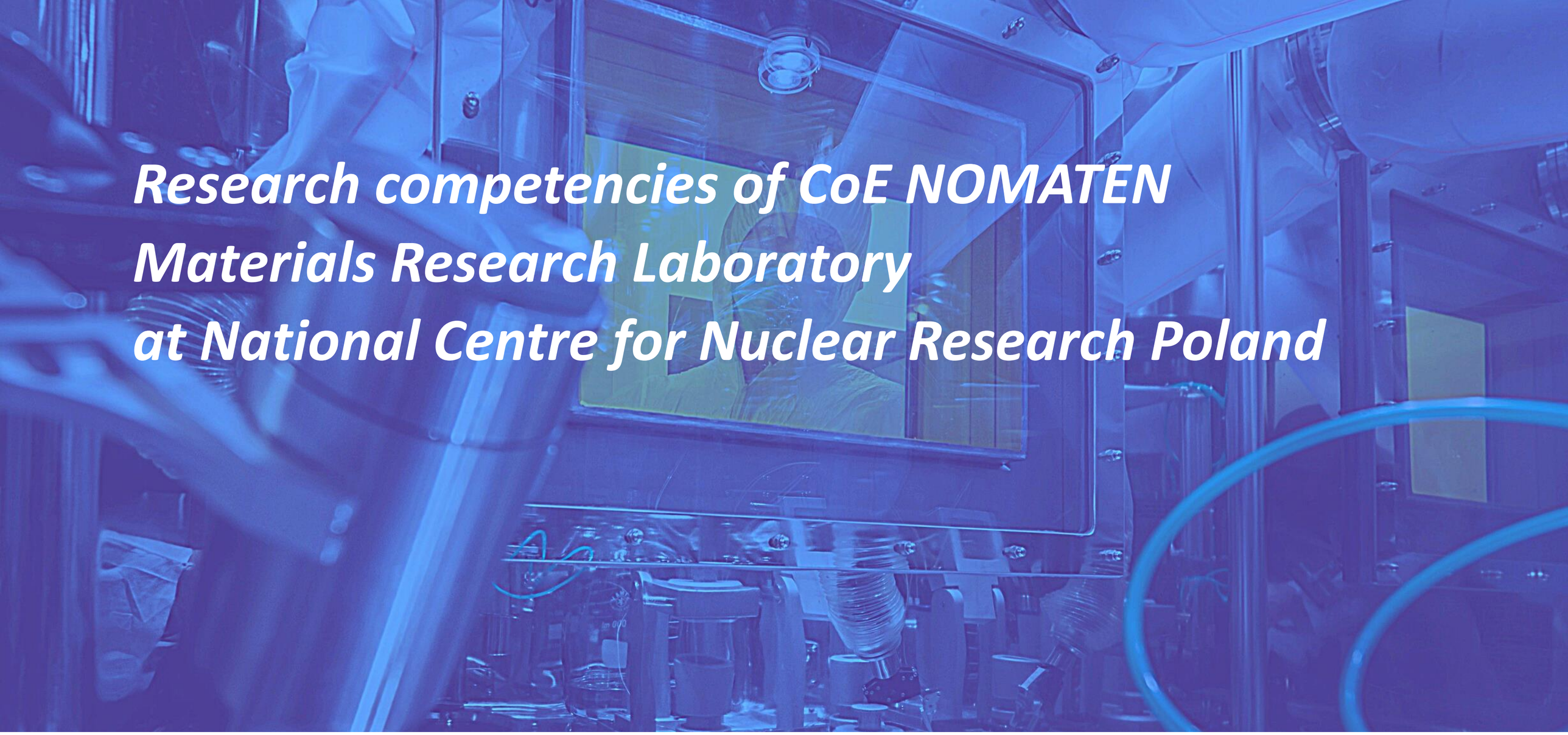


Research competencies of CoE NOMATEN Materials Research Laboratory at National Centre for Nuclear Research Poland

This project has received funding from the European Union's Horizon 2020 Research and Innovation programme under grant agreement No 857470

