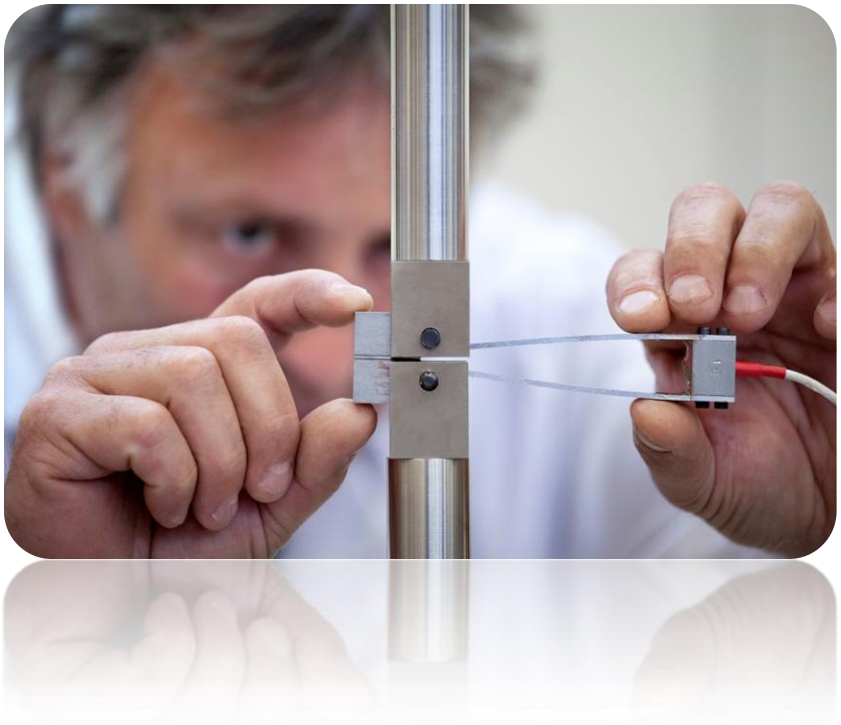
the materials ageing institute

Materials Ageing Institute

An international initiative to support long term operation

MNTK, May 21-23, 2014



Dr. Jan van der Lee
Dr. Michel Debes
EDF, France

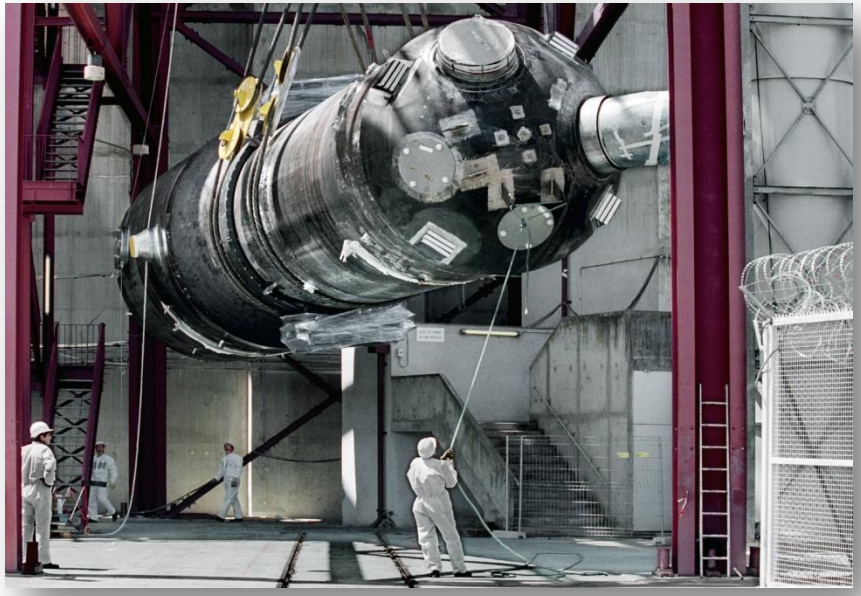
EDF

What the utility does

Ageing Management

- **Inspect**
- **Mitigate**
- **Replace**

Example: Steam Generator PWSCC



- **Inspection of tubes (EC)**
- **Slow down**
- **Plug and/or pull tubes**
- **Replace the SG**

