reinforcement layers applied using tape winding and laser consolidation
- FEA and laminate analysis used to design reinforcement layers (thickness and orientation) and optimise liner design









Vessel burst tests

Burst tank

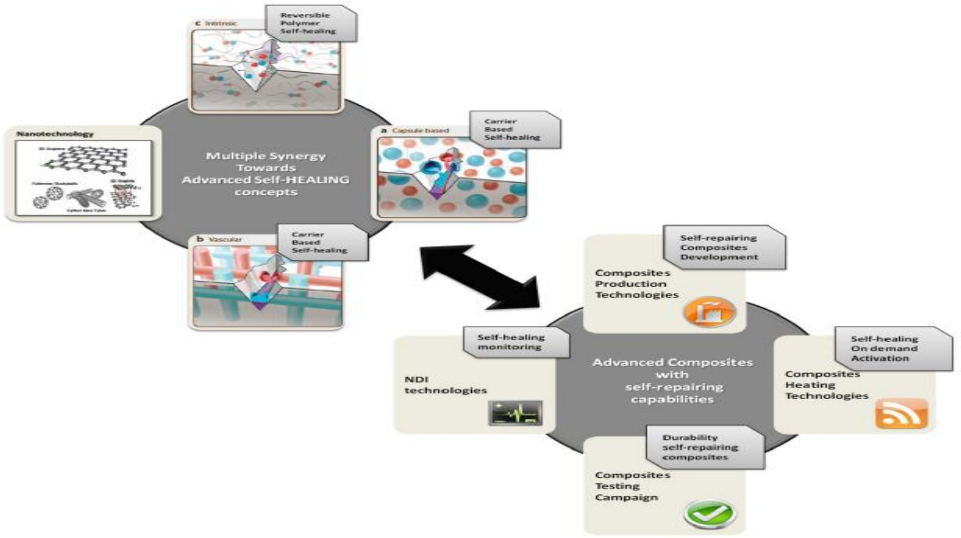
Vessel in test frame

- Vessel pressurised with water
- Failure occurred in predicted location due to failure of the liner
- Measured strains on outer surface correlated well with FE predictions

element™

HIPOCRATES - Self-healing Polymers For Concepts On Self Repaired Composites

- **Requirements & Selection of Materials**
  - Development of a state-of-the art database of aerospace qualified resins for liquid processing and prepreg technologies
  - Selection of critical structures that would benefit from self-repaired composites
- **Encapsulation Strategy**
  - Experimentally evaluate the developed nano-capsules and materials through self-healing performance
- **Reversible Polymer Strategy**
  - Experimentally evaluate the developed polymer blends
- **Integration of Technologies in Structures**
  - Performance evaluation testing
- **Validation Platform for Self-Repaired Composite structure**
  - Realise performance and functional tests on the platform



Eurostars project - LaWoCS- Laser Transmission Welding Of Thermoplastic Composite Structures

Project Goals:

- Development of adapted thermoplastic base materials and manufacturing of real components.
- Development of laser welding process for thermoplastic composite materials and welding of real parts.
- Testing of novel thermoplastic composite structures and real parts according to industrial specifications.

Consortium:

TENCATE materials that make a difference

element™

TodsCompositeSolutions AGC AEROSPACE & DEFENSE

EPL Composite Solutions

FASERINSTITUT FIBRE BREMEN

LZH LASER ZENTRUM HANNOVER e.V.

KVECOMPOSITESGROUP

DE Kunststoff-Technik

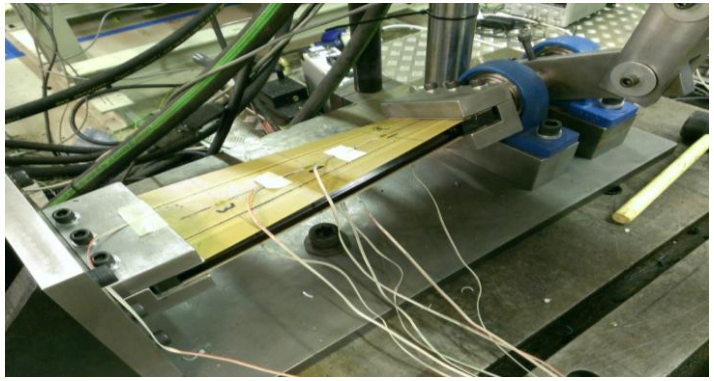
Funded by:

