



# ETIP Deep Geothermal Meeting WG on Deep Drilling

TWI Ltd

EGEC Offices, Brussels  
14<sup>th</sup> November 2017

Materials Joining and Engineering Technologies



# TWI – An Extension of your Resources

- Research & Technology Organisation
- Membership based
- Non-profit distributing
- Effectively owned and run by representatives from Member Companies
  - TWI Council (appoints the Executive Board)
  - Research Board



# Some of our Members



To provide our Members with authoritative and impartial expert advice, knowhow and safety assurance through engineering, materials and joining technologies

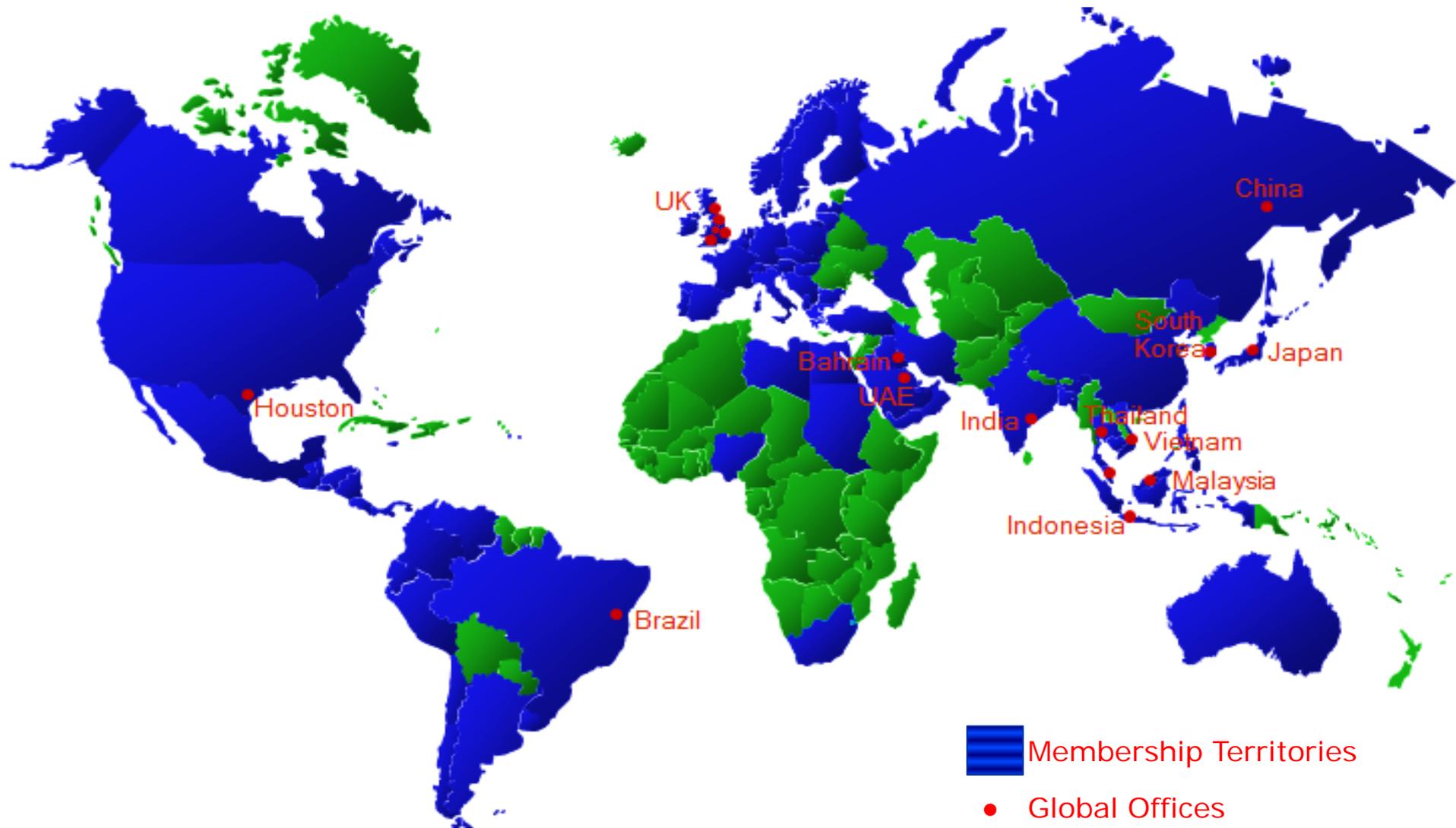


- 5 UK technology centres
- 14 international training centres
- £85m of R&D in materials joining, structural integrity and NDT
- ~700 Industrial Members in 4500 locations worldwide
- Over 950 staff
- Non-profit distributing