NOMATEN
Centre of Excellence in Multifunctional Materials for Industrial and Medical Applications

Narodowe Centrum Badań Jądrowych
National Centre for Nuclear Research
ŚWIERK

National Centre for Nuclear Research Poland (NCBJ)

Nuclear Facilities Operations Department — Reaktor MARIA

Materials Physics Department

Materials Research Laboratory

Fundamental Research Department

Nuclear Equipment & Technology Department

Department of Complex Systems — Centrum Informatyczne Świerk

Radioisotope Production Centre — POLATOM

Nuclear Equipment Division (HITEC) — HITEC

Science and Technology Park (PNT)

Location: Otwock / Świerk 35 km from Warsaw

NATIONAL CENTRE FOR NUCLEAR RESEARCH ŚWIERK

The largest Research Institute in Poland:

- *over 1000 Employees,*
- *the research staff includes 76 Professors & 200 PhDs*
- *PhD School ca. 80 Students*

Research achievements:

- *over 500 reviewed papers, with over 16 000 citations/year*

Research projects:

- *over 117 projects funded by H2020, EURATOM, NCN, NCBR, FNP, RPO*
- *success rate for EU projects ca. 35%*

Scientific cooperation:

- *International cooperation with the largest Laboratories in the world JRC, CERN, DESY, Grenoble, JParc, FAIR, Julich, ESS, JINR, T2K, XFEL and many Universities…*

Scientific and Industry Centres

NOMATEN Centre of Excellence in Multifunctional Materials for Industrial and Medical Applications

IDEA INTERDISCIPLINARY DIVISION FOR ENERGY ANALYSES

NOMATEN Centre of Excellence

The NOMATEN Centre of Excellence has been created at the Poland's National Centre for Nuclear Research Poland as a new research organization in which international world-class research teams design, develop and assess innovative multifunctional materials – combining advanced structural and functional properties – for industrial and medical applications.

CoE NOMATEN will develop a Long-term Science and Innovation Strategy and will be the Self-Driven Laboratory SDL in Multifunctional materials by focusing on two strategic research and innovation topics

Novel high-temperature, corrosion and radiation resistant materials for industrial applications

Novel high-temperature, corrosion and radiation resistant materials for industrial applications topic is focused on:

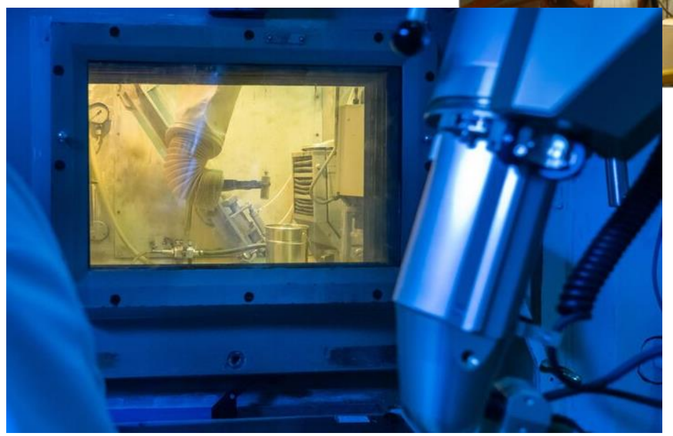
Material synthesis *– to develop key materials for High-Temperature applications and be able to connect to leading partner and other groups for providing samples and establishing collaborations*

Functional properties of materials *– to investigate materials range from heat resistance to mechanical properties as friction, resistance to chemical environments and radiation and finally to their combined multiphysics effects*

Analytics and characteriztion – *to quantify the properties of materials after synthesis and characterizing advanced functional materials important for high-end customers*

European Funds Smart Growth
Republic of Poland
European Union Horizon 2020 Framework Programme
European Union European Regional Development Fund