eurostars™

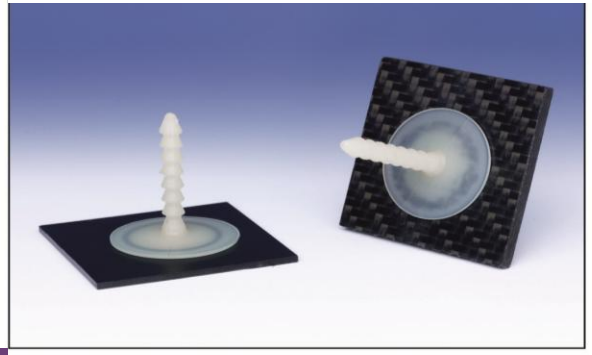
EUREKA

Bundesministerium für Bildung und Forschung

Technology Strategy Board Driving Innovation



Testing of welded stiffened panel at Element Hitchin

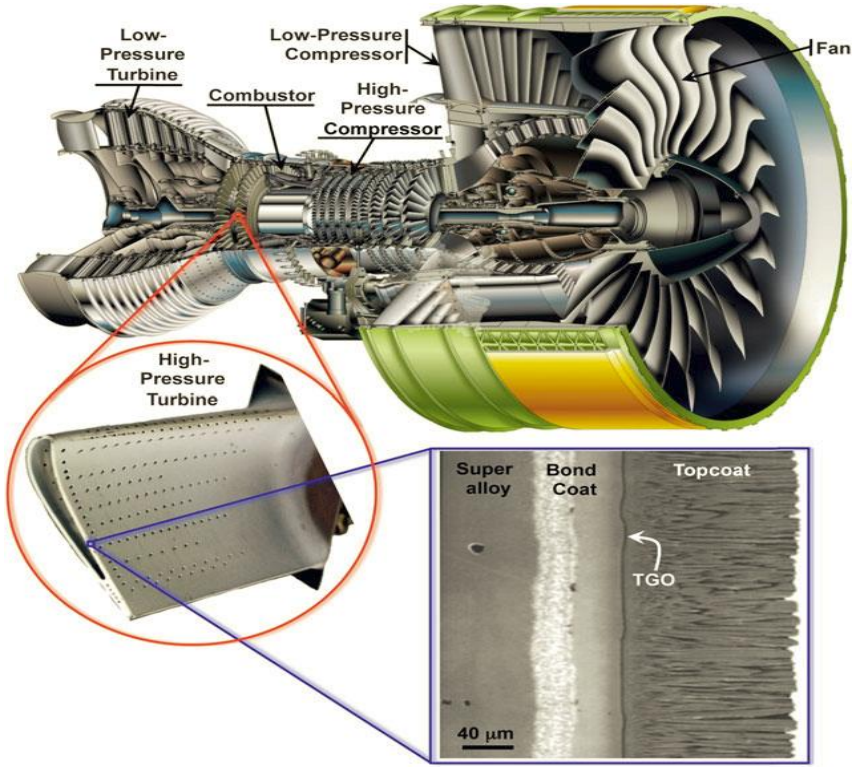


Pin used in aircrafts welded onto PA6.6 with a carbon fibre fabric and carbon black

element™

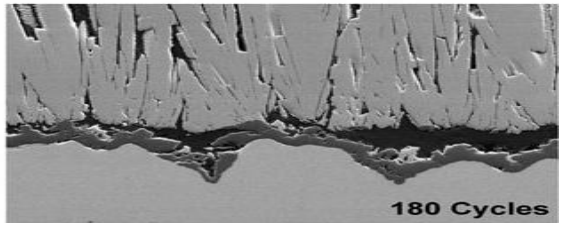
Development of multifunctional Thermal Barrier Coatings and modelling tools for high temperature power generation with improved efficiency (BARCODE – FP7)

Development of techniques to predict spallation phenomenon and failure mechanisms of Thermal Barrier Coatings