Key questions for the utility:

- **Inspecting which tubes?**
- **When do we replace?**

What the utility idealy needs

Predictive Capability for

- **Inspections**
- **Mitigation**
- **Replacement**

Mechanistic understanding of material ageing processes

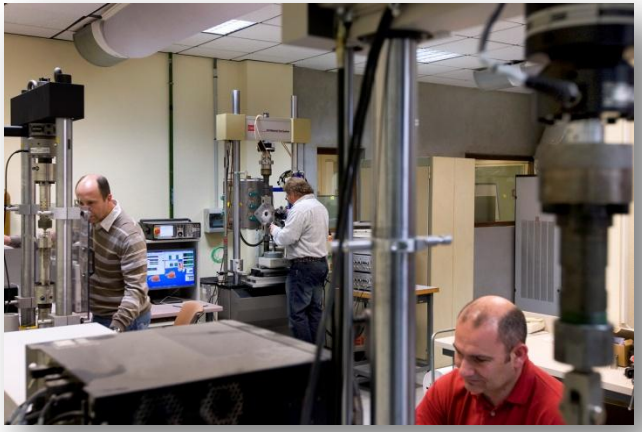
- **Feedback**
- **Experiments**
- **Modelling**

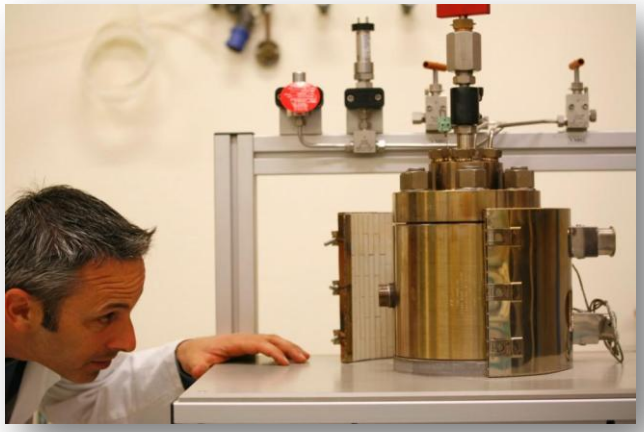
What the utility idealy needs

Predictive Capability for

