European R&D Projects on Materials for Next Generation Nuclear Systems

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http://ie.jrc.ec.europa.eu/

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Requirements for innovative nuclear systems:

- Sustainability and waste minimisation
- Enhanced economics, safety and reliability
- Enhanced proliferation resistance

Material-related operational conditions envisaged:

- High in-service and off-normal temperatures
- High burn-ups
- Long service life-time (~ 60 years)
- Corrosive coolant environment: coolant compatibility

$\Rightarrow$ **Considering the operational experience with current nuclear industry, these conditions imply demanding challenges from the structural materials point of view.**

Outlook

GETMAT: **GEn IV and Transmutation MATerials**
(cross-cutting materials issues)

HPLWR 2: **High Performance Light Water Reactor Phase 2**
(WP on materials for SCWR)

RAPHAEL: **ReActor for Process heat, Hydrogen And ELectricity generation**
(WP on materials for VHTR)

HycycleS: **Materials and components for Hydrogen by sulphur based thermochemical cycleS**
(materials for a specific VHTR process heat application)

GETMAT: GEn IV and Transmutation MATerials

Start of the GETMAT project	February 1st, 2008
Duration	60 months
Number of partner organisations	24
Budget (total)	14 M€
EC contribution	7.5 M€

GETMAT Partners

P	Beneficiary name	Beneficiary short name	Country
1	Forschungszentrum Karlsruhe GmbH	FZK	Germany
2	Commissariat à l’Energie Atomique	CEA	France
3	Studiecentrum voor Kernenergie/ Centre d'étude de l'Energie Nucléaire	SCK-CEN	Belgium
4	Ente per le nuove Tecnologie l’Energia e l’Ambiente	ENEA	Italy
5	Paul Scherrer Institute	PSI	Switzerland
6	Nuclear Research and Consultancy Group	NRG	Netherland
7	Centro de Investigaciones Energeticas Medioambientales y Tecnologicas	CIEMAT	Spain
8	Electricité de France SA	EDF SA	France
9	Forschungszentrum Dresden-Rossendorf	FZD	Germany
10	Université Libre de Bruxelles	ULB	Belgium
11	Kungliga Tekniska Högskolan	KTH	Sweden
12	The University of Liverpool	UL	United Kingdom
13	The University of Edinburgh	UEDIN	United Kingdom
14	University of Alicante	UA	Spain
15	University of Helsinki	UH	Finland
16	Materialpruefungsanstalt Universitaet Stuttgart	MPA.USTUTT	Germany
17	Consiglio Nazionale delle Ricerche	CNR	Italy
18	Centre National de la Recherche Scientifique	CNRS	France
19	Ústav jaderného výzkumu Řež a.s	UJV	Czech Republic
20	Joint Research Centre (IE, ITU)	JRC	Belgium
21	Technical Research Centre of Finland	VTT	Finland
22	Chalmers University	CHALMERS	Sweden
23	Universidad Politécnica de Madrid	UPM	Spain
24	CESI RICERCA	CESI-RI	Italy

Materials Cross-Cutting Activities

System	GFR	SFR	LFR & ADS	VHTR thermal neutrons	SCWR thermal & fast n	Fusion	
EC projects	GCFR	EISOFAR CA	ELSY and Eurotrans	RAPHAEL	HPLWR	He, 80bar 300-480°C	Pb 17Li, 1bar 480-700°C
Coolant	He, 70 bars 480-850°C	Na, few bars 390-600°C	Lead alloys (Pb, LBE)	He, 70 bar 600-1000°C	SC H_2O, 250bar, 280-500°C		
Fuel	(UPu)C / O2 in plates of pins in hexagonal subassemblies	(UPu)O2 in pins in hexagonal subassemblies	various concepts	Coated particles (SiC or ZrC) in a graphite matrix	UO_2 enrich	Dual coolant blanket	
Core structure	SiC-SiCf composite or (backup) **ODS**	Cladding: **ODS** Wrapper: 9Cr MS	Cladding: 9Cr MS, **ODS** Wrapper: 9Cr MS	Graphite composites C/C, SiC/SiC for control rods	Clad aust SS, Ni alloys?, **ODS**	SiCf-SiC, MS, **ODS FS**	
Temp.	500-1200°C	390-750°C	350-480°C	600-1600°C	280-750°C	Up to 650°C	
Dose	60-90dpa	up to 200dpa	100dpa	7-25dpa		100dpa + He	
Out of core struct. and others	vessel & core struct: **9-12Cr MS** 350-500°C <<1dpa	prim/sec/steam circ.: **9-12Cr MS** 390-600°C	ADS target: **9Cr MS** 350-550°C 100dpa+He+H	-----	------	------	

Courtesy CEA

Objectives defined in view of other experimental programs in progress and results already obtained:

- Improvement and extension of 9-15 Cr F/M steels qualification
- ODS alloys development and characterisation
- Joining and welding procedures qualification (relevant for both ODS and F/M steels)
- Development and definition of corrosion protection barriers
- PIE program of relevant running irradiation experiments
- Improved modelling and experimental validation

Work Plan

WP1: Metallurgical and mechanical behaviour

Task 1.1: Materials procurement basic characterisation and distribution
Task 1.2: Welding/Joining activities
Task 1.3: High temperature creep/fatigue in inert atmosphere
Task 1.4: Database of the existing data

WP2: Materials compatibility with coolants

Task 2.1: Corrosion tests in different media
Task 2.2: Advanced corrosion barrier development
Task 2.3: Environmental effects on materials mechanical properties

WP3: Irradiation behaviour of structural materials

Task 3.1: PIE of Matrix - Task 3.2: PIE of STIP
Task 3.3: PIE of MEGAPIE - Task 3.4: PIE of ASTIR
Task 3.5: LEXUR II - Task 3.6: PIE of IBIS/SUMO

WP4: Multiscale modelling of FeCr alloys and experimental validation

Task 4.1: Modelling of fundamental properties of Fe and FeCr alloys
Task 4.2: Modelling of radiation effects in Fe and FeCr alloys
Task 4.3: Modelling-oriented experiments in Fe and FeCr alloys

Martensitic or ferritic ODS ?

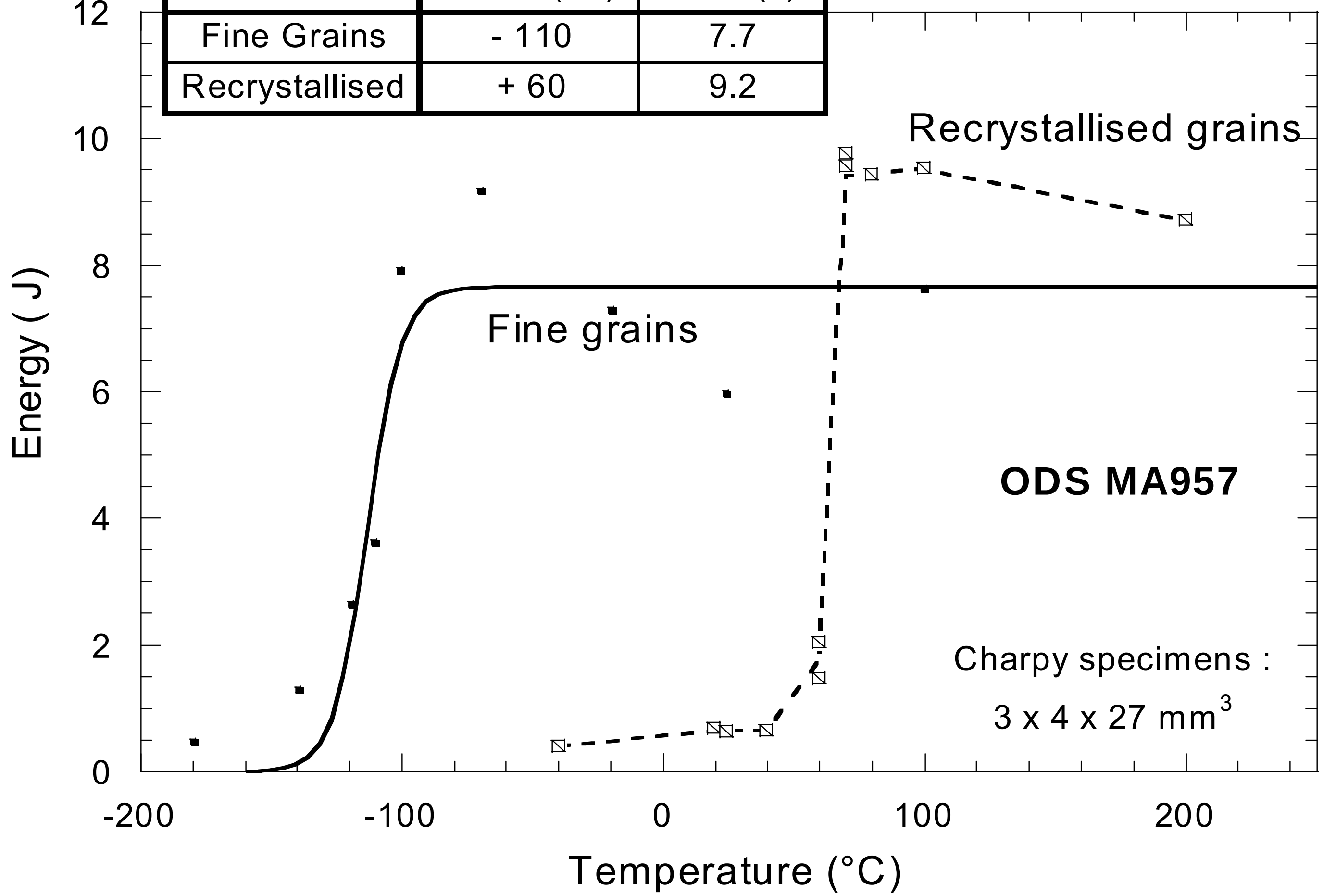
Martensitic:

- isotropic
- easier to manufacture
- not for use above 800°C- 850°C
- corrosion resistance can be a key issue

Ferritic (high chromium content):

- anisotropic => mechanical behaviour (creep properties….?).
- possible embrittlement under irradiation
- better oxidation / corrosion behaviour
- difficult to manufacture: homogeneity, control of recrystallization

MA957	DBTT (°C)	USE (J)
Fine Grains	- 110	7.7
Recrystallised	+ 60	9.2

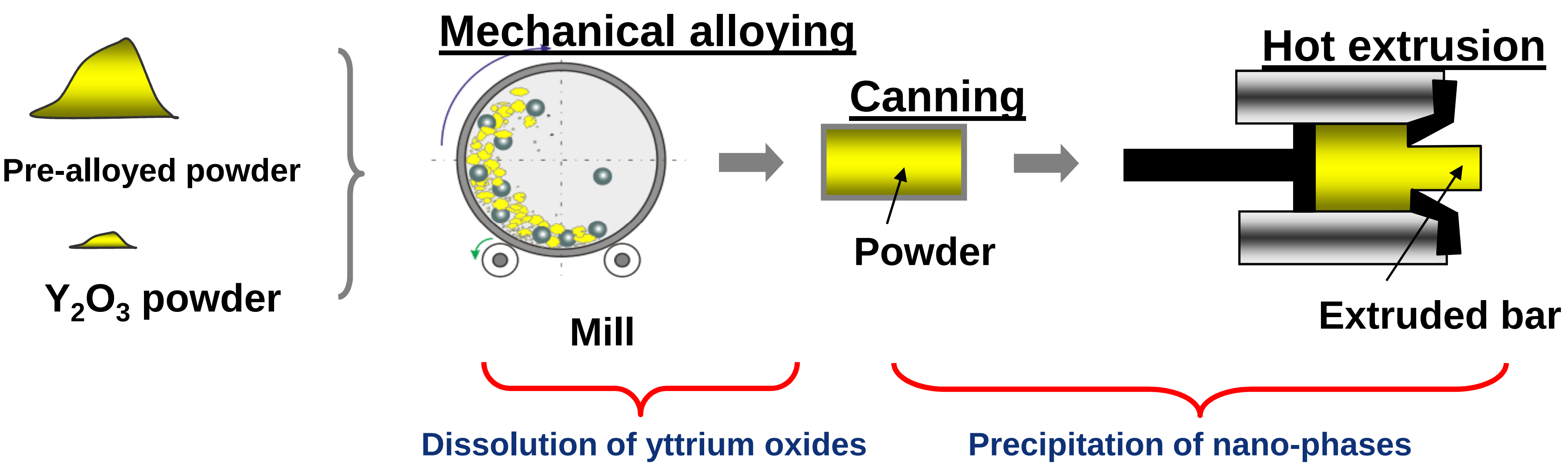


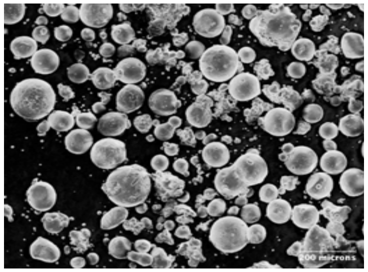
A. Alamo et al.

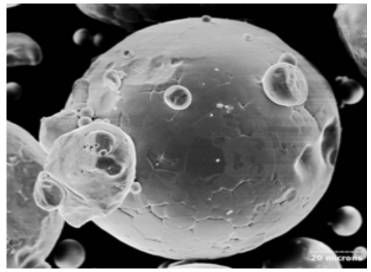
Mechanical alloying at CEA

CEA: production of Fe-**14Cr** 1W 0.3Si 0.3Mn 0.15Ni-Ti **+ 0.3 Y_2O_3 ODS**

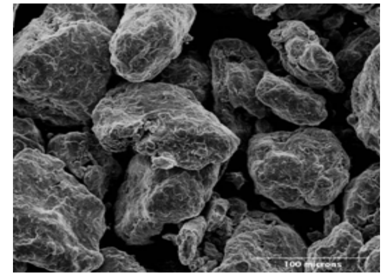
Fabrication route: Powder metallurgy





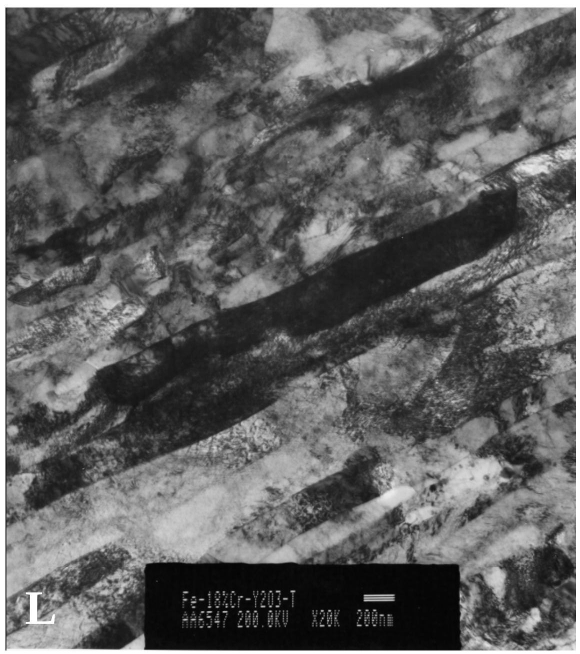


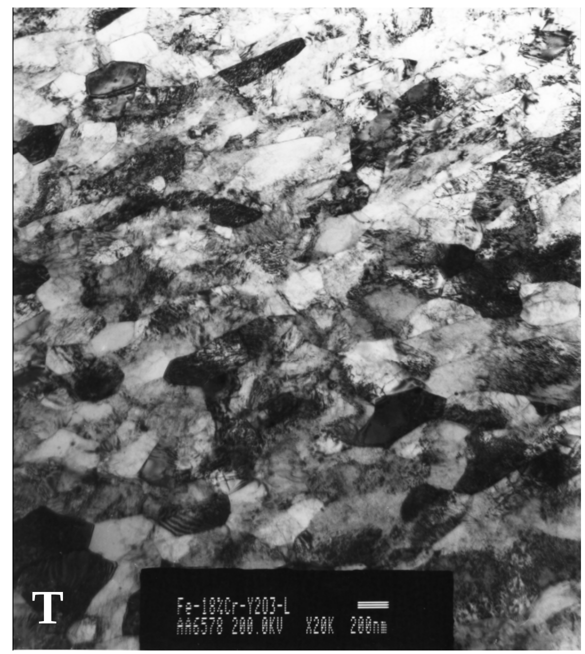
Before mechanical alloying



After mechanical alloying

After hot extrusion





Mechanical alloying at FZK

FZK: Production of **9%Cr** ODS steel

Chemical composition

Steel P91

DIN 1.4903 X10CrMoVNb9 1

	C	Si	Mn	P	S	Cr	Ni	Mo	V	Nb	Al	N
Spec.	0.08 - 0.12	0.20 - 0.50	0.30 - 0.60	max. 0.020	max. 0.010	8.0 - 9.5	max. 0.40	0.85 - 1.05	0.18 - 0.20	0.06 - 0.10	max. 0.04	0.03 - 0.07
Insp. Cert.	0.097	0.39	0.44	0.013	0.002	8.70	0.25	0.92	0.216	0.070	0.005	0.059