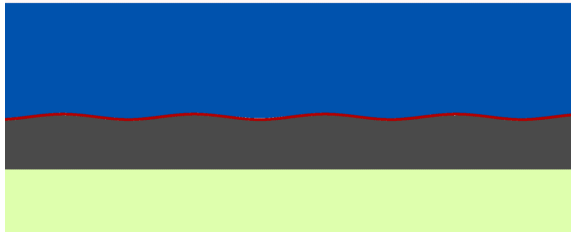


Mechanical Characterisation at temperatures up to 1400C

Predicting spallation of TGO due to thermal



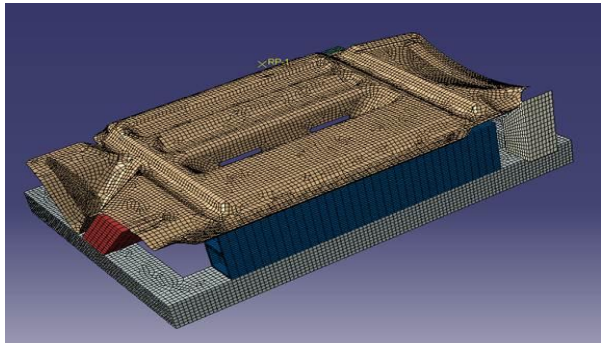
Experiment



Simulation

Other Public Sector Projects

- CAD_TPC – Cable Carrying and Acoustically Damped Thermoplastic Sleepers, TSB 2012-2014
- DURASTOR – Low cost, Durable Thermoplastic Hydrogen Storage Tanks, TSB 2009-2014
- HOST – Hydrogen – Optimisation of Transfer and Storage, TSB 2014-2016
- BMAX – Tidal Turbine Blades, Maximizing Reliability and performance and Reducing Cost, TSB, 2010-2013
- NEW-MMEETT - New Materials and Methods for Energy Efficient Tidal Turbines, TSB, 2008-2011
- INN-VIN - Innovative materials solutions for Transport, Energy and Biomedical sectors - Support to Networks of Excellence with durable integrated structures

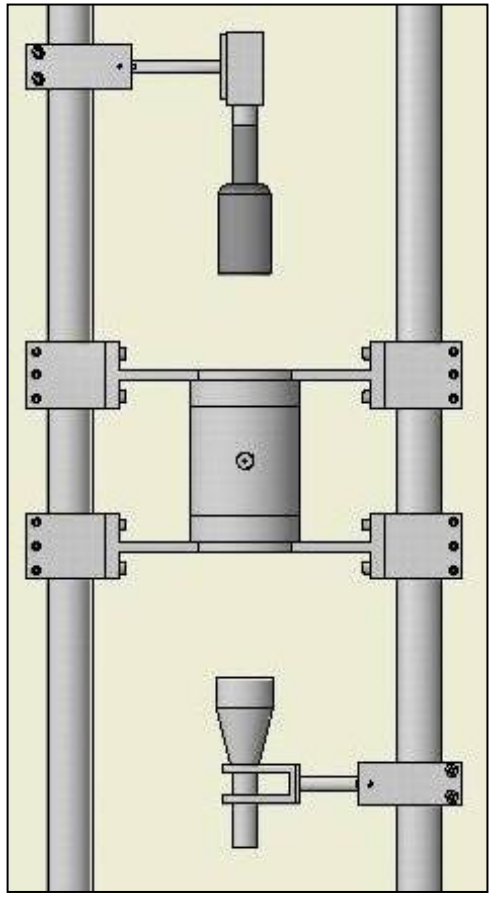


Current Challenges in O&G

- Protection of the environment
- Subsea Reliability
- Clean Operations (Surface & Sub-surface)
- Robust, uniform Qualification methods
- Operations in remote/Arctic places
- Higher recovery in each type of reservoir
- Sour wells
- Corrosive injection media (EOR, CO_2 sequestration)
- LNG
- Extreme High Pressure & Temperature
- Composite materials in Deepwater fields