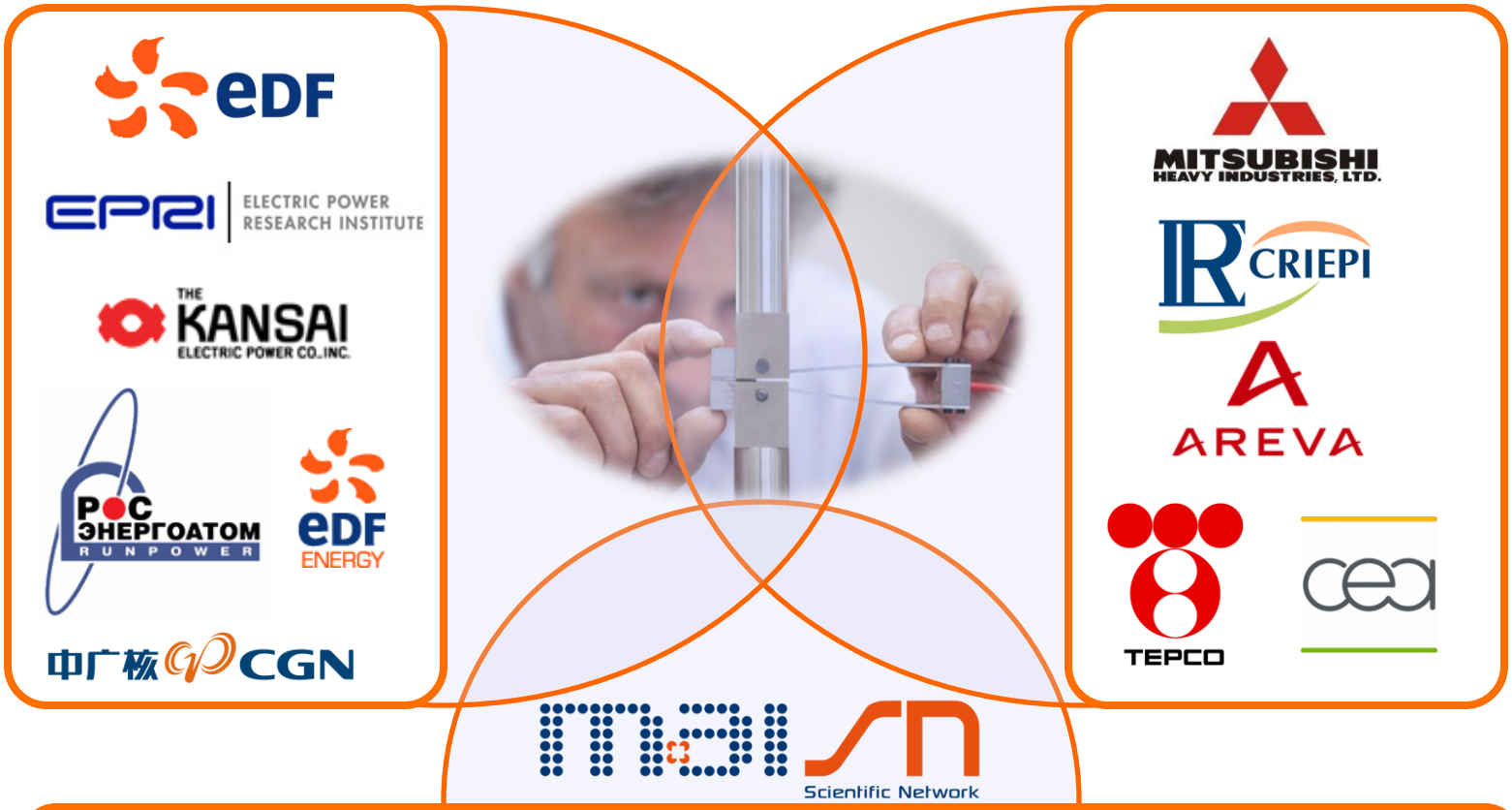
- **Inspections**
- **Mitigation**
- **Replacement**

Materials Ageing Institute





About the MAI

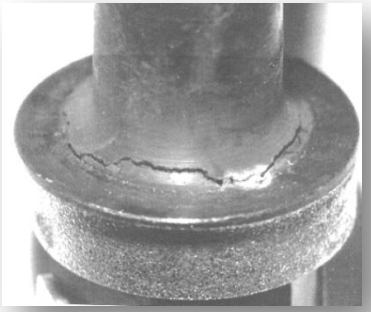


Universities (Michigan, MIT, Tohoku, Manchester, Imperial, Oxford, Rouen, Lille, Paris…), ParisTech (Mines, Ponts, Chimie, Arts & Métiers), INP-Grenoble, INSA de Lyon…

MAI Research Areas

- **Metallic materials**

  Steels and Alloys of RPV, RPV Internal Structures, Pressurizer, SGs, Pipes, welds, …