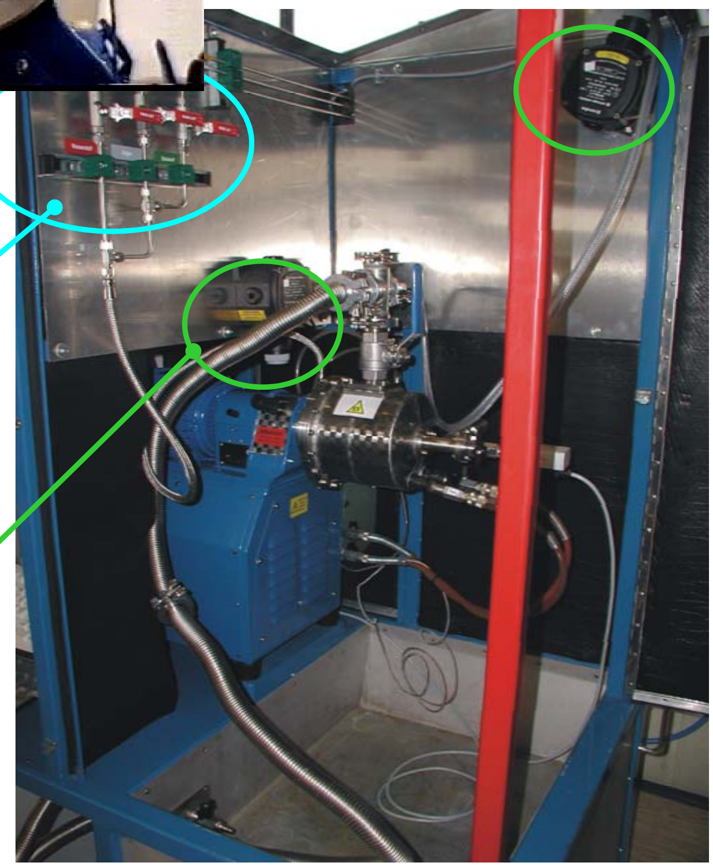
Solid solution strenghtening (Mo)

Corrosion resistance (Cr)

Carbide precipitation (V, Nb)

Mechanical alloying at FZK

ZOZ Simoloyer CM01

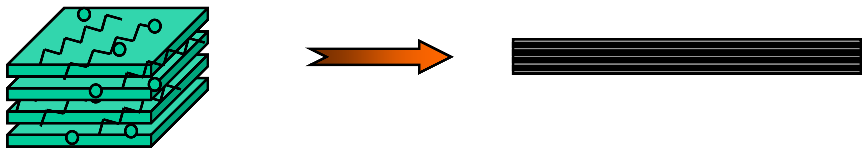


Mechanical alloying in various atmospheres (Ar, H_2, N_2)

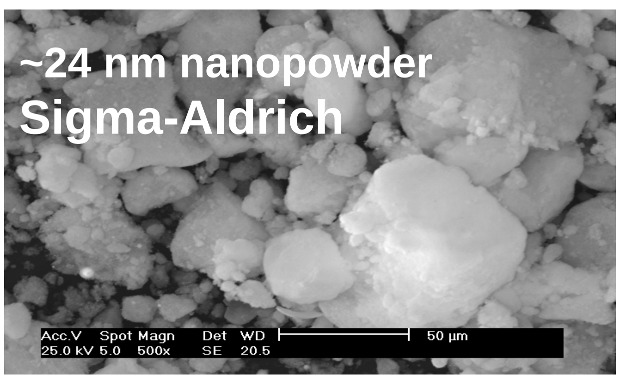
Gas sensors for local H_2 concentration

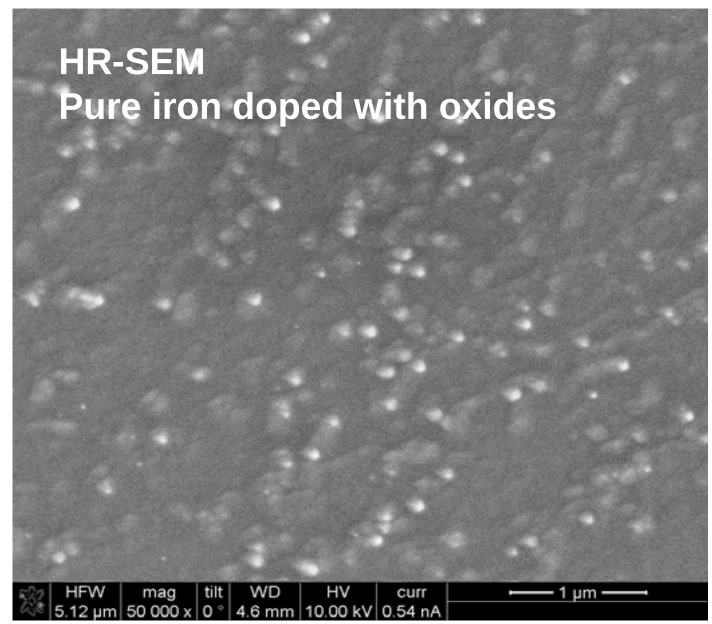
Arcelor production routes for T91 ODS

Route 1: T91 ODS production via hot roll-bonding

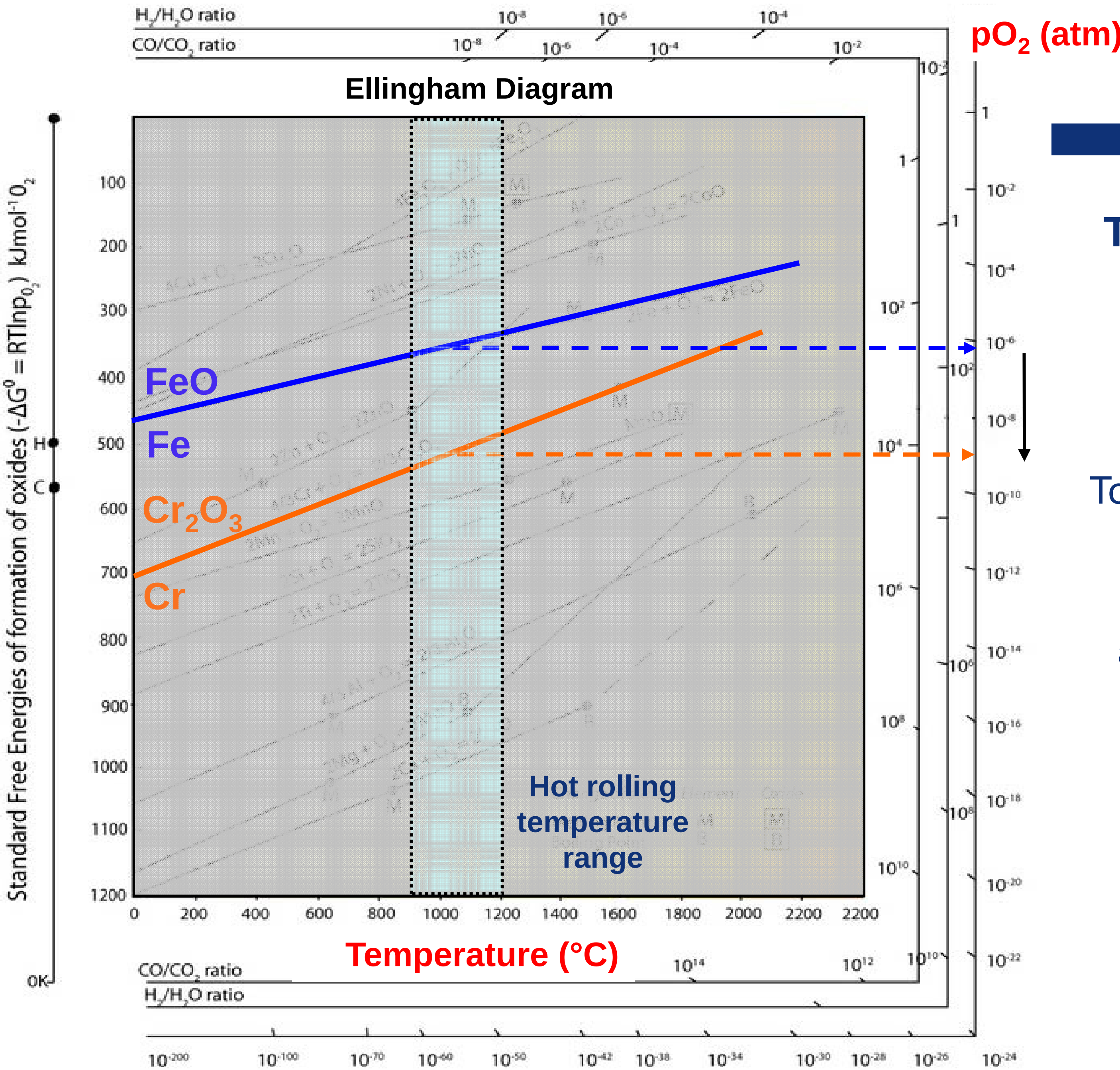


Route 2: Dissolution of ODS particles in steel via in-mould electromagnetic stirring (EMS)





T91/nano-Y_2O_3 ODS production by roll-bonding



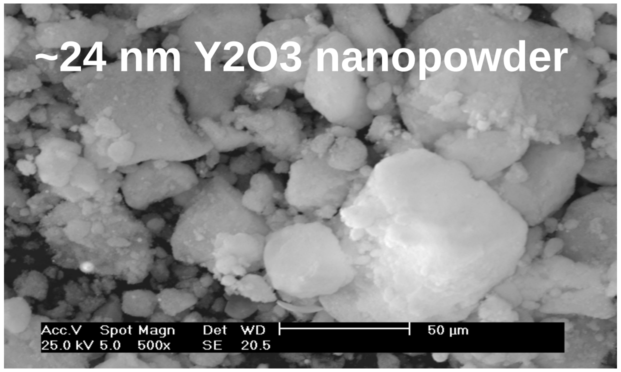
To suppress oxidation of Cr,

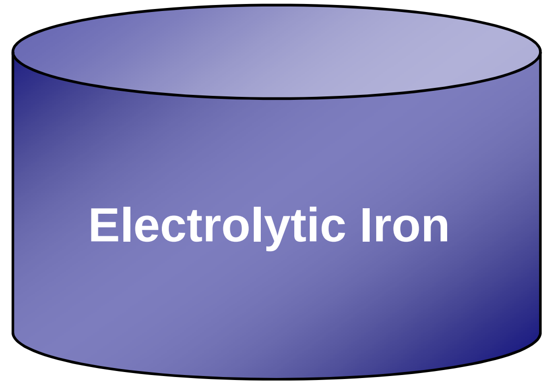
the pO_2 needs to be approx. 1,000x lower

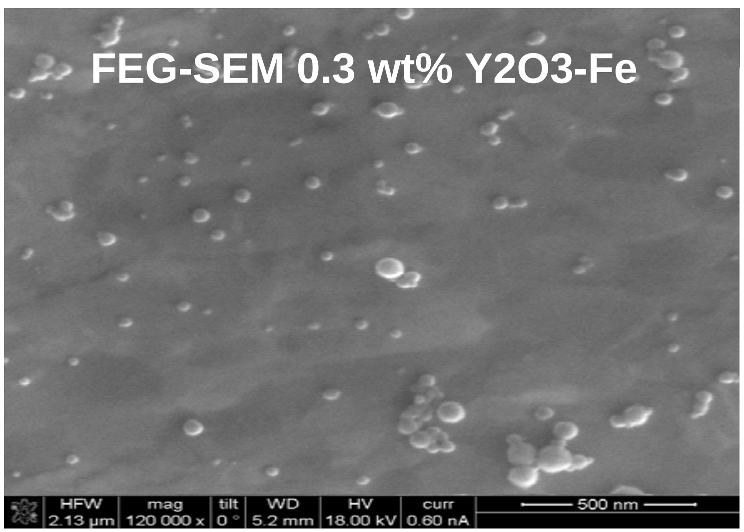
as compared to suppression of FeO

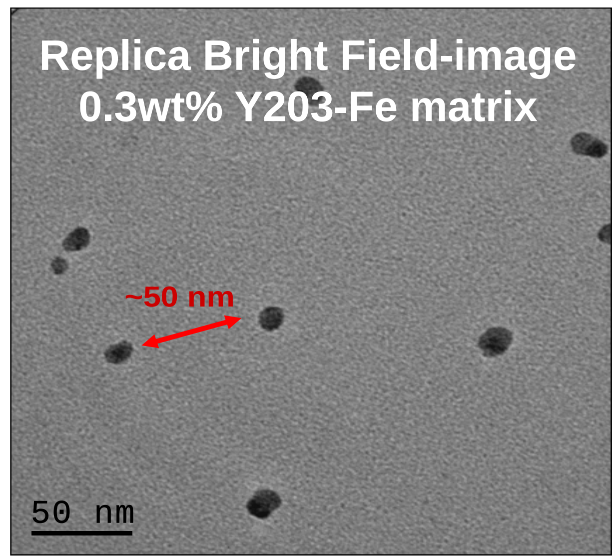
Need for improved atmospheric control

Dissolution of ODS in steel via EMS









Issues: sufficient wettability, to avoid agglomeration of particles

GETMAT and the SNE-TP roadmap

2008 → 2012 → 2020

SNE-TP Vision Report:

1. **2009 – 2012** SFR R&D Programmes to bring innovations.
2. R&D to assess viability and performance of gas and LFR or ADS.
   2010-2012 selection
3. **2012** Viability of SCWR

SNE-TP Vision Report:

1. **2012** SFR Confirmation of design options; preliminary and detailed design, safety analysis report; validation R&D; construction of prototype
   2020 Start-up operation
2. **2012** Second prototype confirmation
   2020 Start-up operation

SNE-TP Vision Report:

1. **2020-2040** Further R&D to design and optimise full-scale systems, to build a first-of-a-kind fast reactor and start of commercial deployment

GETMAT:

- contribute to the **specifications** of **components** from design to licensing
- address **materials availability** according to specific safety issues
- Define **range of application** of selected materials
- strengthen and enhance **training and education**

Beyond GETMAT:

- The results of GETMAT and other international projects / initiatives will help to define research priorities in the field of materials beyond 2012.