element™

The future – testing requirements for non-metallic materials

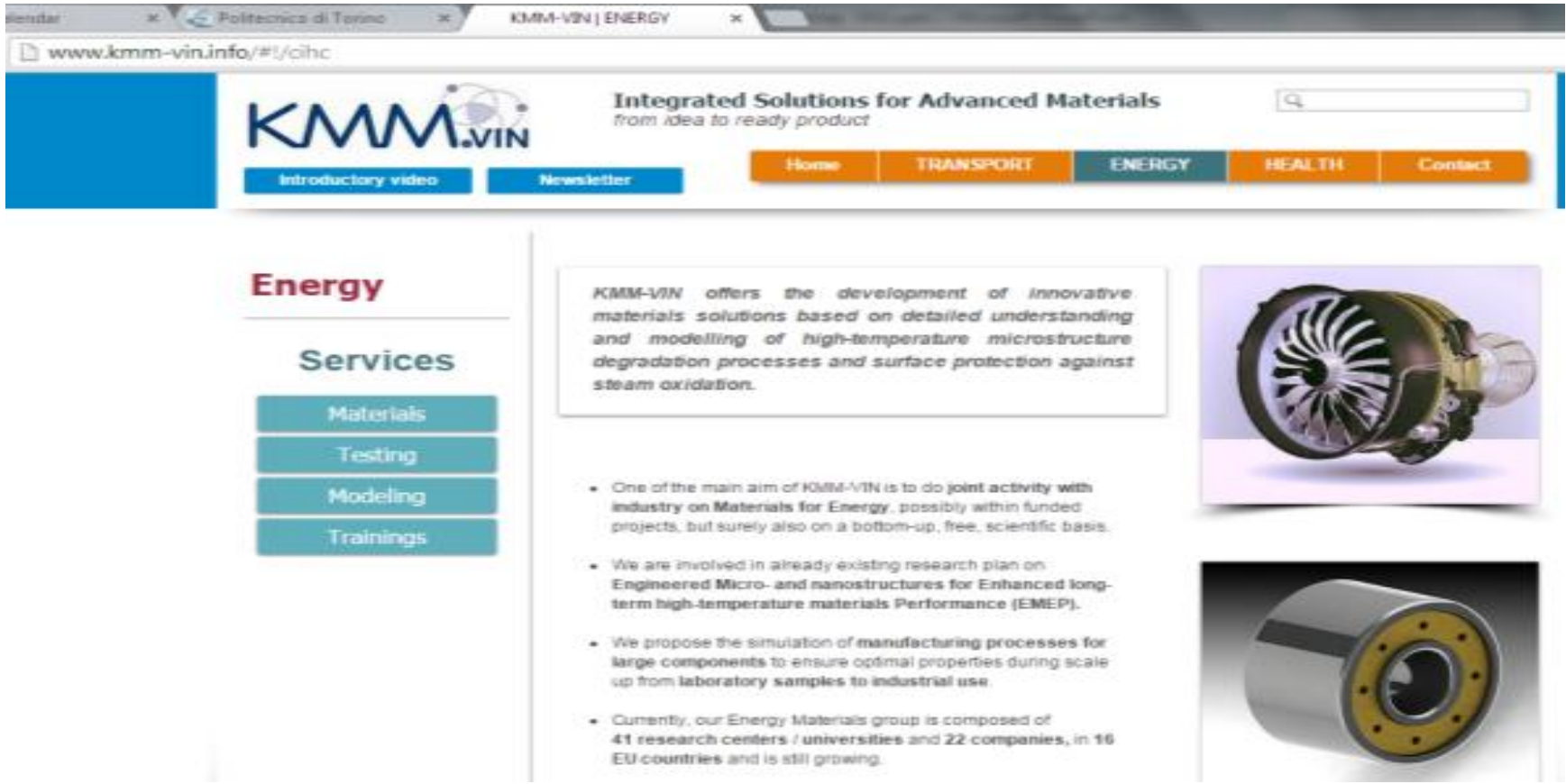


- Sapphire windowed cells (350 bar) - visual, seal contact; auto calc...)
- Blowdown rigs
- Permeation cells – measure permeating species for mixed media...
- Hose pressure cycling rig
- Fixture/vessel design, DAQ & machine control
- Small-medium scale dynamic testing

- Fluid compatibility with aggressive media
- RGD (seals)
- Test procedures (>>standard)
- H_2S ageing and permeation
- Supercritical CO2 exposures
- Arctic environment test rigs...
- ...

KMM VIN - WG2. Materials for Energy

- 61 WG2 members
- Networking
- Scientific activity
- Projects
- H2020 proposals
- Industrial workshops



KMM VIN Materials for Energy - Work Topics

- Advanced Materials Modelling and Design

- Materials Development and Manufacturing
  - Pipework and Tubing
  - Castings
  - Forgings

- Materials Process Development
  - Welding Consumables and Welded Fabrication
  - Surface Engineering

- Testing and Validation

CoACH consortium

POLITECNICO DI TORINO

HR EXCELLENCE IN RESEARCH

Which roles?