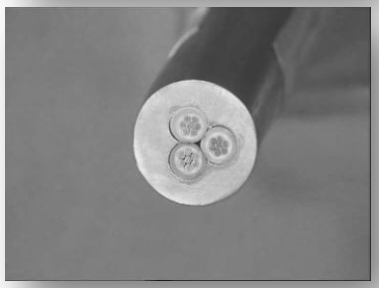


- **Concrete**

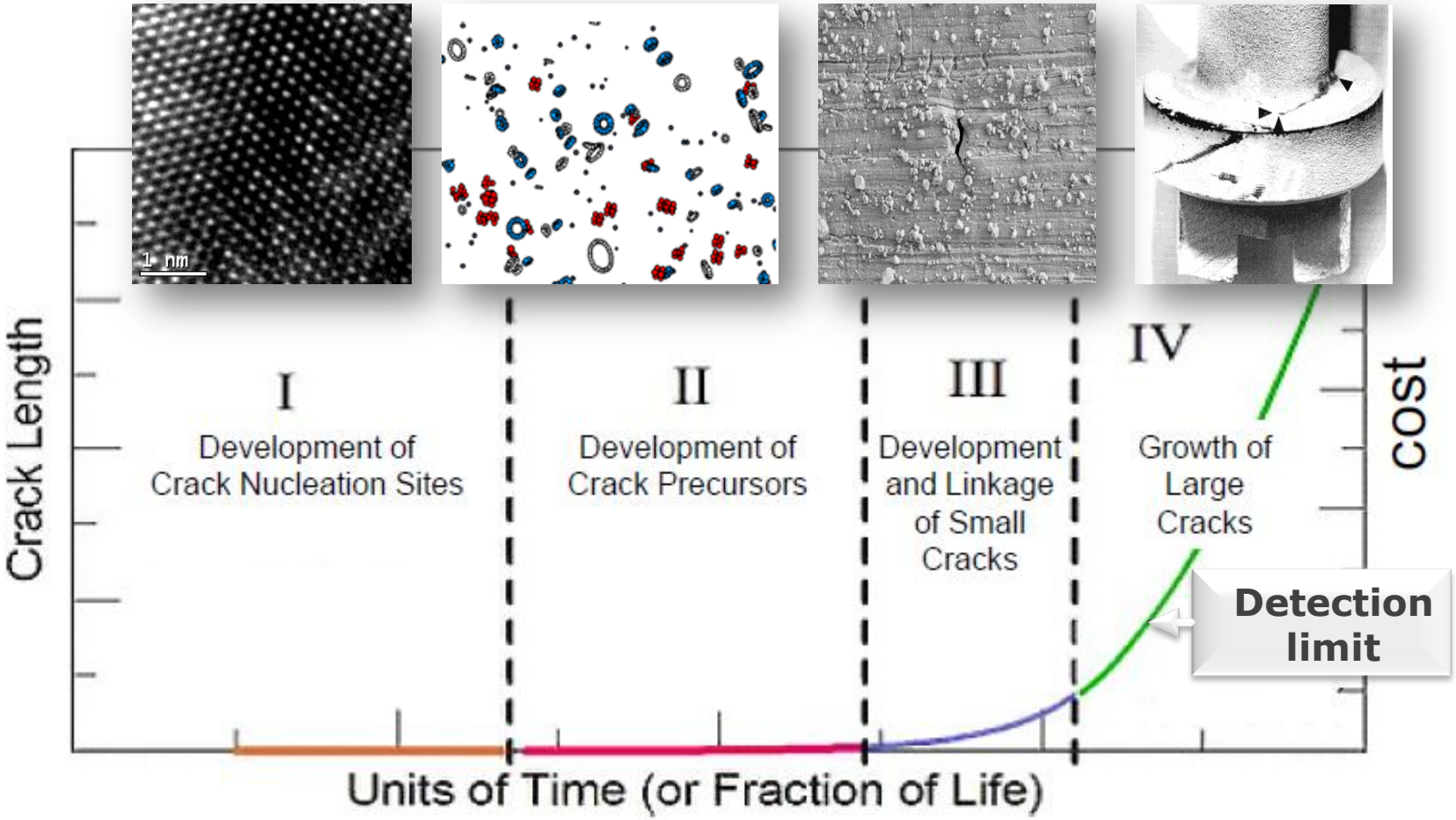
  Containment structure, cooling towers, pipes, spent fuel pools, …