E.g.:

- 9-12Cr F/M and their welds: further needs consistent with detailed design, safety and licensing for prototype
- ODS and their welds: R&D for extension and completion of feasibility and viability assessment.
- Viability of corrosion protection methods

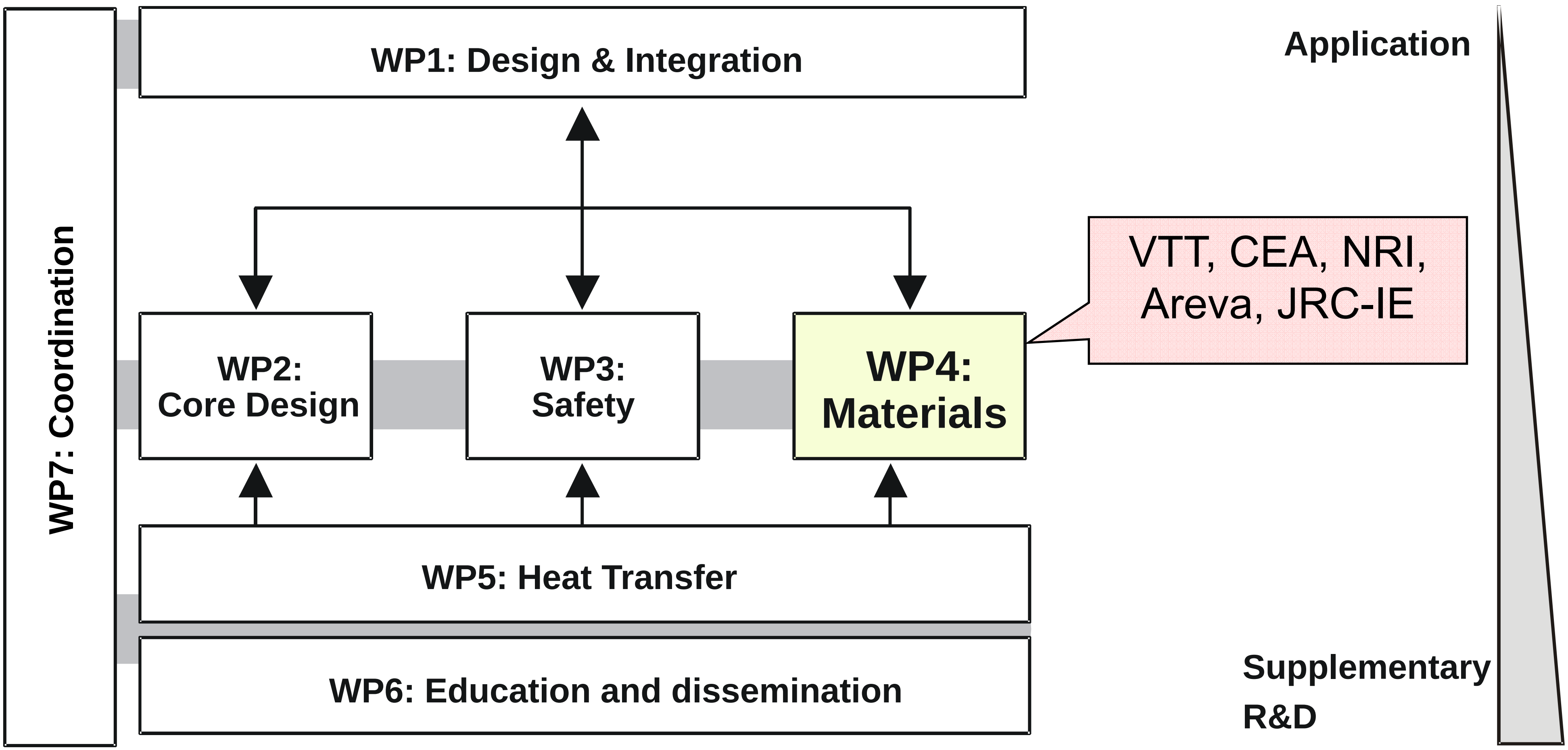
HPLWR 2: High Performance Light Water Reactor Phase 2

SCWR Materials and water chemistry

HPLWR 2

High Performance Light Water Reactor Phase 2

Materials - HPLWR Phase 2



WP4: Corrosion, SCC and creep tests

Objective

- Investigate materials behaviour in supercritical water and to select optimal in-core and out-of-core materials with respect to
  - Stress Corrosion Cracking (SCC) resistance
  - Oxidation resistance
  - Creep resistance
  - Irradiation resistance

Tasks

- Autoclave experiments:
  - Oxidation mechanisms of ferritic/martensitic and austenitic steels
  - Combined mechanism of creep and oxidation
  - Stress corrosion cracking tests
- *Materials Data Base and Models for uniform corrosion, stress corrosion cracking, etc.*
- *Construction of Supercritical Water Loop for in-pile materials testing*

HPLWR WP4: Materials

DATABASE ON MATERIALS PERFORMANCE FOR CORE COMPONENTS AND RPV INTERNALS, OUT-OF-PILE

SC-water chemistry and monitoring

PREPARATION OF IN-PILE TESTS

Partner	Test/activity type	Material and environment	Potential component
CEA	**Materials performance studies (review):** Provider for a SC-materials database including all test	Austenitic stainless steels Ni-based alloys Simulated irradiated materials	Fuel cladding RPV internals
VTT, JRC	**Corrosion and creep studies:** - Oxidation and general corrosion with coupons - SCC with U-bend and 3-point bend specimens - Creep-oxidation using bellow loading (500-600°C) for controlled slow tensile loading	Ferritic steels and **ODS** Ferritic and austenitic stainless steels Ni-based alloys at 300-600°C H_2 and O_2 water chemistry	Fuel cladding RPV internals Out of core components
AREVA	**Expert contribution:** specifications, evaluation of results and water chemistry concept		Fuel cladding Internal support Out of core components
NRI	**Supercritical water Loop construction** and qualification out-of-pile. Preparation of the loop for future in-pile tests	Varying water chemistry (H_2 content optimisation to suppress radiolysis)	Fuel cladding Internal support Out of core components

Institutional work outside HPLWR

Interaction with GIF and Euratom test programme

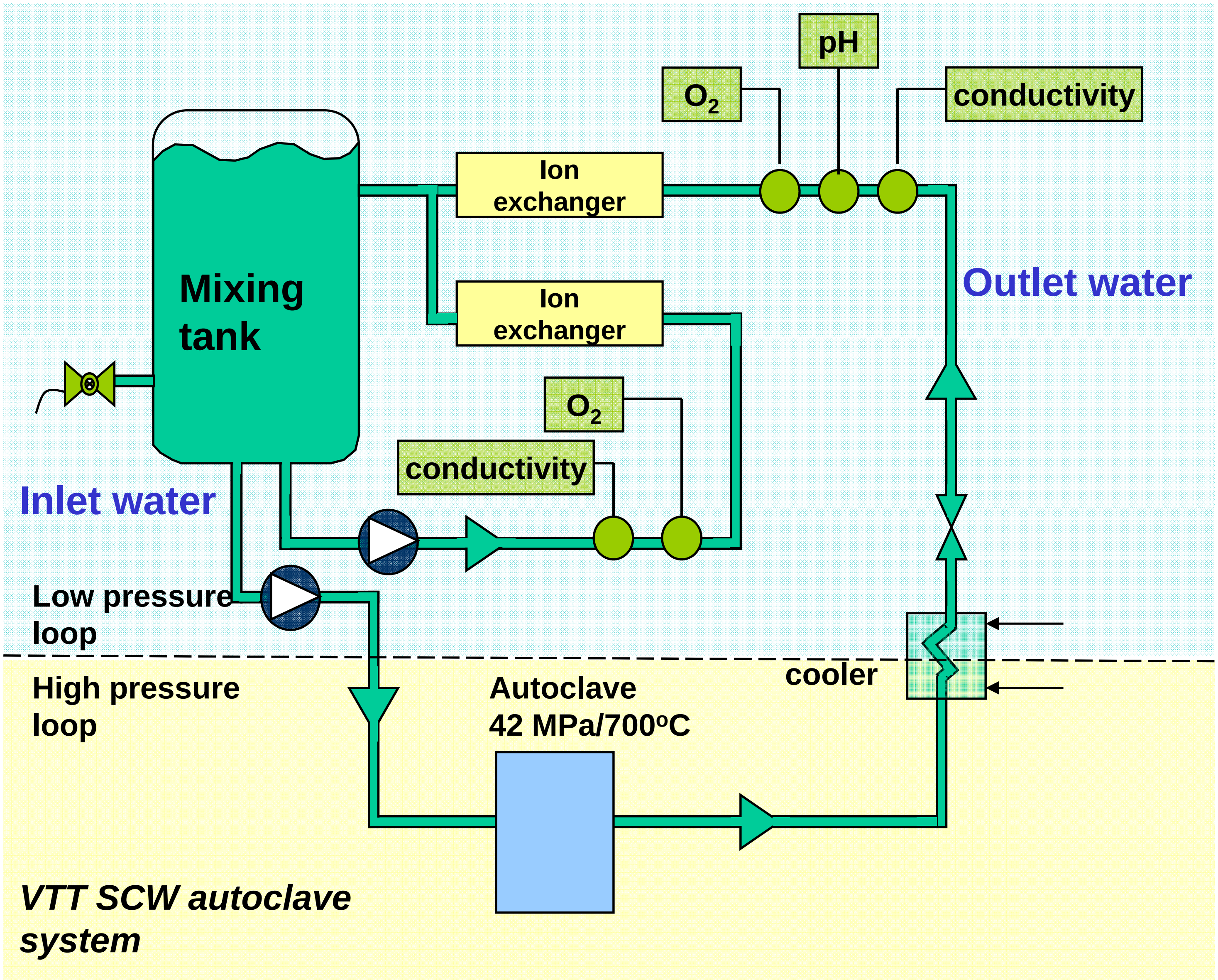
HPLWR Corrosion test facilities

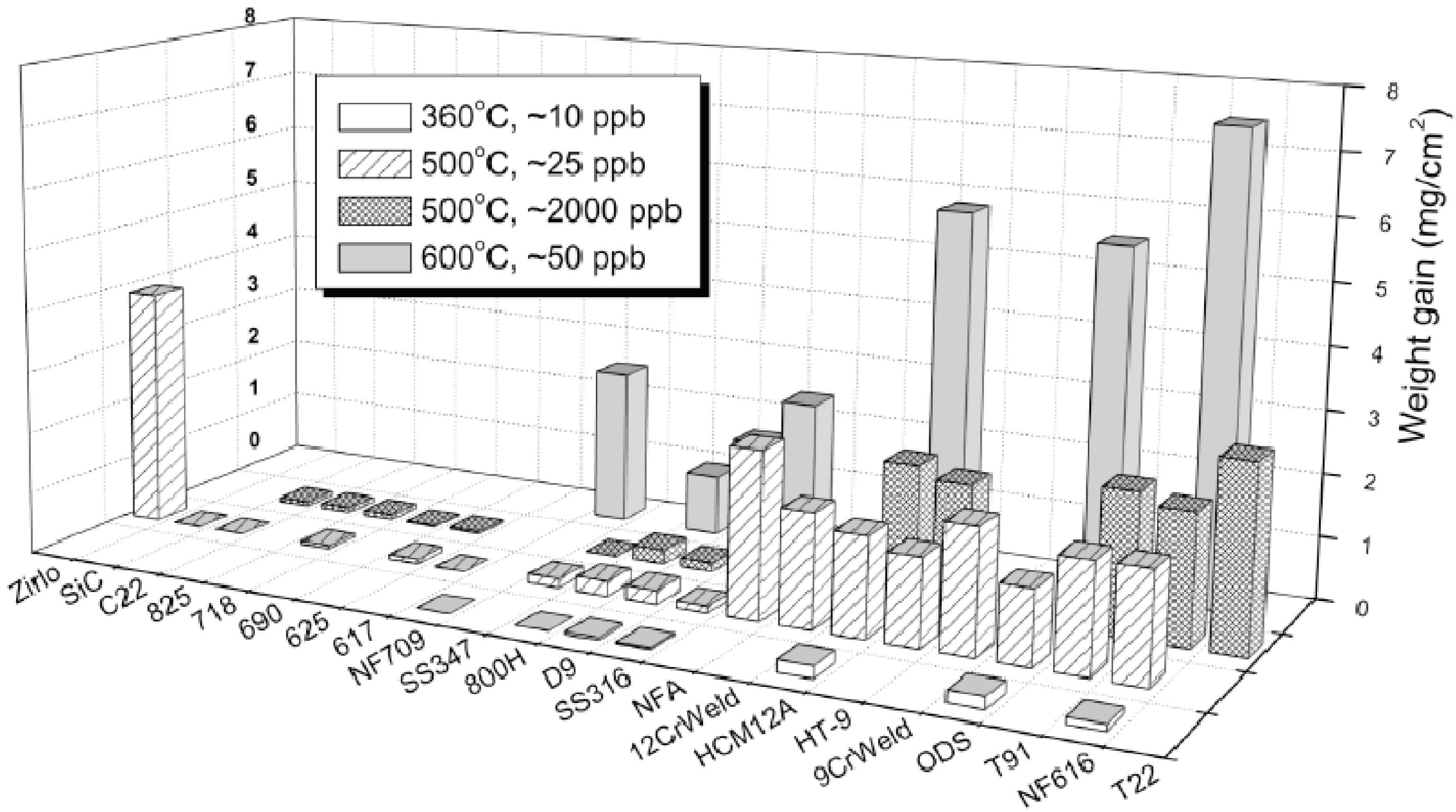
- VTT autoclaves 2 x (695°C / 35 MPa) with bellow loading option for mechanical testing
- JRC-IE autoclaves 2 x (650°C / 35 MPa) with different loading systems
- On-line corrosion monitoring (electrochemical potential, el.chem. noise, contact electrical impedance, acoustic emission)
- Reference electrode Ag/AgCl development (VTT)
- SCWL development at Rez (NRI)
- Parallel corrosion tests at CEA using tubular specimens and furnace batch for SCC testing. >> reporting to GIF

HPLWR WP4 Materials investigated

	Material	Chemical analysis
1	P91**	0.1Ni 8.3Cr 0.96Mo 0.11C 0.43Mn 0.23V 0.41Si
2	P92**	0.02Ni 8.9Cr 0.49Mo 0.08C 0.42Mn 2.1W 0.22V 0.09Si
3	HCM12**	0.28Ni 11.9Cr 0.34Mo 0.09C 0.62Mn 1.96W 0.25V 0.34Si 0.45Cu
4	Eurofer 97**	---
5	Eurofer ODS (9%Cr)*	0.03Ni 9.2Cr 0.02Mo 0.035C 0.4Mn 1.3W 0.21V 0.03Si
6	Eurofer ODS (9%Cr, FZK)*	0.05Ni 9Cr 0.02Mo 0.021C 0.36Mn 1.3W 0.21V 0.12Si
7	PM2000, ODS (19%Cr)*	0.03Ni 20.1Cr 0.09Mo 0.005C 0.08Mn 0.03V 0.02Si 0.43Ti
8	316NG (LN)*/**	11.3Ni 16.6Cr 2.11Mo 0.014C 0.8Mn 0.42Si 0.07Co 0.23Cu
9	321**	9-12Ni 17-19Cr 2Mn 1Si 0.08C >5*%C Ti
10	TP347H*	10.7Ni 17.6Cr 0.048C 1.8Mn 0.29Si 0.56Nb
11	Sanicro 28*	30.6Ni 26.7Cr 3.34Mo 0.015C 0.065N 1.7Mn 0.41Si 0.87Cu
12	BGA4*	15.4Ni 22.9Cr 0.14Mo 0.11C 0.19N 6.1Mn 1.5W 0.31V 0.61Nb 0.49Si 2.7Cu
13	15Cr15NiTi (1.4970)*	15Cr 15Ni + Ti
14	Incoloy 800H*	30.8Ni 20.5Cr 0.13Mo 0.06C 0.67Mn 0.36Si 0.36Ti 0.26Al
15	Inconel 625*	2.6Fe 22.4Cr 9.1Mo 0.02C 0.05Mn 0.12W 3.3Nb 0.07Si 0.25Ti 0.29Al
16	Inconel 690**	27-31Cr 7-11Fe 0.05C 0.5Mn 0.5Si 0.5Cu

VTT SCW recirculating loop (schematic)