Materials Research Laboratory MRL



Reaktor MARIA

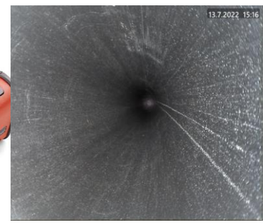
NOMATEN Centre of Excellence in Multifunctional Materials for Industrial and Medical Applications

MRL conducts following materials research:

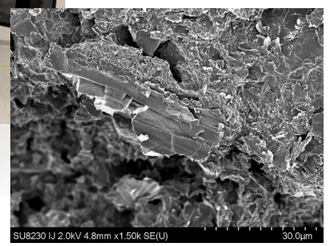
- *Re-approval and diagnostic works on construction materials (MARIA Reactor)*
- *Assesment of welded joints (Accredited Procedures >> Macro- Microstructure)*
- *Research in the field of widely understood materials science, using destructive and non-destructive methods.*
- *Mechanical testing (Accredited Procedures >> ISO, BS, ASTM)*
- *Thermal testing*
- *Non-irradiated and irradiated materials testing*
- *Quality assurance testing of the materials and weldments*
- *Materials components testing for qualification procedures*
- *Consulting in materials testing and materials physics & surface science*

Thermal testing of the materials

Mechanical Testing



Non-destructive Testing



Structural characterization

MRL actively cooperates with the Polish Ministries and National Technical Inspection Units, which supports the development of new research methods and allows for the maintenance of modern scientific equipment, including the only group of 12 Hot Cells in Poland with a protection of 100 Ci, 3.7 TBq

For more than thirty years, MRL have been accredited by the Polish Center for Accreditation (PCA) and signatory to multilateral agreements within the framework of international organizations active in the field of accreditation, viz: EA MLA, IAF MLA and ILAC MRA.

Nuclear Sector

VTT
EUROfusion
cea
CVŘ
OAK RIDGE National Laboratory
NOMATEN Centre of Excellence in Multifunctional Materials for Industrial and Medical Applications
EERA European Energy Research Alliance JPNM JOINT PROGRAMME ON NUCLEAR MATERIALS
GOBIERNO DE ESPAÑA MINISTERIO DE CIENCIA, INNOVACIÓN Y UNIVERSIDADES
Ciemat Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas
CEN WORKSHOP 64 PHASE 4
Design and Construction Codes for Gen II to IV nuclear facilities
JRC EUROPEAN COMMISSION
INL Idaho National Laboratory
THE UNIVERSITY OF TENNESSEE Oak Ridge Innovation Institute
NUCLEAR AMRC
framatome
Reaktor MARIA
iter
AREVA
boccard kates Alliance for success
eDF
Enea
MIT

Production Technologies Sector
Tools / 3D Printing / Welding / Turbines

AMAZEMET
SALLOYTECH
ALTRAD
edp Obróbka Stali Sp z oo
BIMO TECH
NARZĘDZIOWNIA PSZENICA
BUREAU VERITAS 1828 BUREAU VERITAS
GRUPA ZARMEN

Automotive Sector

TOMEX brakes
ZF TRW
neapco

NATIONAL CENTRE FOR NUCLEAR RESEARCH ŚWIERK

NOMATEN Centre of Excellence in Multifunctional Materials for Industrial and Medical Applications

CoE NOMATEN Materials Research Laboratory
Non Destructive Testing – NDT Services

Non-Destructive Testing NDT Division – Research Infrastructure

The non-destructive testing division carries out tests with using following methods:

- Visual test method (VT)
- Penetration testing method (PT)
- Magnetic particle method (MT)
- Ultrasonic method (UT)
- Eddy current method (ET)
- Magnetic permeability testing

NDT Testing Research Infrastructure

UT Defectoscope Olympus OMNISCAN MX2

ET Defectoscope Olympus NORTEC 600D

Foerster MAGNETOSCOP 1.069

Accredited NDT Testing
Polish Centre for Accreditation
Accreditation number AB 025