- ~800 confidential projects per year
- ~150 ongoing industry-led research projects
- ~18,000 training and examinations students per year
- ~5000 new technical abstracts per annum
- Represent Membership on >100 standards committees



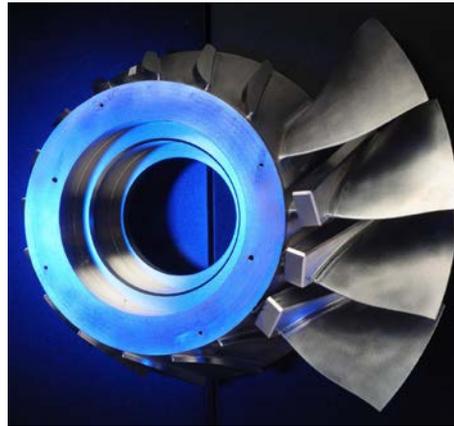
# TWI's Technology Groups

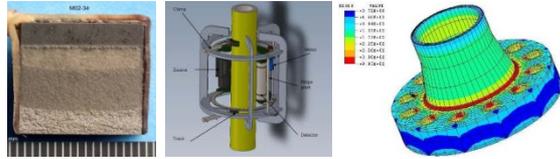


Integrity  
Management

Joining

Materials





## ENGINEERING

- Fitness-for-service assessment (FFS)
- Risk-based inspection (RBI)
- Advanced & specialist NDT/inspection
- Fatigue & fracture testing & assessment
- Testing in critical environments, e.g. sour ( $H_2S$ ), sweet ( $CO_2$ ), HTHP,  $H_2$
- Software tools
- Specialist training

## MATERIALS

- Materials and failure mode characterisation
- Materials/joints performance and degradation testing
- Materials performance improvement for demanding service
- Surface engineering
- Welding engineering and fabrication

## JOINING

- Laser and sheet processes, incl. laser welding and cutting
- Friction and forge processes, incl. linear friction and friction stir welding
- Electron beam welding
- Adhesives and composites
- Ceramics
- Brazing
- R&D developing new technologies



- Development of welding and joining processes and coatings
- Metals, Ceramics, Polymers
- Composite to metal joining
  
- Laser welding
- Friction welding
  - FSW, LFW, rotary
- Electron beam welding
- Brazing and diffusion bonding
- Arc welding



# Materials Performance and Ferrous Alloys (MPF)

## Corrosion



- Corrosion rate measurements
- Electrochemical measurements

## Environmental cracking



- Sulphide stress cracking (SSC)
- Stress corrosion cracking (SCC)
- Hydrogen induced cracking (HIC)
- Hydrogen embrittlement

## Sour Testing



- Corrosion fatigue
- Fatigue crack growth rate
- Fracture toughness
- High pressure and high temperature testing
- Polymer permeation
- Small/medium/full scale

## Key Project Examples:

- Testing and qualification of materials (metals & polymers) for demanding environments – Off-shore, aerospace, medical etc.
- Effects of hydrogen on materials – Fuel Cells, hydrogen storage
- Use of graphene to improve the performance of polymers – structural, durability, selective permeation

# TWI H<sub>2</sub>S Facility

- TWI has operated a hydrogen sulphide facility for over 35 years
- The operation of the current facility (the Trevor Gooch Corrosion Laboratory)
- TWI recently increased its H<sub>2</sub>S laboratory space from 485m<sup>2</sup> to 1000m<sup>2</sup>