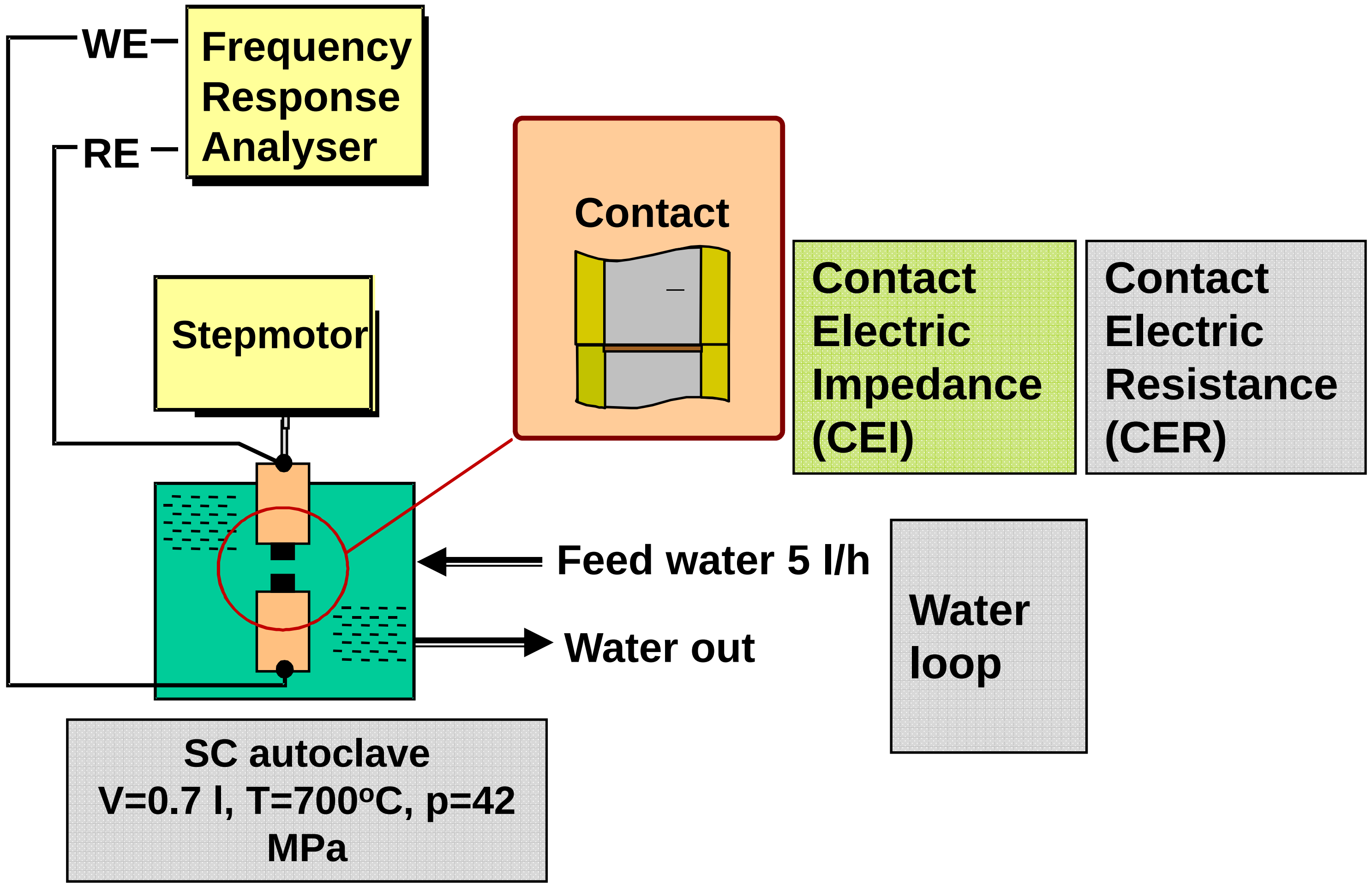




Weight gain of various alloys after exposure to SCW at 360 - 600°C for 6 weeks (1008 h)*

*Allen, T., R., Was, G., S., Novel techniques to mitigate corrosion and stress corrosion cracking in supercritical water, NACE Corrosion 2007, paper 07RTS9

CEI/CER oxidation monitoring

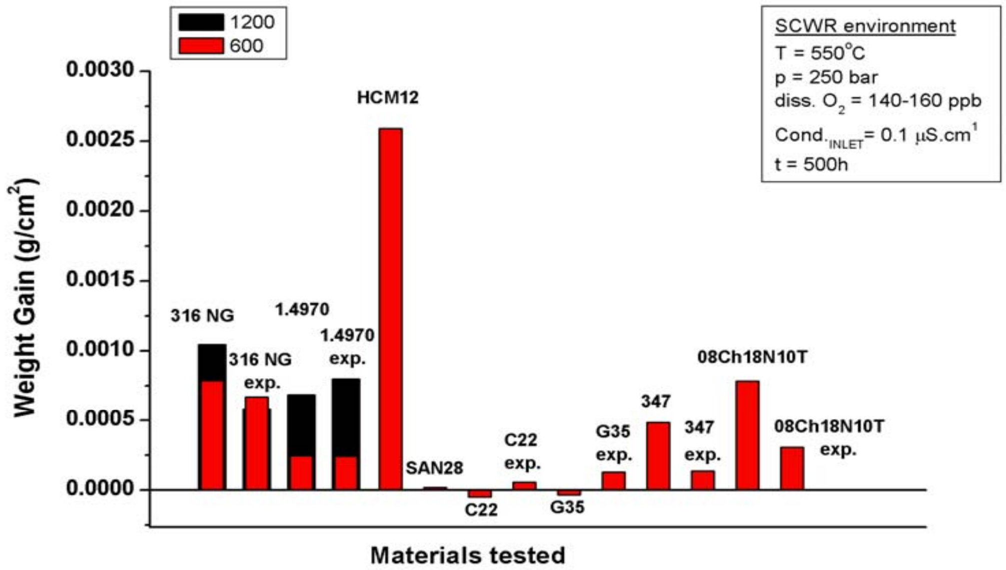


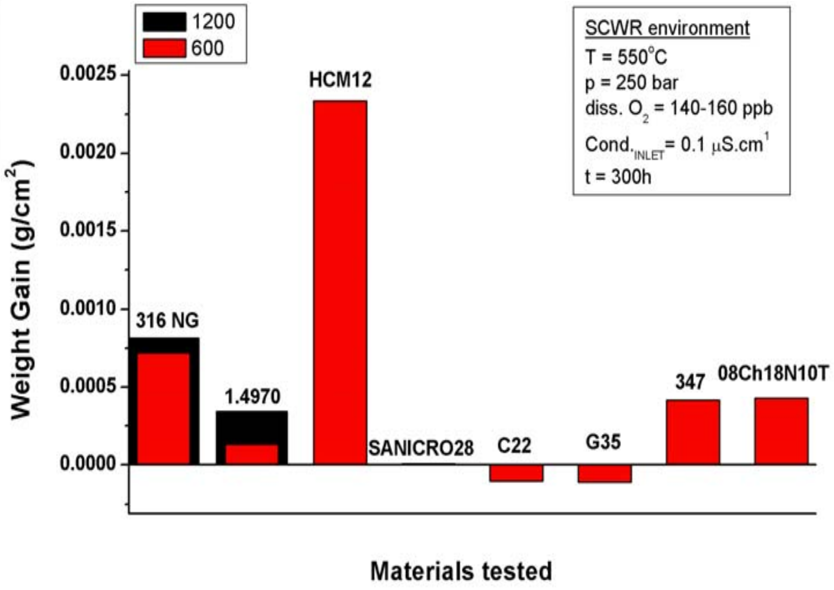
In situ measurement of oxide growth under SCWR conditions (VTT & JRC)

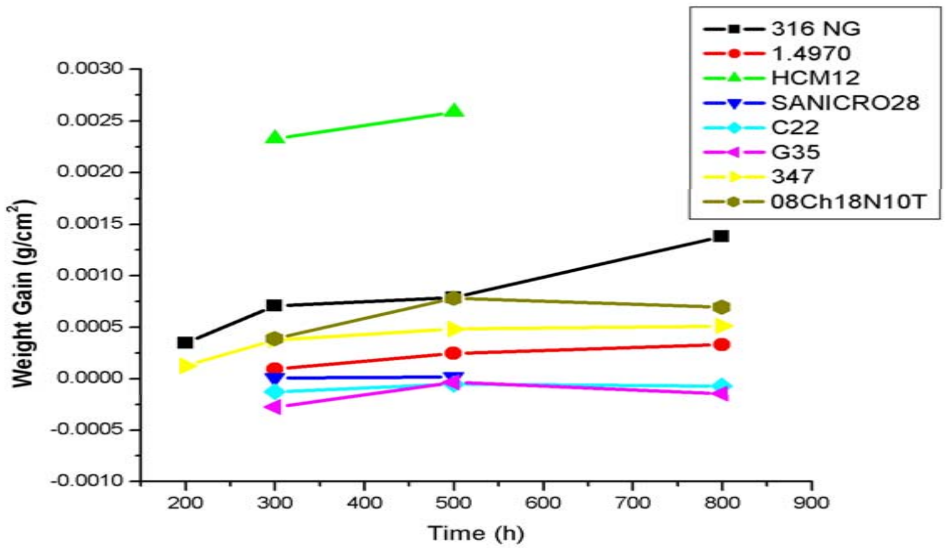
JRC-IE SCWR facilities

1. Autoclave1 – SSRTT and CER/CEI in SCWR conditions
2. Autoclave2 – Corrosion and Fracture Mechanics tests in SCWR conditions

JRC Autoclave1 - Corrosion and SCC Tests





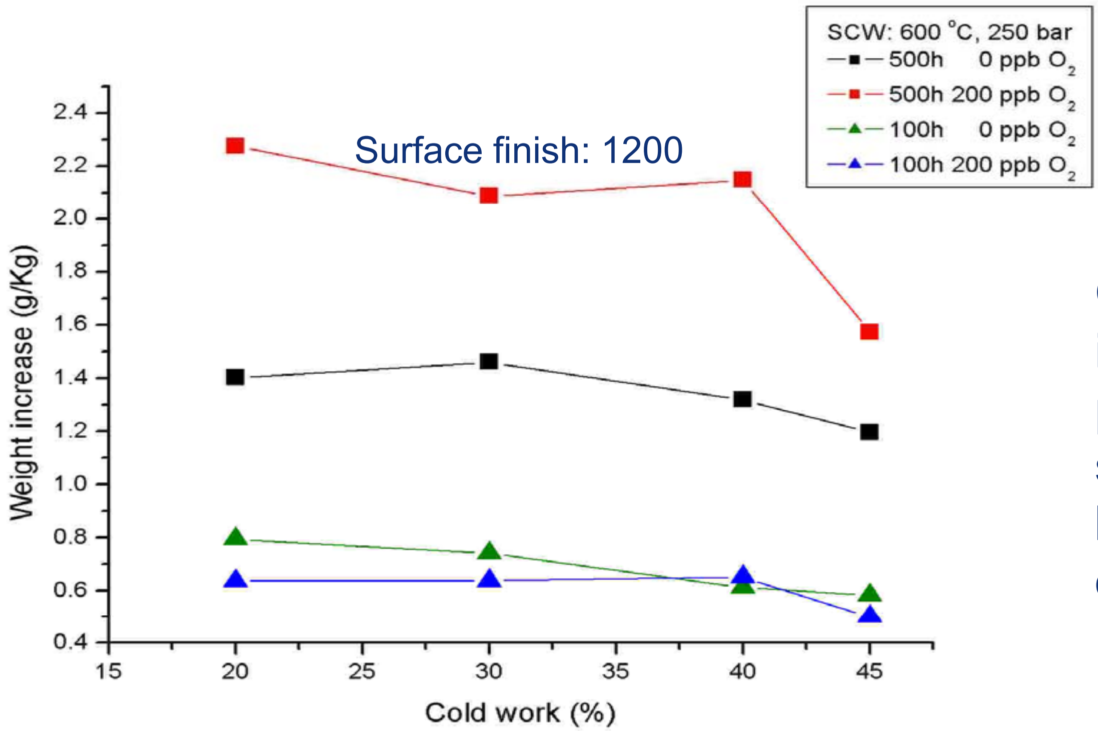


- Some samples were in both expositions: 800h in total
- **Surface finish**: 600 > 1200
- 316NG exhibited high corrossion rate
- Corr. resist. 347 > 08Ch18N10T
- Hast. C22 and G35 initial weight loss
-1.4970 and 347

JRC Autoclave1: Corrosion and SCC Tests

Corrosion properties of **cold-worked AISI-304** stainless steel exposed for 100h and 500h; correlation with XRD, SEM and PAS analyses

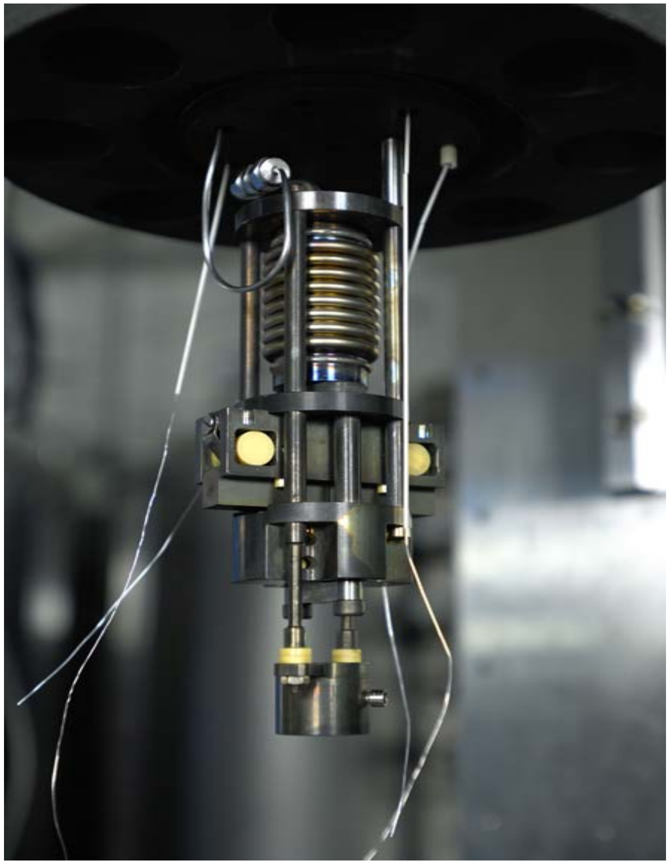
- Benchmarking of CW AISI 304 SS at different levels of deformation
- Evaluate general corrosion resistance
- Simulation of irradiation effect - IASCC



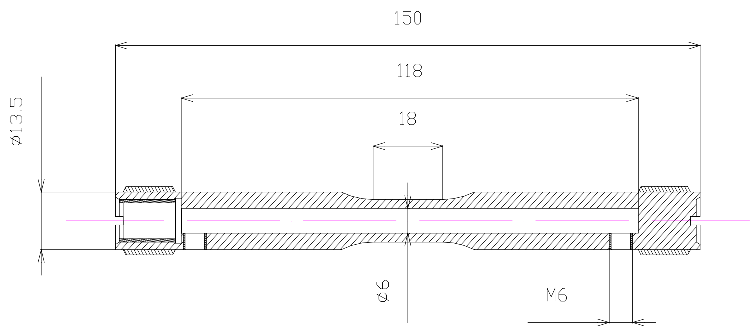
CW deformation influences corrosion processes on the surface: at 40% CW level Cr2O3 formation is observed.

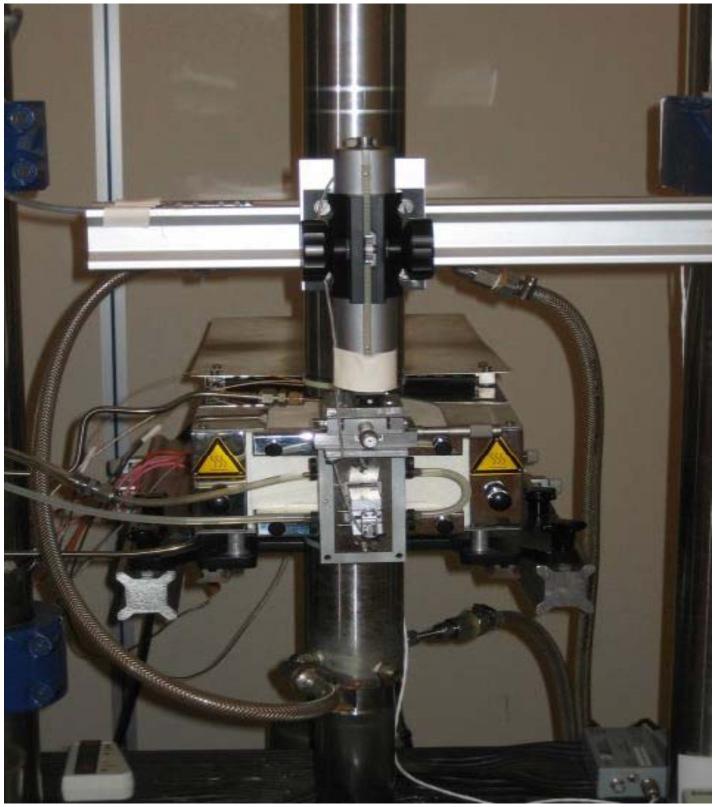
JRC Autoclave1: Fracture mechanics SCC tests