- **Polymers**

  Cables, Coatings, I&C Cards, …

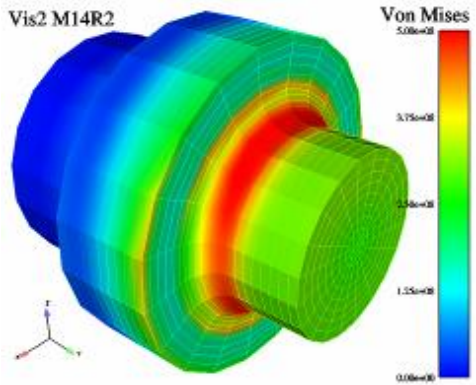


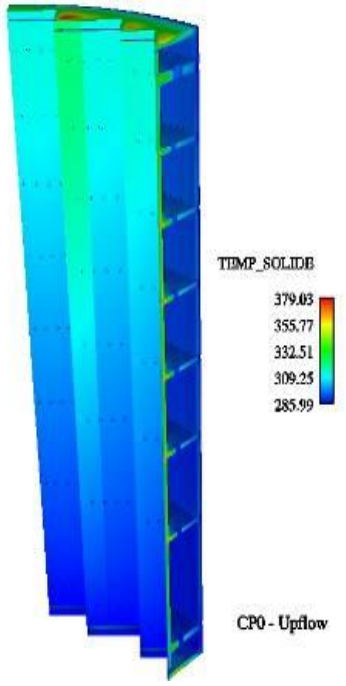
MAI Research Areas
An example: steel corrosion



MAI 2014 Program

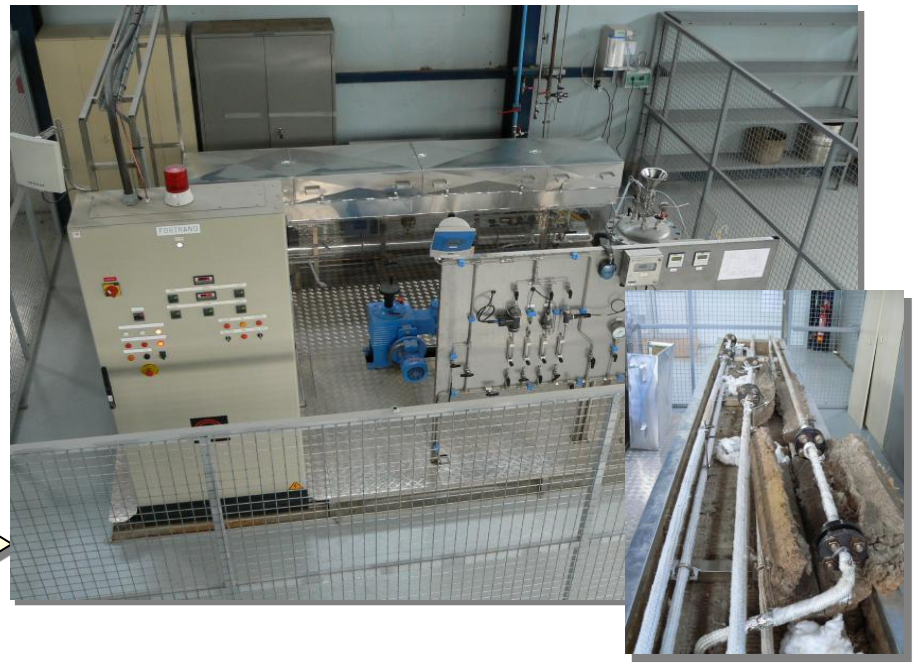
- Lifetime of the Reactor Pressure Vessel (RPV)
- Stress Corrosion Cracking in primary water
- Lifetime of the RPV internal structures
- Thermal & environmental fatigue
- Secondary circuit management
- Concrete degradation
- Vibrational wear
- Cable ageing
- NDE