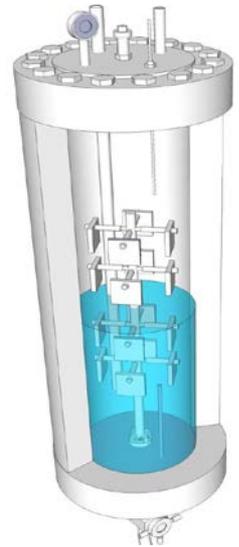


TWIs corrosion and H<sub>2</sub>S facility in Cambridge



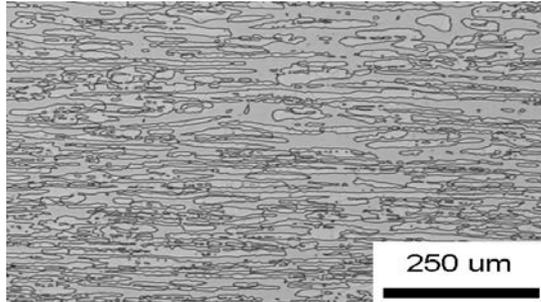
HPHT gas permeation cell

- CO<sub>2</sub> (sweet) and H<sub>2</sub>S (sour) corrosion Testing facilities:
  - 5L, 18L and 33L, 316L and alloy C-276 Autoclaves
  - ~200bar, ~200°C
  - 0.5L, 500bar 316L Autoclave
  - 20bar Ti Autoclave for aerated systems
- Research Themes:
  - Corrosion and cracking mechanisms in sweet and sour environments
  - Materials performance in Carbon Capture and storage environments



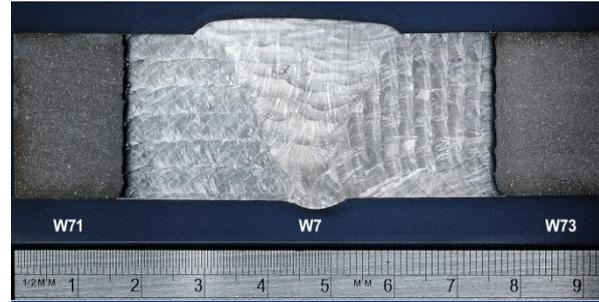
# Stainless Steels & Non-ferrous Alloys (SSN)

Stainless Steels



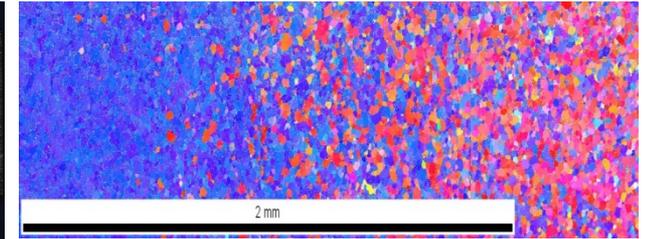
- Weld metallurgy
- Microstructures and properties
- Hydrogen embrittlement (H from cathodic polarisation)
- Environmental performance

Nickel

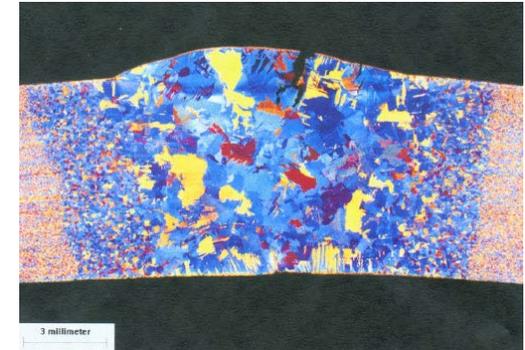


- Weld metallurgy
- High strength Ni alloys for O&G application
- Dissimilar metal interfaces

Al



Ti



+ Others: Cu, Mg, Ta ...