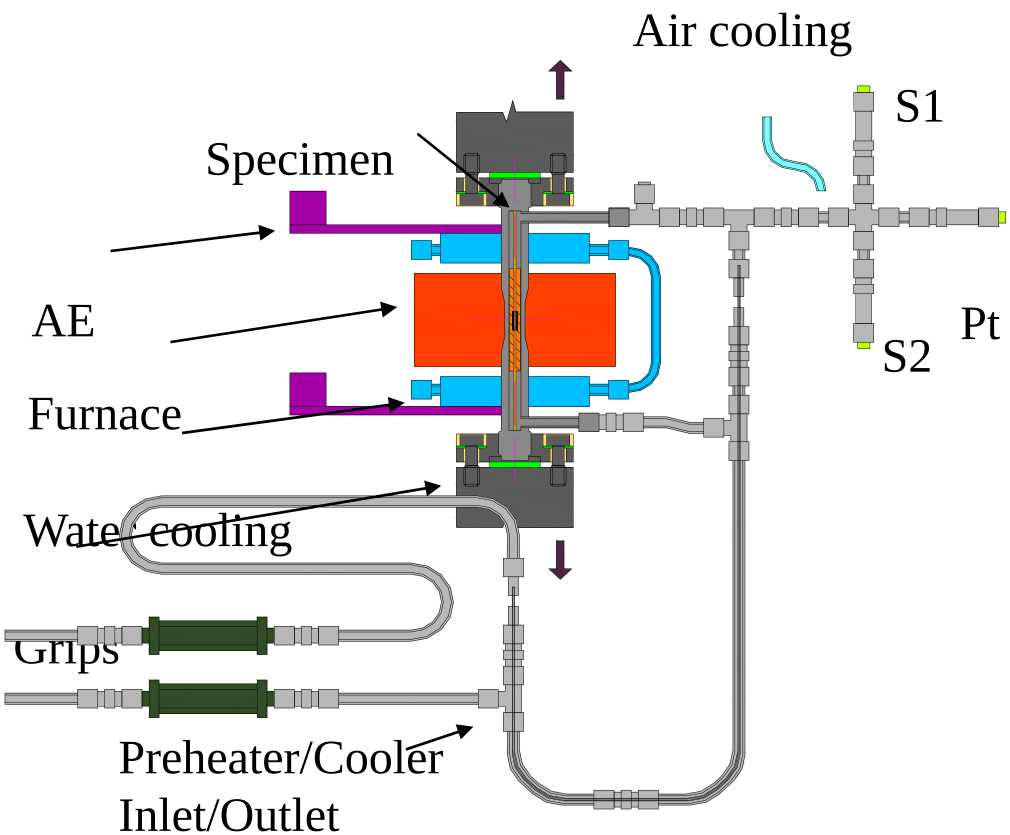
- Servo-controlled pneumatic loading device using bellows (max. pressure 260 bar) with furnace for displacement calibration (VTT cooperation)
- DCPD system
- High T high p LVDT sensor (RDP cooperation)



JRC: SSRTT by means of tubular specimens

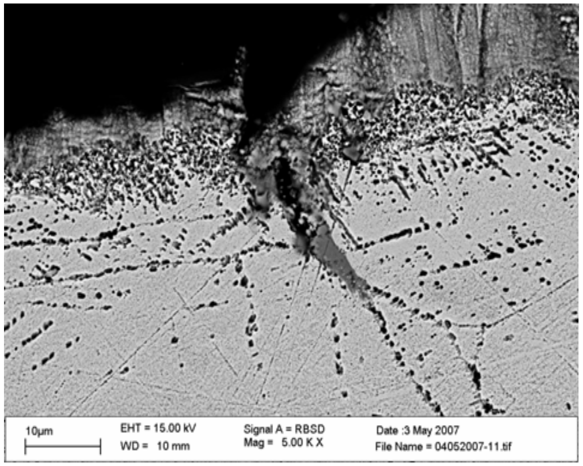


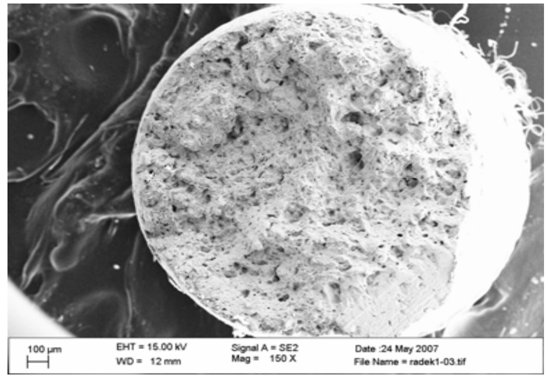




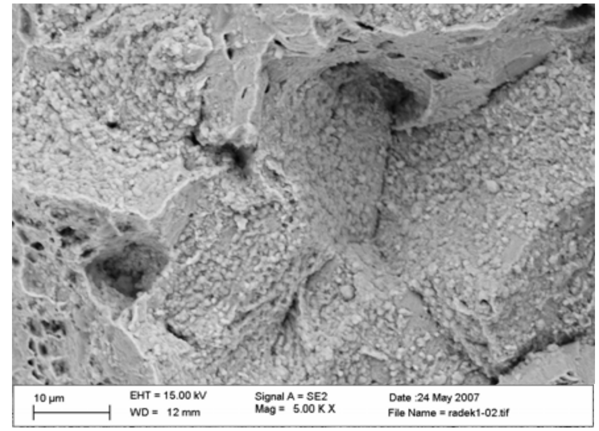
Inlet water from recirculation loop offering full water chemistry control

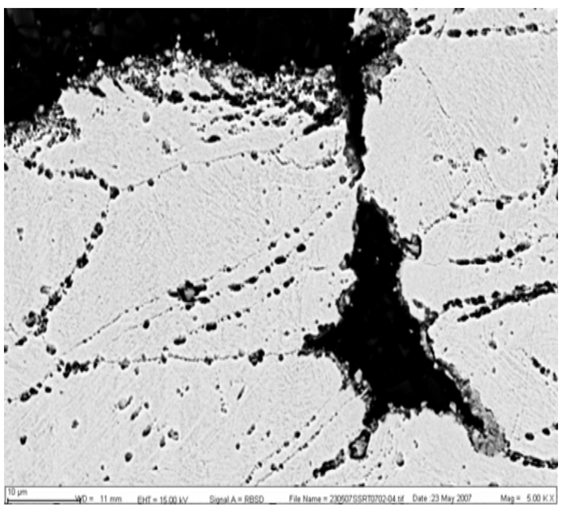
JRC Autoclave2: SEM analysis after SSRTT

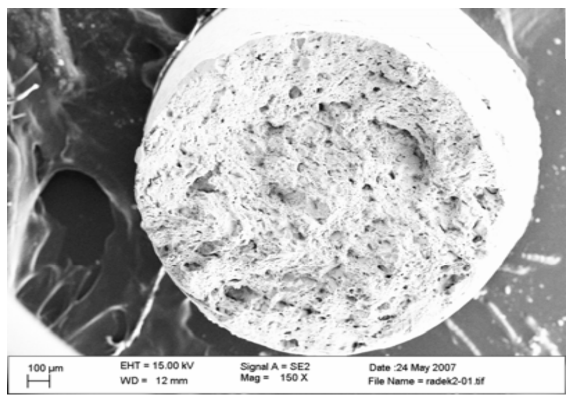




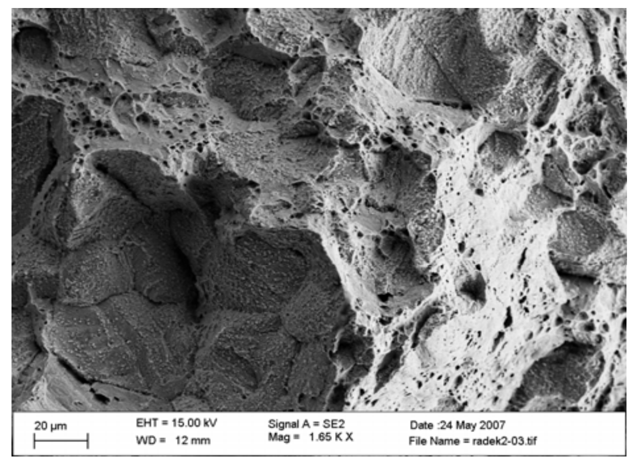
100 ppb O_2 at the inlet



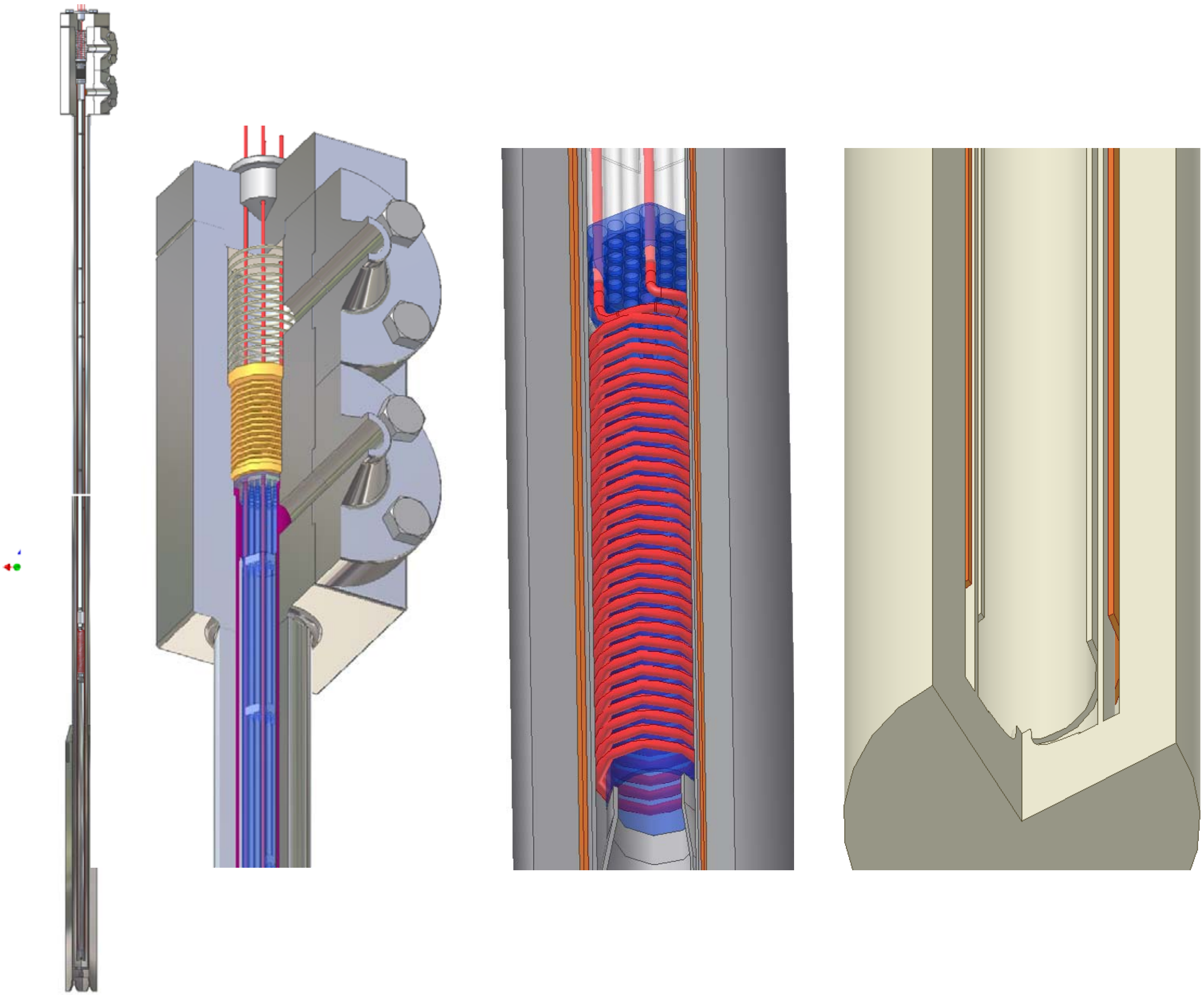




1.7 ppb O_2 at the inlet



NRI: SCW Loop for Radiolysis Tests



- Corrosion studies
- Testing and optimisation of water chemistry
- Coolant **radiolysis** studies
- Development and testing of sensors

HTR/VHTR FP6 project: RAPHAEL

RAPHAEL = ReActor for Process heat, Hydrogen And ELectricity generation

Integrated EURATOM Project, launched in 2005

34 partners from 10 countries

Total budget ~ 20 M€, EURATOM contribution 9 M€

8 sub-projects

- Core Physics
- Fuel technology
- Back-end of fuel cycle
- **Materials**
- Components
- Safety
- System integration
- Project Management
- Communication, Education

2 advisory groups

- Industrial User Advisory Group (executives of nuclear industry, utilities, industrial engineering companies, process heat end users)
- Safety Advisory Group (safety authorities, IAEA)

RAPHAEL Partnership

- nuclear engineering companies, including worldwide leader vendors
- large European Utilities
- safety experts
- graphite manufacturers
- component manufacturers including SME
- fuel cycle companies
- project management consulting company (SME)
- research centres, including JRC
- universities

RAPHAEL: Objectives

RAPHAEL to provide scientific-technical results forming the basis for further development of VHTR technologies for the generation of electricity and/or process heat,

- towards a (European ?) demonstration reactor,

- to attract the interest of future end-users.

Remarks:

- Several countries promote HTR and VHTR development (Japan, China, South Africa, US).
- Generation IV Forum (GIF) includes VHTR for electricity and process heat production within the scope of its six reactor concepts.
- Euratom wishes to use the results of RAPHAEL for exchange with GIF partners

RAPHAEL: Scope

Innovation

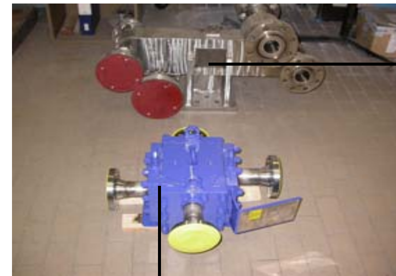
- Development of components for heat applications (IHX, blowers)
- Fabrication of advanced coated particles (UCO kernel, ZrC coating)
- Materials for very high temperatures (Nickel base alloys, C-C composites)

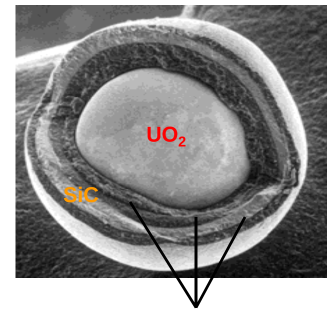
Technical integration

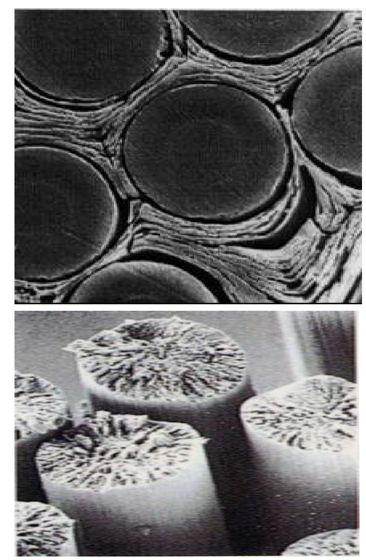
- Specifying R&D needs and boundary conditions resulting from real industrial projects
- Providing R&D results to industrial projects
- Keeping complementarity with industrial and national programmes

Horizontal actions

- Internal and external Communication
- Education and training (EUROCOURSE)
- Quality Management







C-C composites for control rod cladding

Achievements

Materials

- Analysis of irradiated and un-irradiated vessel material (P91)
- Coolant compatibility of Ni-based materials (turbine, IHX)
- Development of high-temperature steel
- Requirements for C/C composite material for control rods
- Investigations of graphite materials in INNOGRAPH experiments (950°C irradiation & PIE)
- Guidelines and codes development for graphites and composites within ASME collaborations

Components

- Test of IHX (He/He plate type) mock-up and blower at ENEA helium loop
- Design of the gas circulator including the design of permanent magnetic bearings
- Programme proposal for further tribology and corrosion tests

HT corrosion in impure He

- Predecessor HTR-M1 project: candidate turbine materials for HTR with direct cycle
- He coolant with contaminants: H_2, H_2O, CH_4, CO, CO_2, O_2 …
- Multi-component gas environment with mixed oxidants (O_2, H_2O, CO)
- Carbon activity & oxygen partial pressure depend on various factors:
  T, *p*, gas flow, prim. circuit inventory, leakage, alloy comp. & ageing state…
- Dynamic far-from-equilibrium corrosion process affected by nucleation, growth, integrity of corrosion product scales
- Corrosion process is also affected by transients (operation cycles, off-normal conditions)
- Corrosion can be associated with **carburisation and/or decarburisation**