Experimental Capabilities

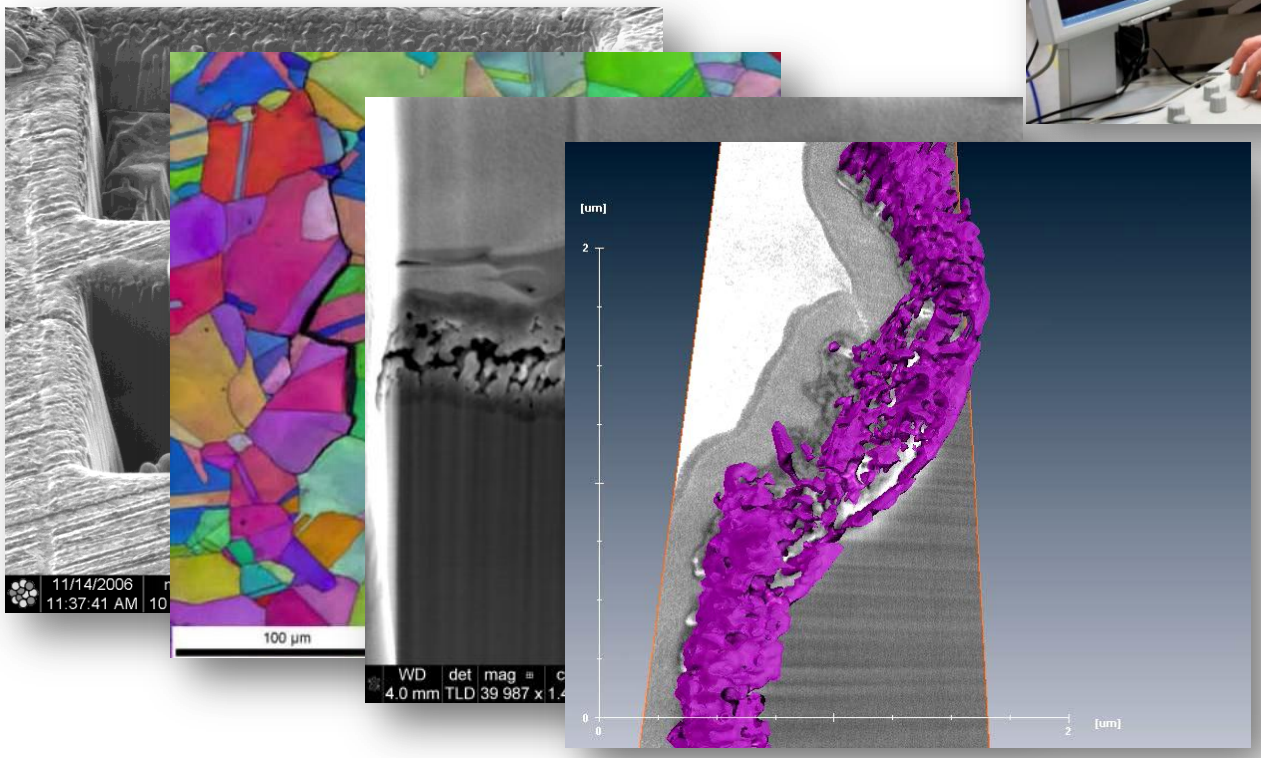
BOREAL device to study the release of corrosion products in conditions relevant for the primary circuit.



FORTRAND device to study the formation and transport of corrosion products in the secondary circuit.

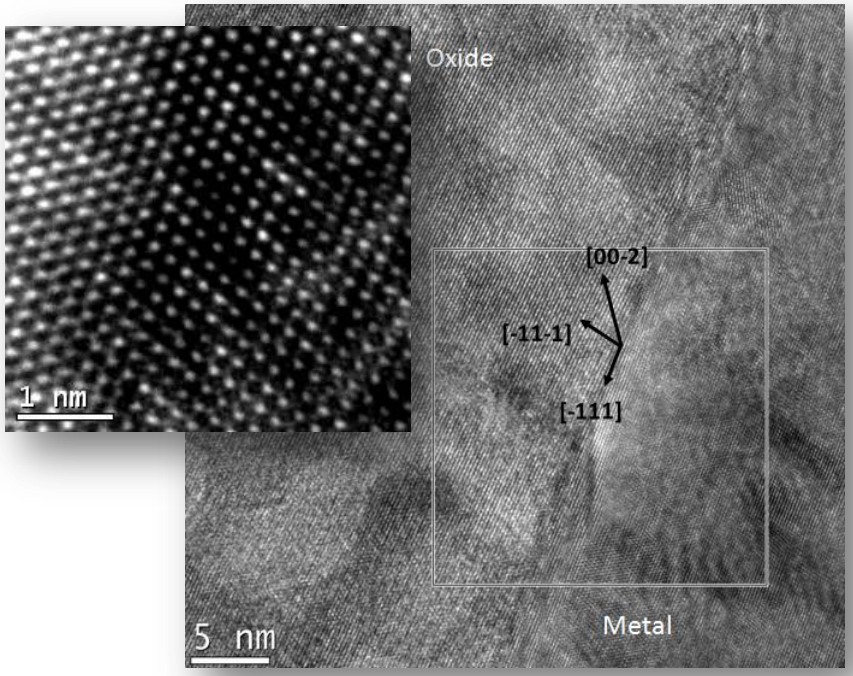
Experimental Capabilities

- **Dual Focused Ion Beam**
  FEI Helios FIB Nanolab
  SEM Resolution < 1 nm
  3D EBSD, EBX, Omniprobe, …