## Key Project Examples:

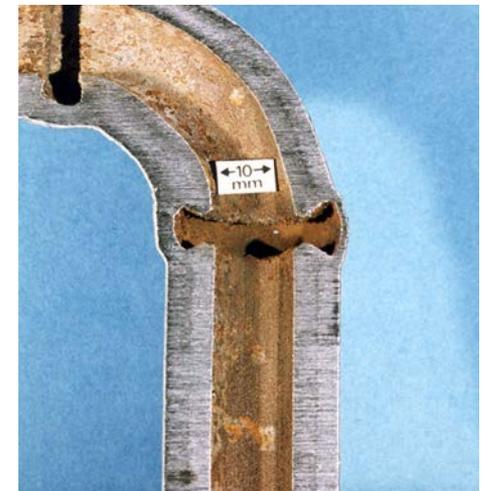
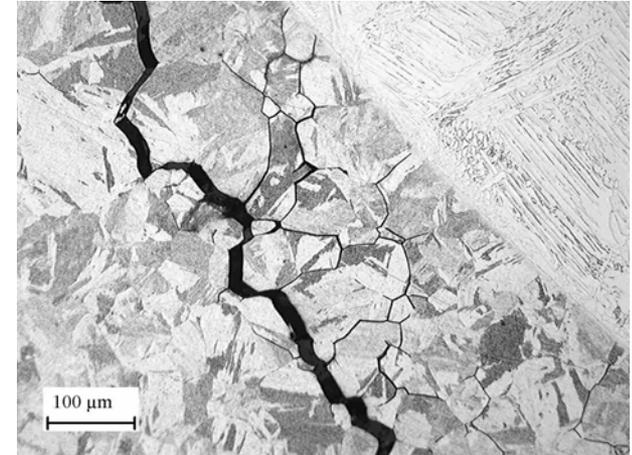
- Development of high-shear processing of recycled aluminium for high performance alloys
- Closed-loop extrusion approach for new Ready-to-Recycle magnesium alloys
- Development of novel joining technologies for high-strength, corrosion resistant Ni-alloy for producing bolts and fasteners for extreme environments

# Hydrogen Economy: Materials Performance in High Pressure Hydrogen (HPH)

- Materials Testing in HPH
  - Tensile, Fatigue and Fracture toughness
- Two systems:
  - 450bar, RT to +60°C
  - 1000bar, -50 to +50°C
- Hydrogen Measurements
  - Diffusion through materials
  - Total and Diffusible hydrogen at T
- Research Schemes:
  - Materials degradation behaviour
  - Performance-microstructure relationship

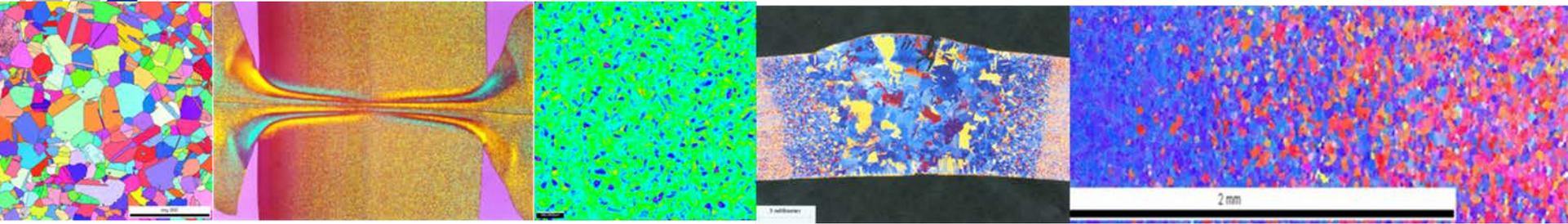


- Drilling
- Corrosion – metallic materials
- Heat exchangers and pumps
- Wear
- Scaling/Fouling
- Efficiency
- Sludge treatment
- Waste and mineral extraction
- Reliability and Costs



- Established track record in delivering framework programme projects (FP5 to H2020)
- Participation in H2020 projects including
  - SMARTREC, SUPREME
- Geothermal proposal in negotiation
  - GeoCoat
  - Development of novel and cost-effective corrosion resistant coatings for high temperature geothermal applications

- LC-SC3-RES-11-2018
  - Geothermal: Novel drilling technologies need to be developed to reach cost-effectively depths in the order of 5 km and/or temperatures higher than 250°C;
  
- LC-SC3-RES-12-2018
  - Thermal storage
  
- LC-SC3-RES-13-2018
  - Deep geothermal: Focus will be on the demonstration of cost efficient technologies to limit the production of emissions and/or to condense and re-inject gases, Turning the emissions into commercial products could contribute to cost reduction but it is not a necessary condition.



**Thank you for your time!**

**Nick Ludford**  
**[Nick.ludford@twi.co.uk](mailto:Nick.ludford@twi.co.uk)**