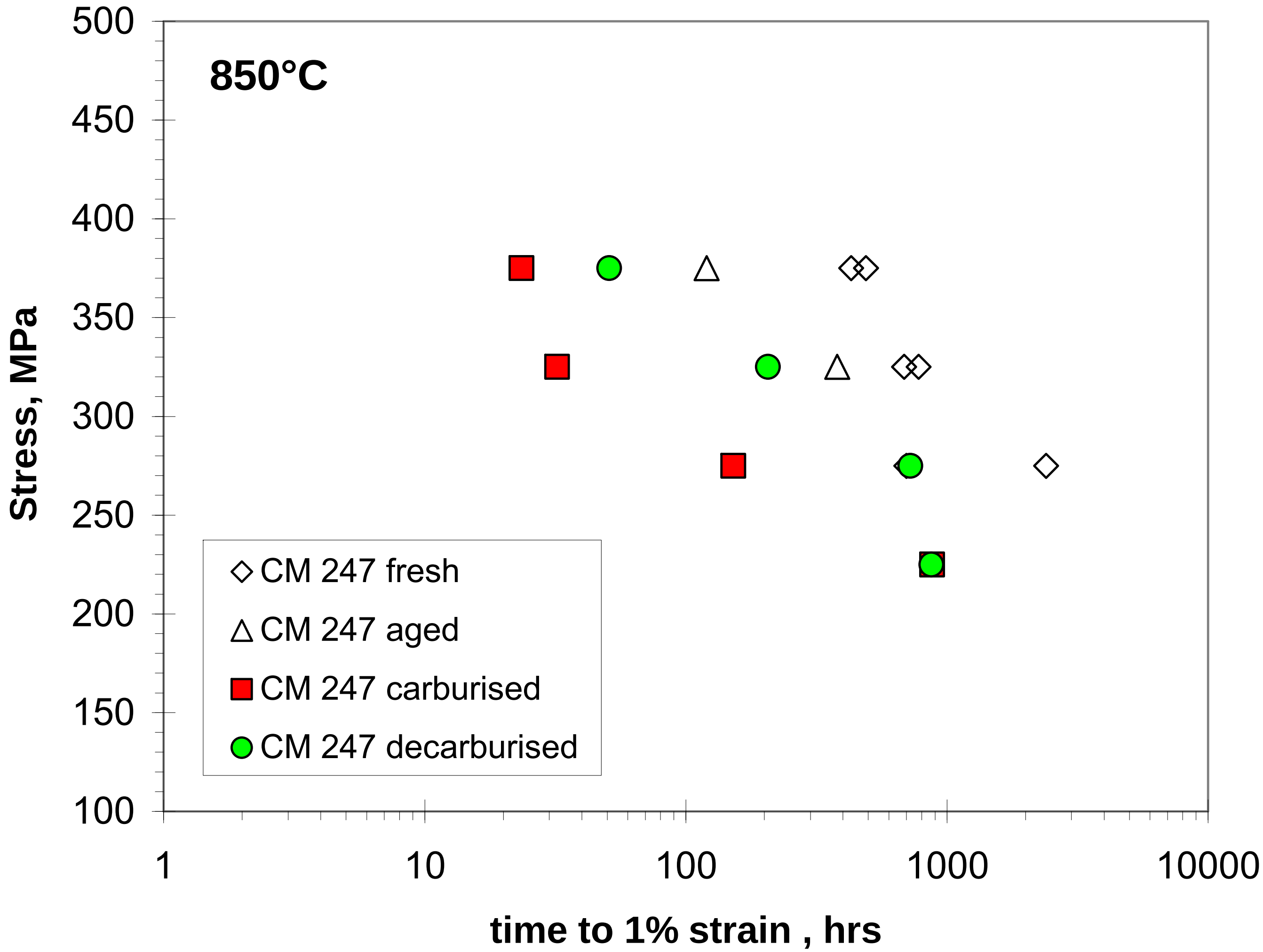
⇒ Meaningful kinetic description is difficult

⇒ **Objective:** to assess materials performance degradation for the limiting cases

- heavily **carburised** state
- **decarburised** state

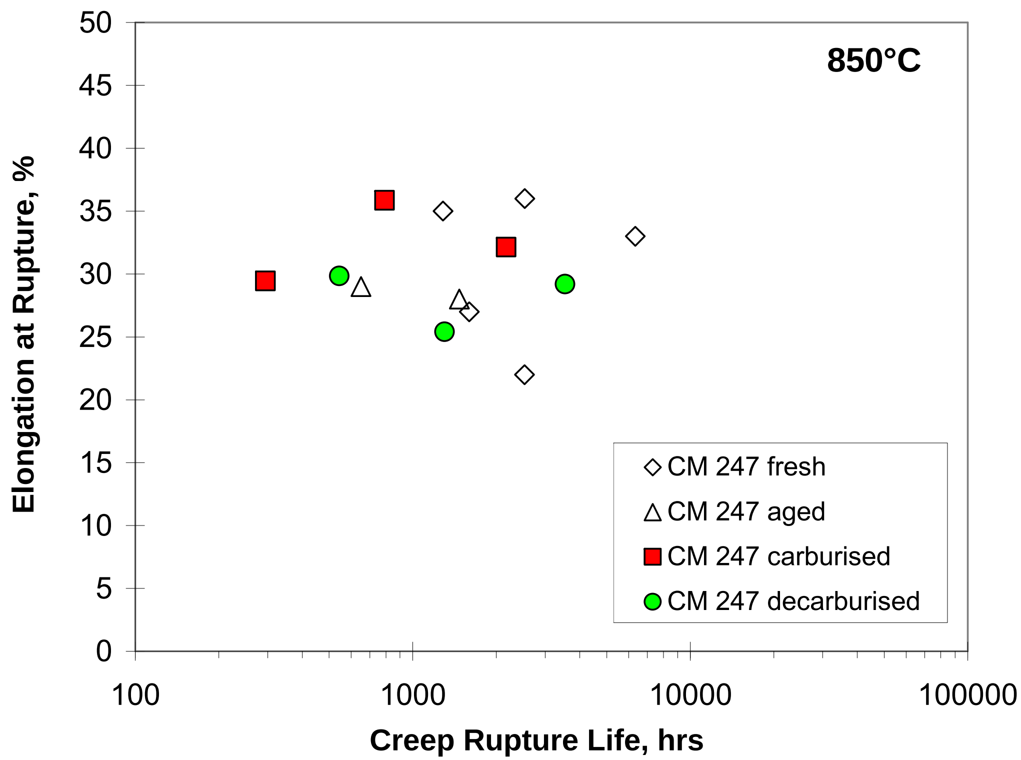
as compared to initial, and thermally aged states

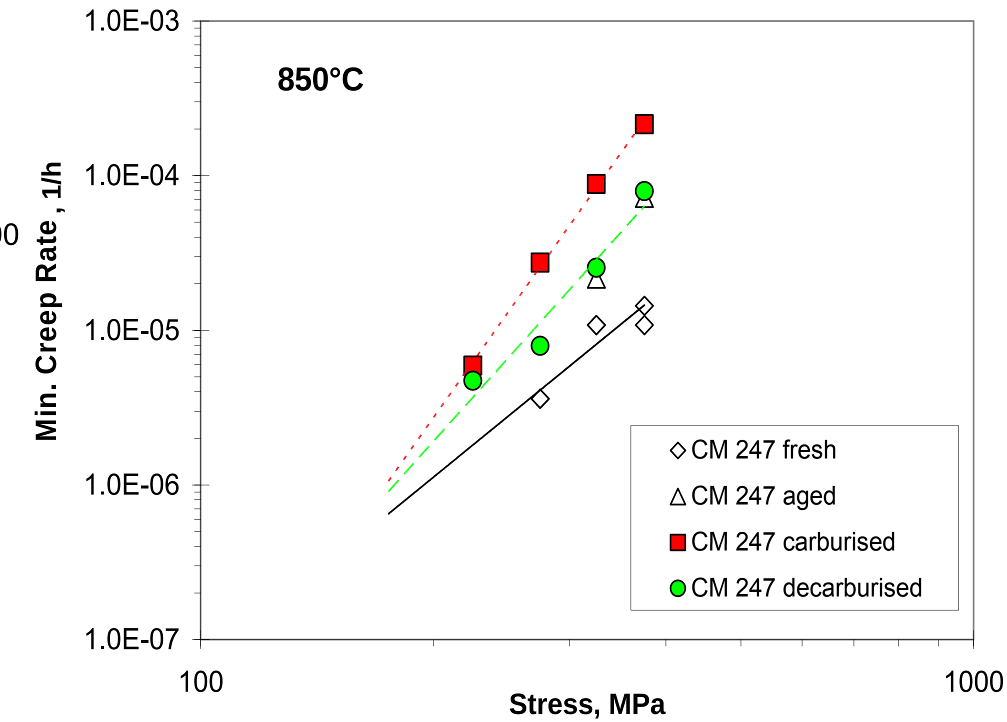
Blade material CM 247 LC DS: creep



Significant deterioration due to carburisation and decarburisation

CM 247 LC DS: creep





Creep strength deterioration is not associated with loss of ductility, but rather with creep rate acceleration

FP7 project: HycycleS

HycycleS **Materials and components for Hydrogen by sulphur based thermochemical cycleS**

Duration: January 2008 – December 2010

9 partners from 8 countries (Coordinator: DLR, Cologne)

Total budget ~ 5.1 M€, EC contribution 3.7 M€

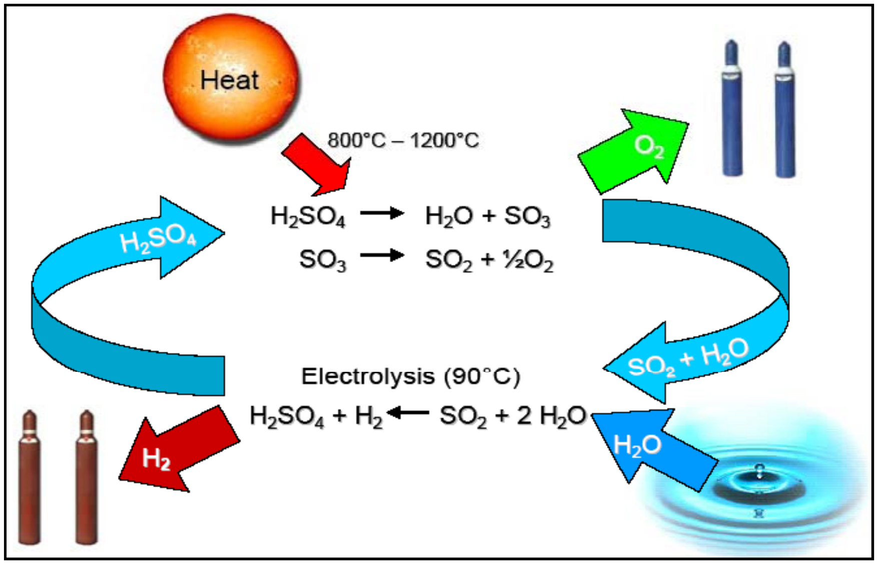
Main topics:

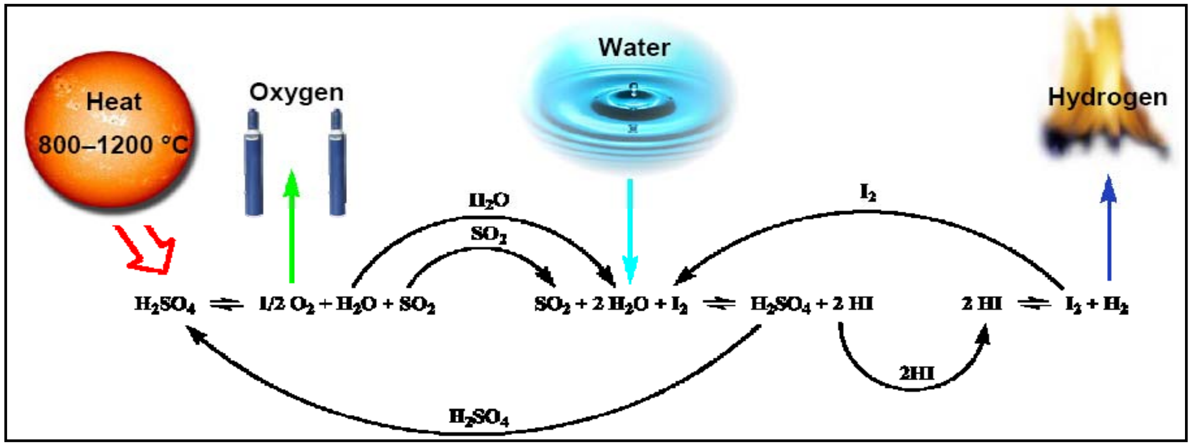
- **Identification and evaluation of suitable materials, in particular SiC based**
- **Development and test of the key components:**
  - H2SO4 decomposer as heat exchanger
  - H2SO4 decomposer as solar recei
  - SO2/O2 separator
  - Qualification of catalysts

HycycleS – Sulphur Based Cycles

Hybrid Sulphur Cycle

(high T decomposition of sulphuric acid combined with low T electrolytic reaction of H2O and SO2)





Sulphur–Iodine Cycle

(pure thermochemical cycle consisting of three separate process reactions)

HycycleS – Work Packages

WP 1- Project management and international cooperation.

WP 2- Advanced construction materials for the production of SO2 from H2SO4.

WP 3- Advanced catalysts and coatings for the decomposition of H2SO4.

WP 4- Key component: plate heat exchanger as H2SO4 decomposer.

WP 5- Key component: solar receiver-reactor as H2SO4 decomposer.

WP 6- Key component: separator for the decomposition products

WP 7- Integration and impact of material and component selection on the overall process

HycycleS

General requirements specification:

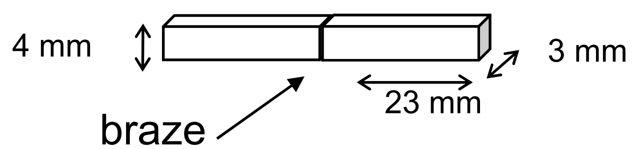
- Corrosion resistance of SiC with respect to gaseous mixture on one side, and helium on the other side (VHTR process heat application).
- Corrosion resistance of the brazings and tightness with respect to gaseous mixture and helium.
- Sufficient mechanical stability.
- Sufficient thermo-shock resistance during steady state and transients (time-dependent and spatial temperature gradients, solar application).
- Suitable heat conductivity.
- Suitable catalytic activity.

HycycleS

A mock-up of the plate heat exchanger is to be constructed by CEA and BOOSTEC.

The SiC plates are brazed using the BraSiC® Process. Three types of braze are used and have to be compared in terms of their corrosion resistance.

JRC-IE performs corrosion exposures and mechanical performance assessment.



Type	Surface condition	Size and quantity
SiC plate	**Sintered, without re-machining**	**5 x [25 mm x25 mm]**
SiC plate	**Sintered, after re-machining**	**5 x [25 mm x25 mm]**
Standard spatial braze BOOSTEC		**25**
braze CEA1		**25**
braze CEA2		**25**

JRC-IE Test Campaign:

Temperature: 850ºC (VHTR application)

Pressure: 1.0 bar

Environments: SO_2 rich: (81.2 H_2O + 12.4 SO_2 + 6.2 O_2) %mol

SO_3 rich: (62.3 H_2O + 2.4 H_2SO_4 + 6.0 SO_2 + 26.3 SO_3 + 2.9 O_2) %mol

Exposure time: total 1000 h with intermediate samplings after 20, 100 and 500 h.

Sample characterisation before and after the corrosion test, incl. weight change, microstructure, XPS and porosity.