Experimental Capabilities

- **TITAN STEM**
  FEI TEM 80-300 kV
  Mono-Chromator corrector
  EDX HAADF detectors
  ΔE < 0.08 eV
  resolution: 70 pm



Using the TITAN STEM to determine at the atomic scale the exact nature of oxyde layers formed at the surface of 600 allay in conditions relevant for PWR primary circuits.

Workshops and Seminars

Objectives

- Promote technical exchanges and sharing of knowledge (workshops, seminars)
- Contribute to the training of master & Ph.D. students
- Increase knowledge on material ageing and ageing management to engineers of the nuclear industry
- Promote the MAI and its members (communication)

Example: MAI Workshop on Inspection and Degradation Management of Concrete Structures in the Nuclear Industry, September 2011. Next offering: October 2015

Workshops and Seminars

International Nuclear Plant Electrical Cable Ageing Management Symposium

- September 17 – 19 2013, at the MAI
- ~90 participants from 19 countries, 5 continents
- Mainly industrials (utilities, vendors) and focused organizations (IAEA, NRC, IRSN, EPRI, SCK-CEN, …)
- Major brainstorming sesssion on available data and NDE techniques, practical approaches applied by NPPs
- Roadmap

Workshops and Seminars

MAI-CGN seminar, April 9 – 12, 2013

- Experimental capabilities and approaches (presentations and labtour) of SNPI (Suzhou); exchange on LTO approaches; MAI contributions, FAC, fatigue…

MAI-REA seminar, Moscou, June 19–20, 2013

- REA/VNIIAES/Kurchatov/MAI exchange on lower-core internals materials – irradiation, thermal ageing, corrosion; erosion-corrosion and FAC; RPV embrittlement and lifetime assessment

Workshops and Seminars

- **Oxide Formation, Transport and Deposition**
  MAI (Moret-sur-Loing): March 17 – 18, 2014 restricted (MAI and invited)
- **Optimization of Hydrogen Concentration in the Primary Circuit**
  MAI (Moret-sur-Loing): March 20 – 21, 2014 restricted (MAI and invited)
- **Materials Degradation Course for Engineers in the Nuclear Industry**
  Suzhou (China): April 22 – 25, 2014, co-organized by SNPI, unrestricted
- **Uncertainty Management in Computational Materials Science**
  MAI (Moret-sur-Loing): May 12 – 14, 2014 (MAI and invited)
- **Nuclear Materials and Components – Ageing Processes**
  INP-Grenoble/MAI, September-December 2014:
  - Reactor Design and Material Selection
  - Internals and RPV – Irradiation Issues
  - Component Ageing:
    Fundamentals and Examples (MAI)

Handbook of Destructive Assays

Written by François Cattant

This handbook is all about observation. It provides a comprehensive collection of unique photographs, detailed schematics, concise analyses, precise measurements and recommendations.

The work is organized in such a manner that engineers and scientists can use the observations to arrive at their own reasoning, to learn and subsequently improve their knowledge on specific material ageing issues

The handbook can be obtained from the MAI website, ***www.themai.org***

MAI in numbers

35 M€ total investments by EDF (2008 – 2016)

11 M€ annual budget in 2013

80 researchers, technicians involved

20 universities/institutes associated

11 members, representing 66% NPPs

250 participants yearly in the E&T program

Summary

- **Material issues have by far the largest impact on safety, reliability and economics**
- **The more operational feedback, the more effective these issues can be addressed**
- **International cooperation and collaboration is essential**

The MAI's mission is to address all three points

Thank you

Getting the best of what materials can give

http://www.themai.org