	Beneficiary	vs.	Partner Organisation
Signs Grant Agreement	✓		✗
Recruits and Hosts Researchers	✓		✗
Trains/Hosts Researchers on secondment	✓		✓
Participates in Supervisory Board	✓		✓
Directly Claims Costs	✓		✗

EU funding

Research Executive Agency

Source: ITN Information Day, 15 October 2014, Paris, Olivier Pastre, ITN Call Coordinator, Research Executive Agency

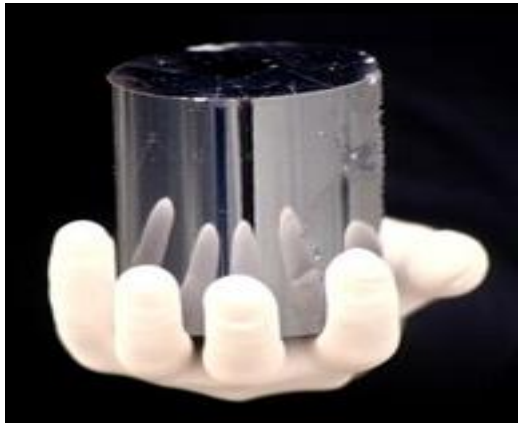
COACH European Training Network

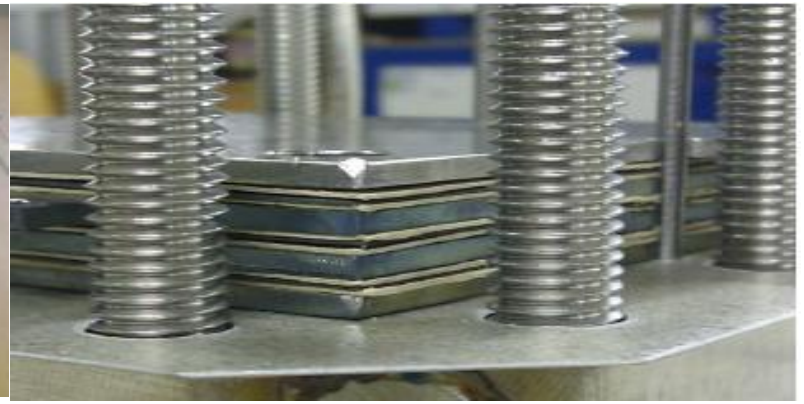
Horizon 2020 European Union Funding for Research & Innovation

CoACH - Scientific and Technoloigcal objectives

Development, processing and characterisation of:

- Innovative and low cost glass fibre based sensors for chemicals and new tests and modelling methods for **glass fibre reinforced composites in harsh environments.**WP2
- New glass, ceramic and composite materials and synthesis routes for **energy harvesting/scavenging**. WP2
- Novel glasses, glass-ceramics and ceramics for **solid oxide electrolysis cell** (SOEC): thin films and sealants. WP2



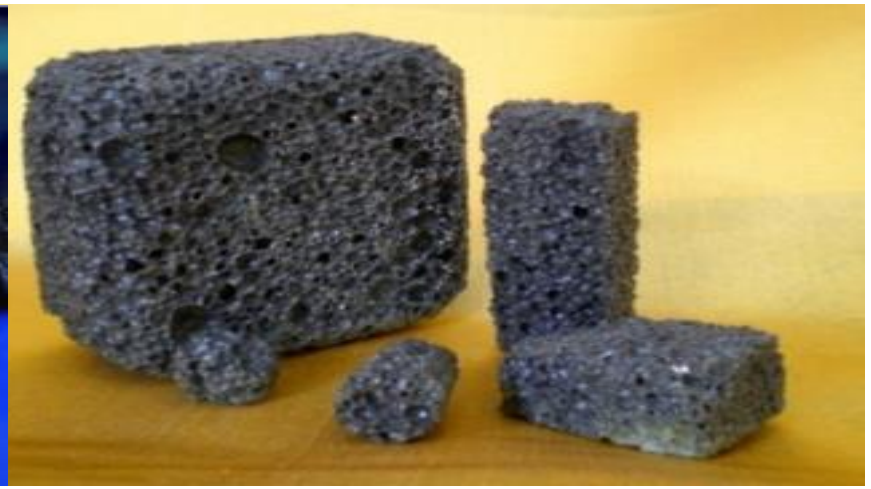


CoACH - Scientific and Technoloigcal objectives

Development, processing and characterisation of:

- New glass-ceramic materials from **waste** for oil and gas industry. WP3
- Low cost glass, ceramic and composite materials from **waste**: new eco-friendly insulation materials, geopolymer based materials. WP3





Summary of KMM VIN in energy

- KMM VIN is very active in the EU materials science arena...
- Industrial and academic organisations work side by side in developing projects, R&D etc
- Membership is growing steadily
- Addressing the many challenges for materials in extreme environments
- KMM VIN seeking to stimulate exchange of ideas, projects and have an impact
- KMM VIN in ideal position to act as dissemination partners for H2020 projects

element™

Thank you for your attention

peter.hansen@element.com