HycycleS

Plate Heat Exchanger as $H2SO4$ Decomposer

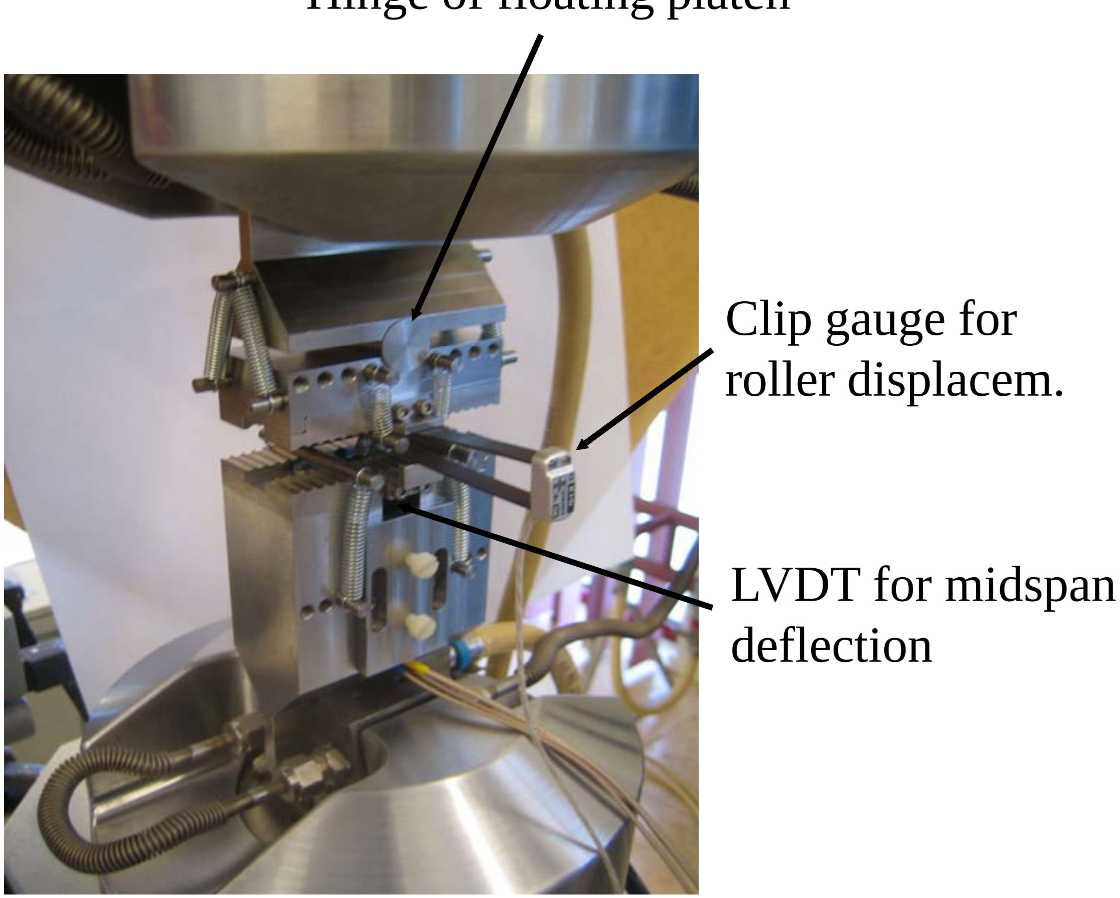
JRC Setup for High Temperature Corrosion Studies

HycycleS

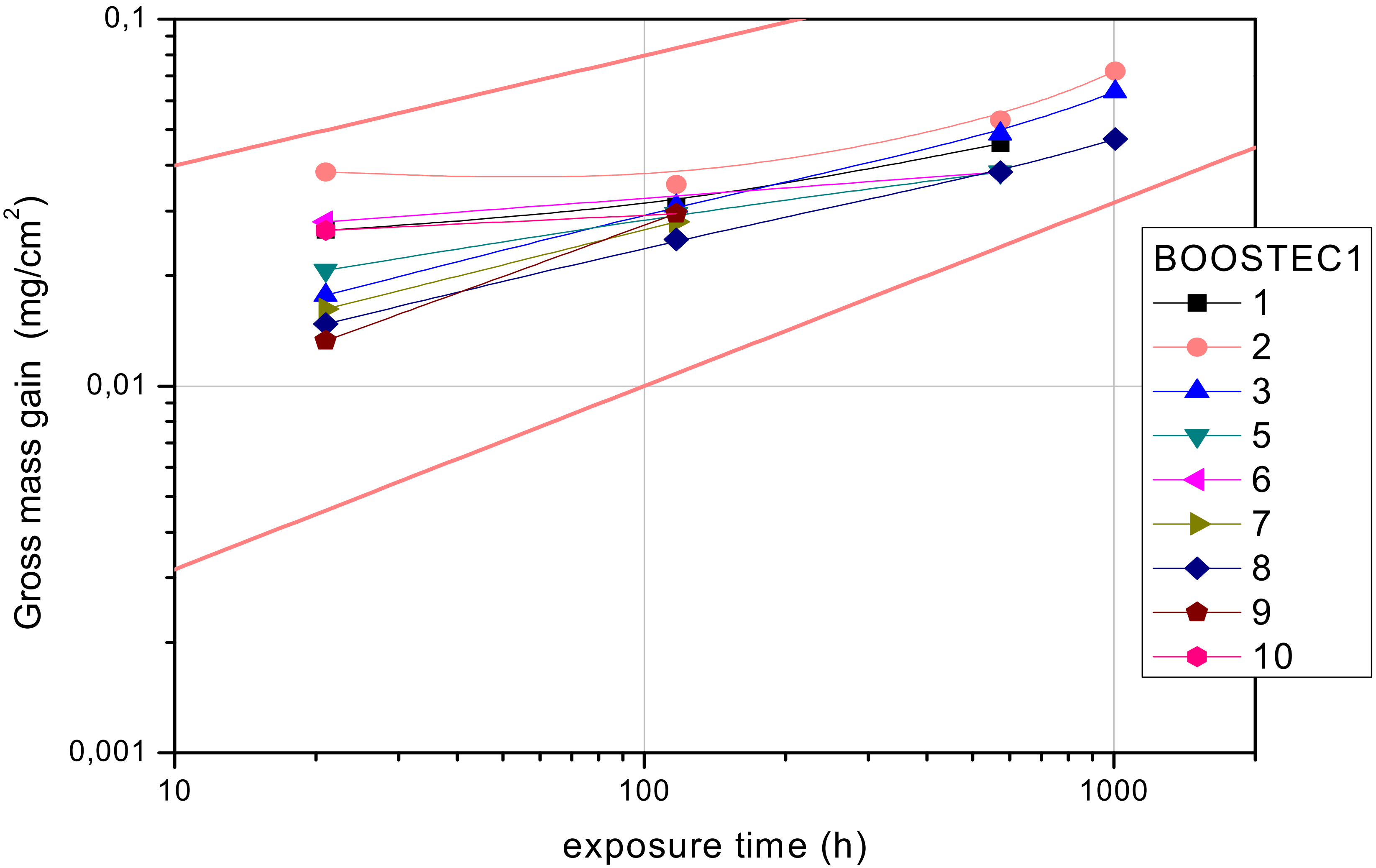
Test rigs for flexural strength measurements

3PB and 4PB at 850 and 1550°C

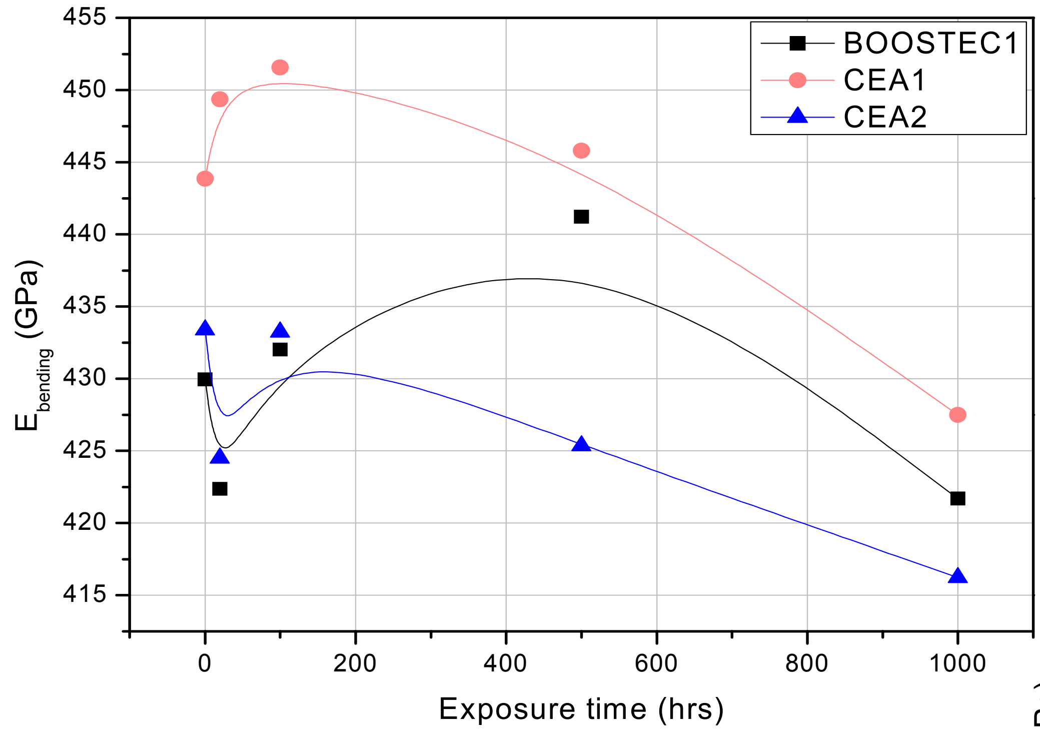
3PB and 4PB at RT

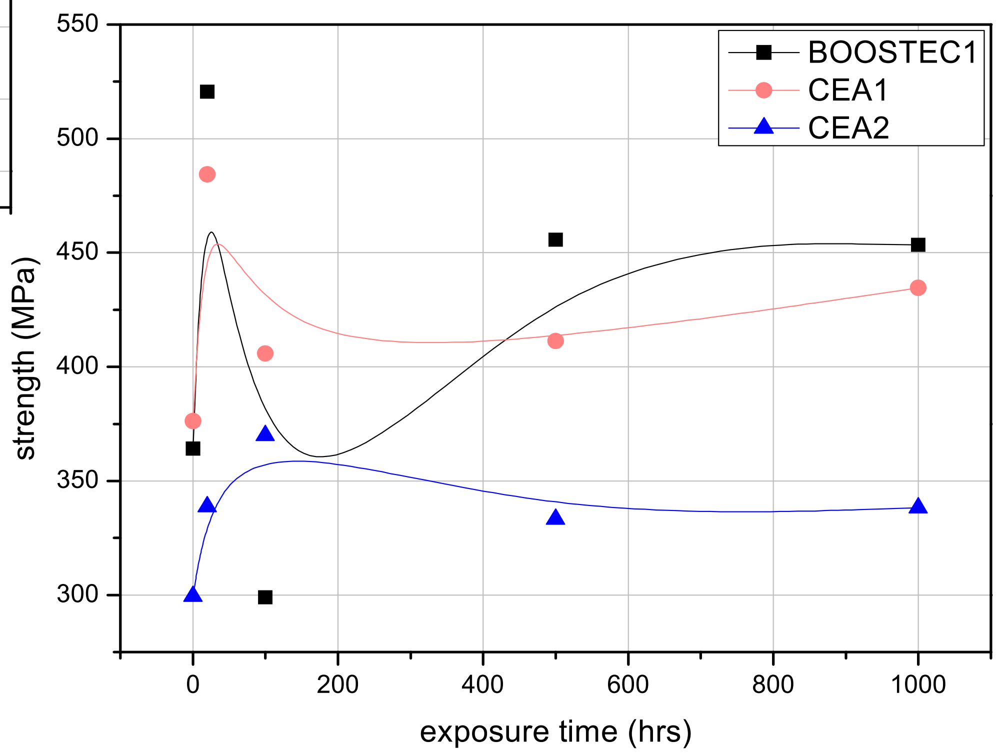


Brazed SiC plates



Brazed SiC plates





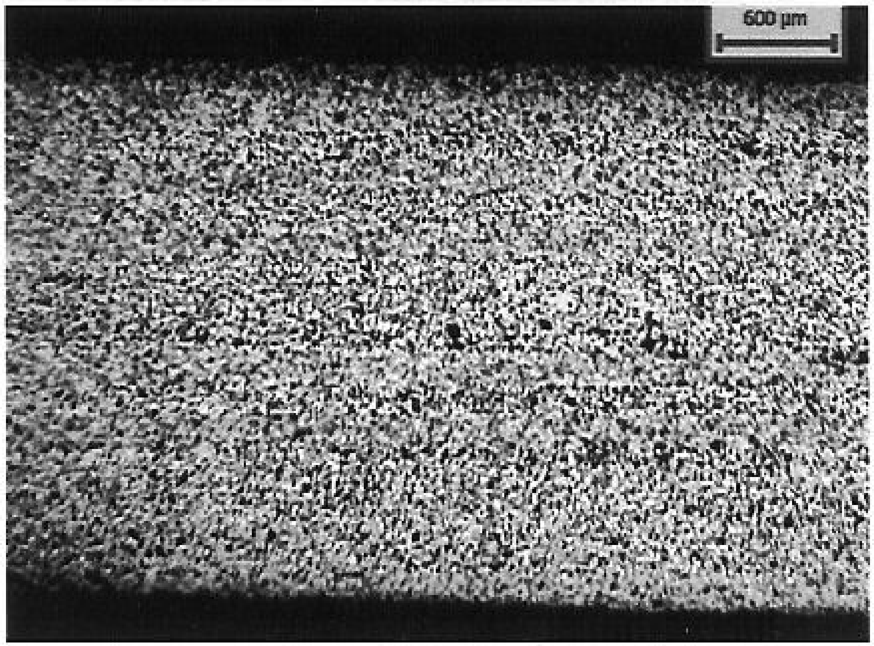
Multilayer SiC

Material batches rec'd from PoliTo:

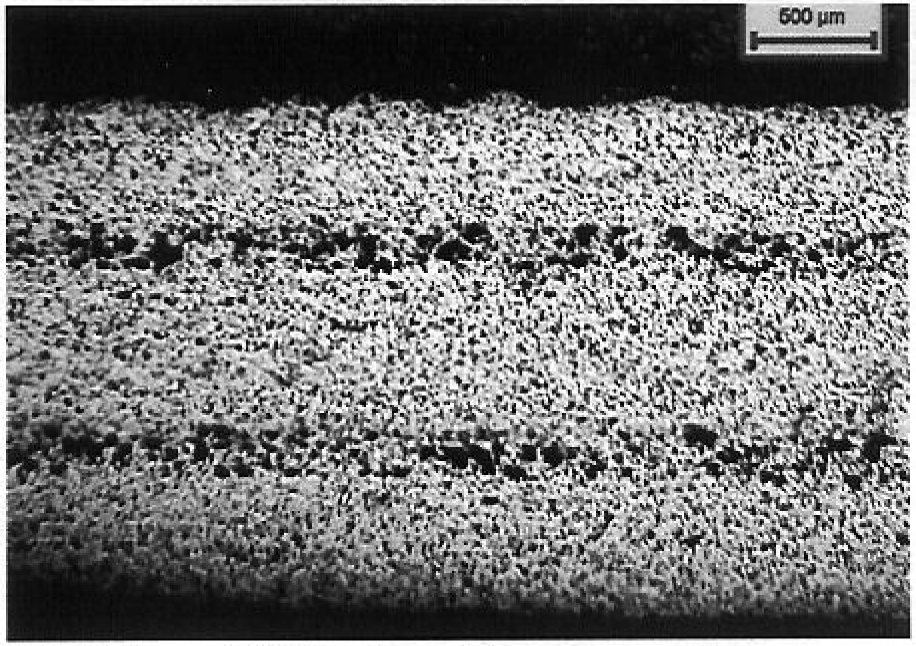
4 flat plates, 60x60x2 mm^3, 11 SiC layers, sintered @ 2200°C

2 plates incorporate porous interlayers (slurry with 20vol.% starch):

Architecture: D_3 P_1 D_3 P_1 D_3

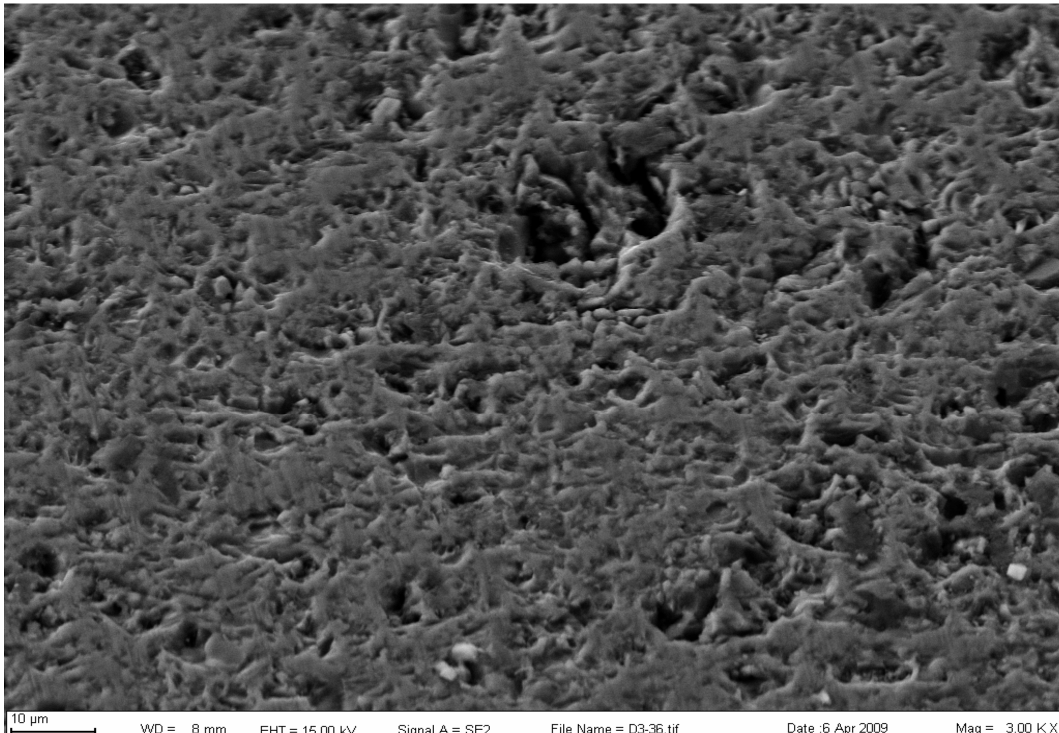


Multilayer SiC with dense layers only.