PCA Polskie Centrum Akredytacji BADANIA
AB 025

ilac-MRA

Financed by
PROJECT HTGR

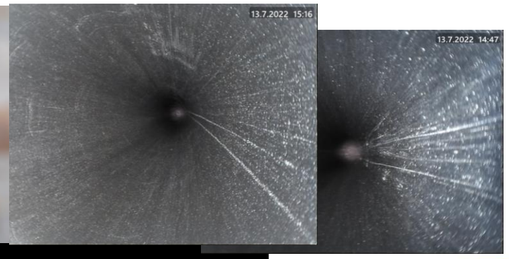
VT Flexible Videoendoscope
Mentor Visual iQ - Waygate Technologies

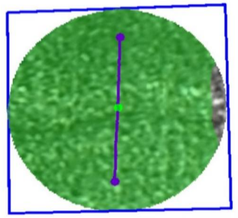
Penetrant method

Magnetic particle method

Non-Destructive Testing NDT Division – NDT Expertise works and testing

AISI 316L seamless pipes NDT testing for ITER Blanket System components (First wall panels cooling system) – commissioned by ITER's supplier BIMO TECH





Accredited NDT tests realized according to:

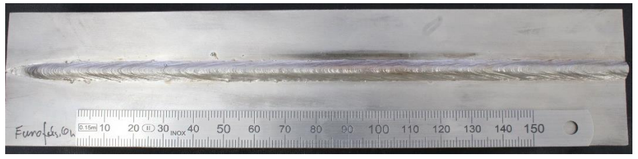
X2CrNiMo17-12-2, (AISI 316L) First Wall Panels for ITER Blanket System Specification

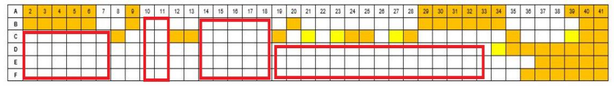
Visual Testing VT *– visual inspection outer / inner surface*
Ultrasound tchickness test UTT *– wall tchickness*
Direct meaurements *– pipes dimensions*

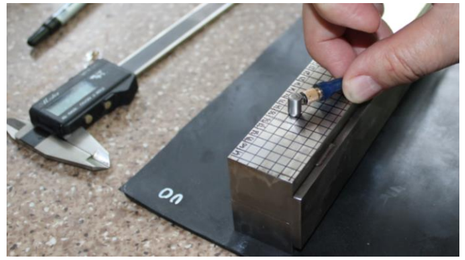
Magnetic Permeability Test according to IEC 60404-15 and ASTM A342M

Cold drawing effects depth measurements
Analysed by VT Flexible Videoendoscope

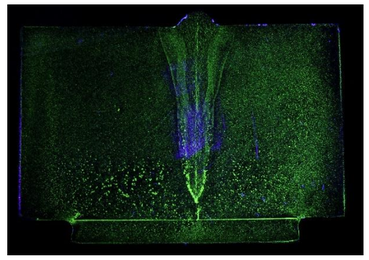
EUROFER 97 after Electron Beam Welding NDT testing in cooperation with Karlsruher Institut für Technologie







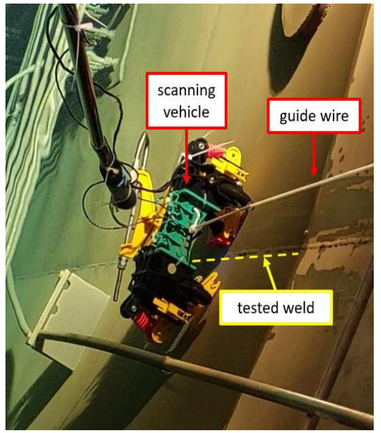
Ultrasound testing UT



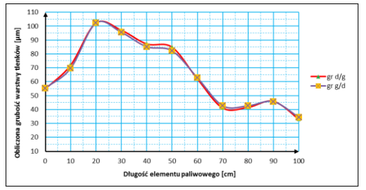
Magnetic particle inspection MT

MARIA Reactor NDT Inspections

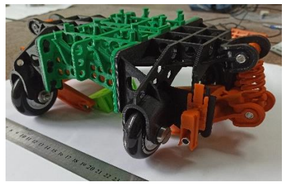
Welded joints on secondary circuit piping with UT, VT, MT