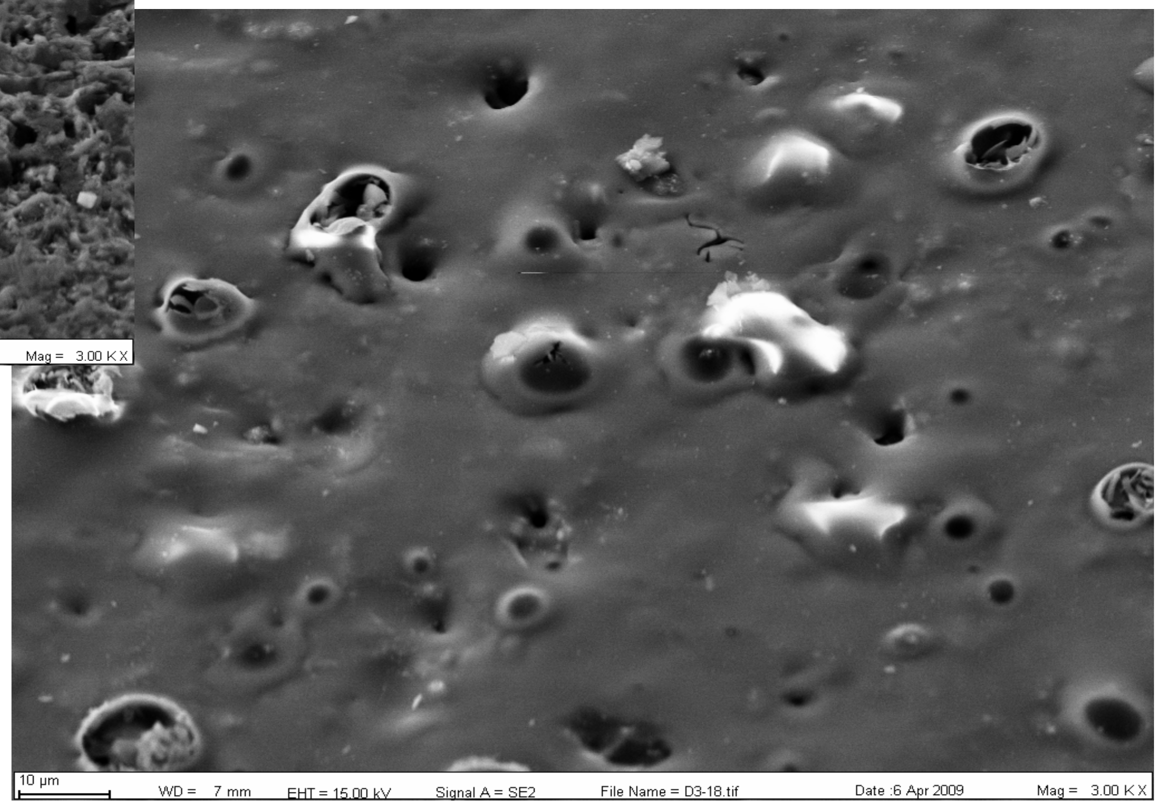
Multilayer SiC integrating porous layers.

Multilayer SiC: SEM Micrographs

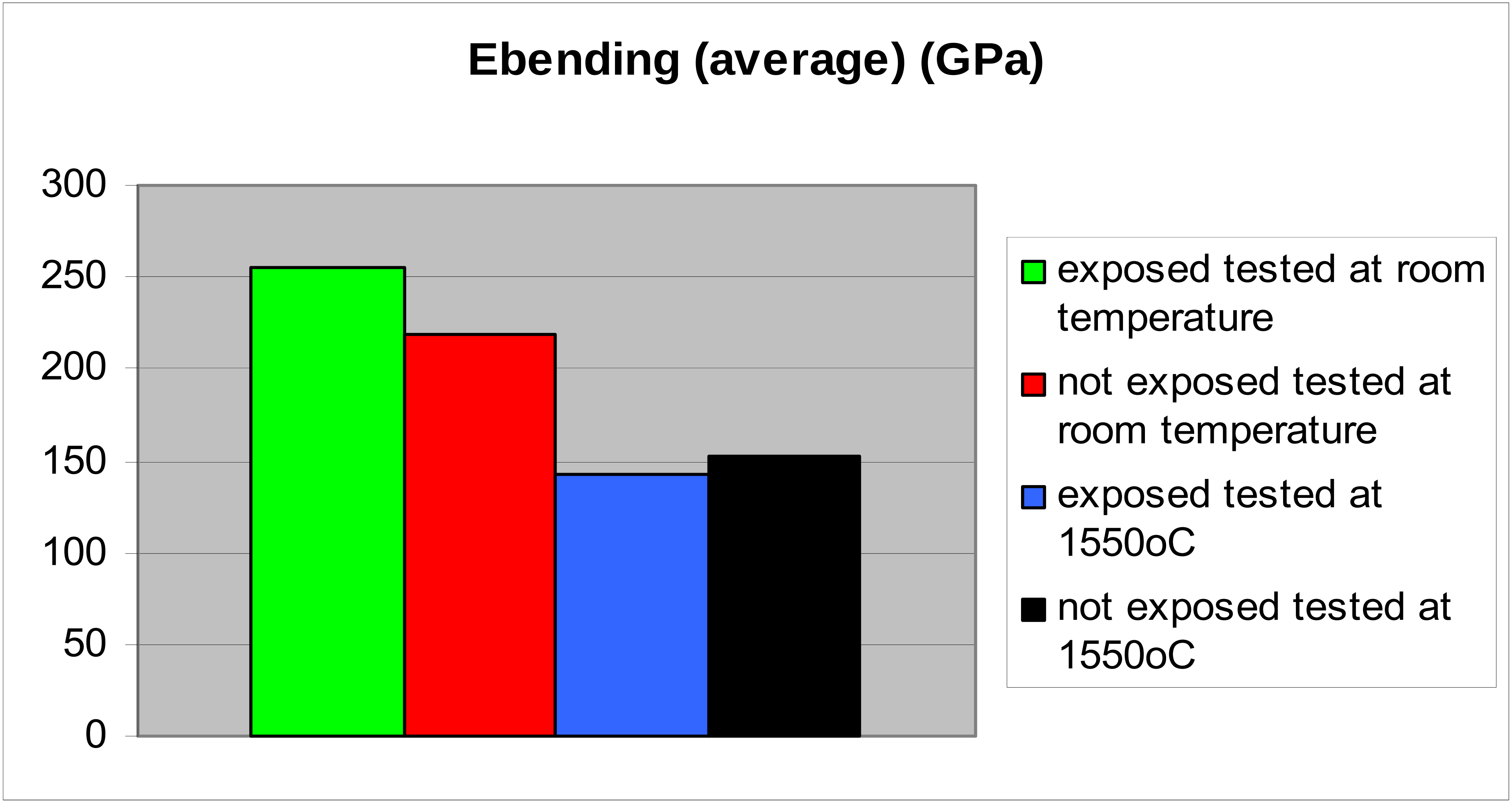


Surface prior to exposure

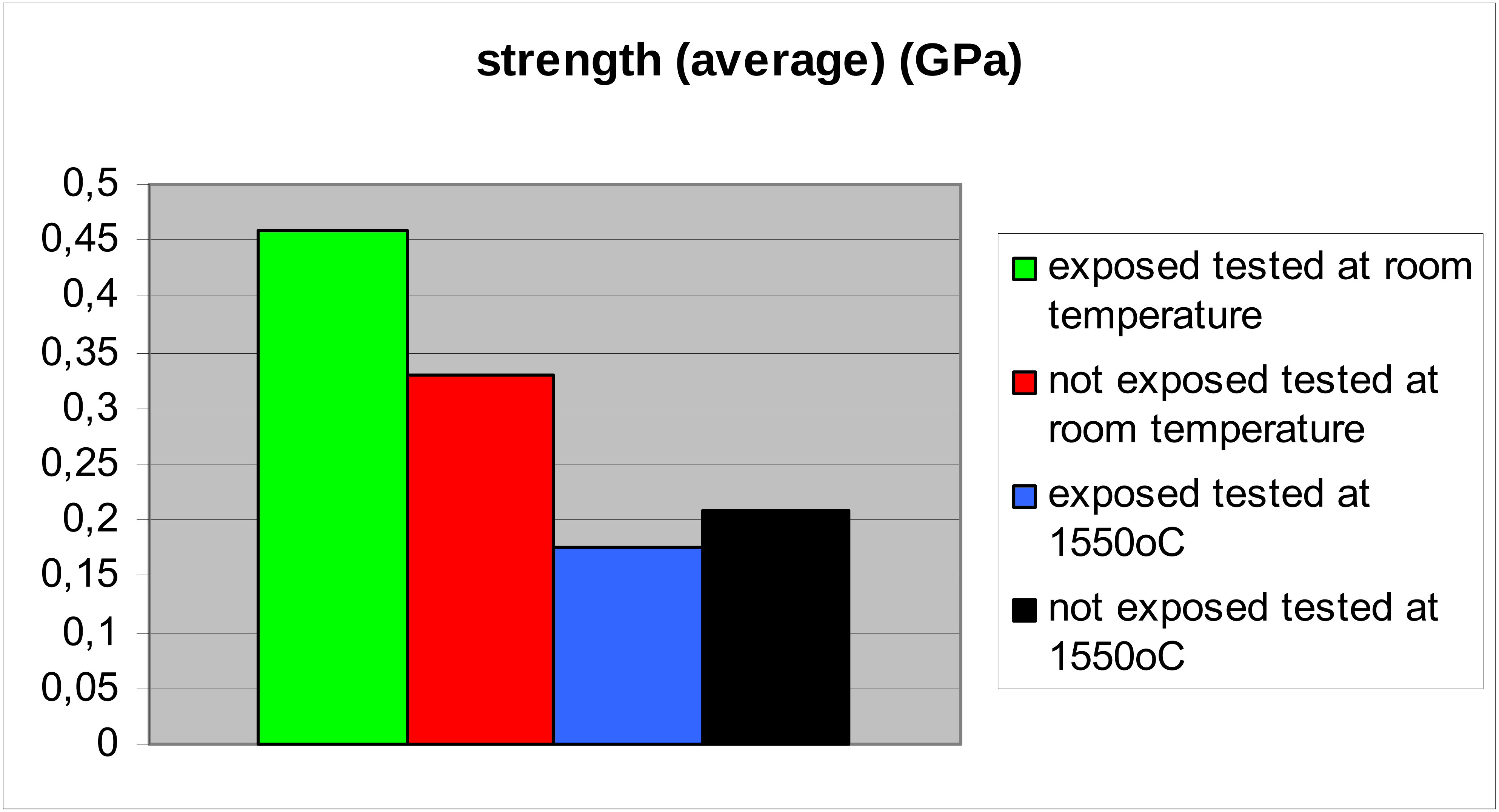
After exposure to SO2 rich environment for 1000 hr



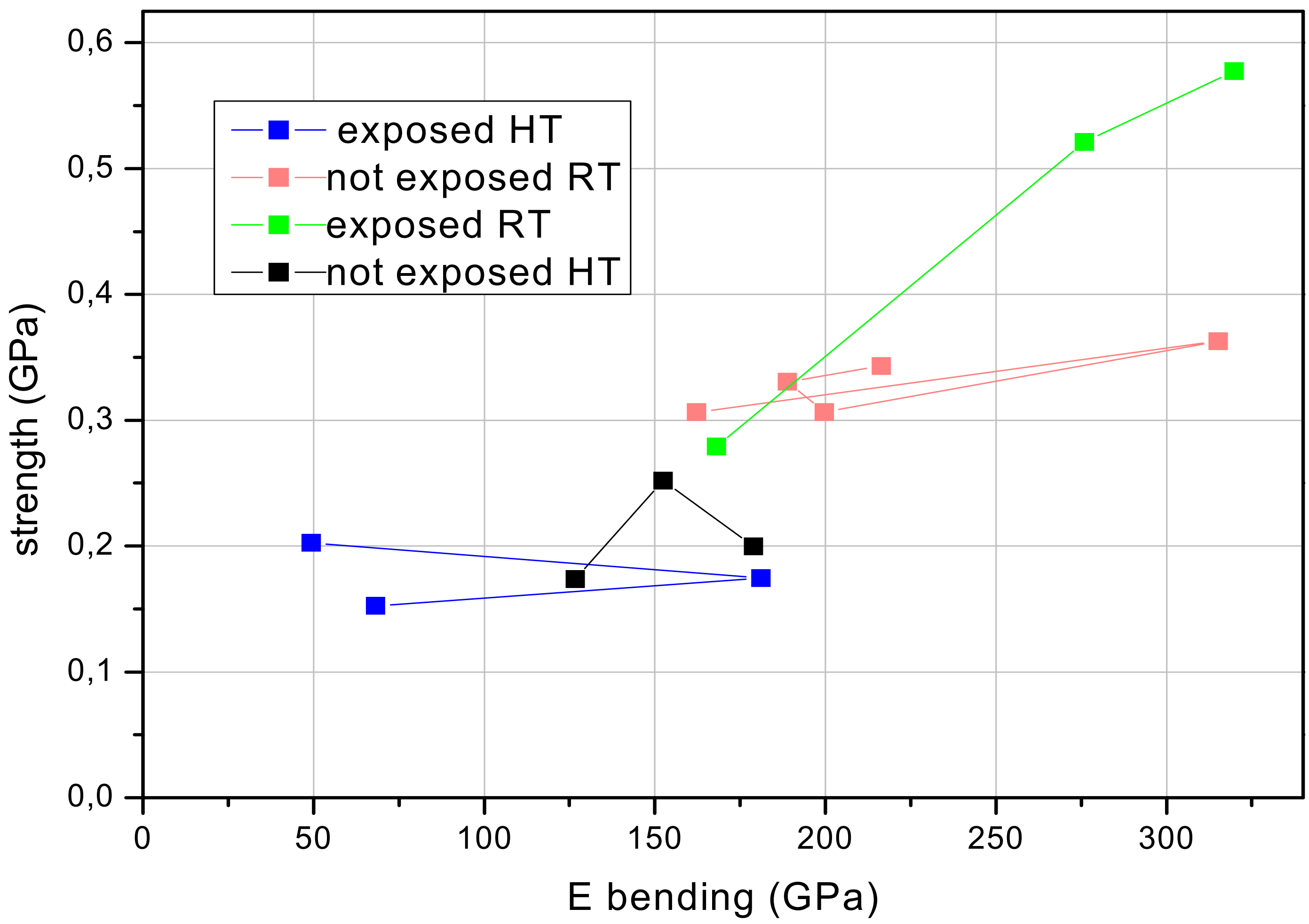
Multilayer SiC



Multilayer SiC



Multilayer SiC



Outlook

2007: Launch of **SNE-TP**: Sustainable Nuclear Energy Technology Platform, the European Platform for promoting R&D of next generation nuclear fission technologies

2008: Development of **long-term vision** of the role of nuclear energy
Launch of **European Industrial Initiative** for **SFR prototype**, and **LFR or GFR demonstrator** technology
Initiative for **VHTR demonstrator** technology

2009: Formulation of SNE-TP
Strategic Research Agenda

=> **Guidelines for FP7 R&D programmes and beyond**