VT, UT reactor pool weld joints inspection



Thickness evaluation of Al_2O_3 layer of the fuel element shells, Eddy Current Testing



MARIA reactor weld joints UT scanning vehicle designed by Reactor and MRL engineers

Research Nuclear Reactor MARIA upgrade – Neutron Diffractometers / NDT Testing

Reaktor MARIA

New Large-Scale Scientific Instruments for the MARIA reactor….Installation already started …..ready to use in 2024

NCBJ cooperation with Helmholtz-Zentrum Berlin

HZB Helmholtz Zentrum Berlin

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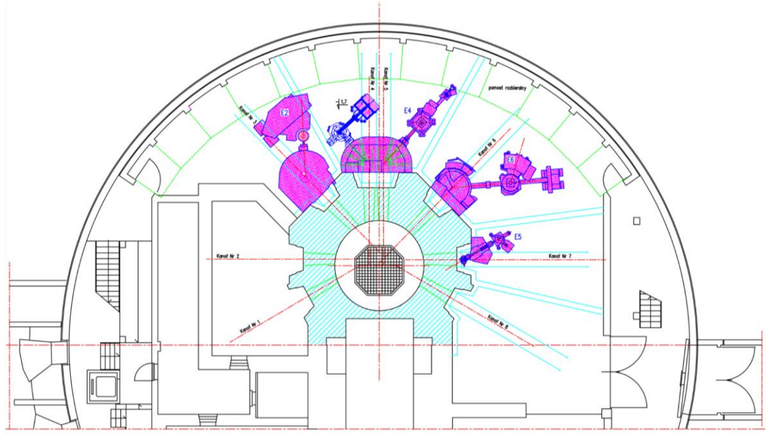
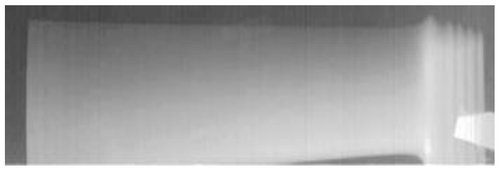


Visualization of the MARIA reactor experimental hall after upgrading



NR of Aircraft Engine Turbine Blade

Source: IAEA-TECDOC-1604

NR of Diesel Engines Nozzle

Source: IAEA-TECDOC-1604

H1	*Thermal neutron*	*Spectrometer*
H2	*Flat Cone*	*Diffractometer*
H3	*Residual*	*Stress Analysis Diffractometer*
H4	*Two-Axis*	*Diffractometer*
H5	*Four-Circle*	*Diffractometer*
H6	*Focusing*	*Diffractometer*

Materials Research with new Neutron Infrastructure

- *Neutron Radiography NR – NDT Testing of ready elements i.e. Microcracks analysis, Porosity after casting, Weldments quality control etc.*
- *Analysis of internal and residual stresses deep within a crystalline material*
- *Determination of the atomic and magnetic structure of a crystalline solids, gasses, liquids or amorphous materials.*
- *Measurements of highly-textured elements*

NATIONAL CENTRE FOR NUCLEAR RESEARCH ŚWIERK

NOMATEN Centre of Excellence in Multifunctional Materials for Industrial and Medical Applications

CoE NOMATEN Materials Research Laboratory Mechanical Testing Services

Mechanical Testing Division – Research Infrastructure

Accredited Mechanical Testing
Polish Centre for Accreditation
Accreditation number AB 025

AB 025

Static and dynamic strength testing

INSTRON Universal Testing Machine

- Servohydraulic (static/dynamic testing)
- Load capacity ±100 kN
- Class 0.5 starting from 200 N
- Clip-on extensometers class 0.5
- AlignPRO Alignment Fixture provides full angularity and concentricity adjustment while load is applied to the specimen
- Additional 1kN load cell

Temperature test chamber with cooling module
Temperature range:
from **-150°C to +350°C**

Three-Heating zone split furnace
Nominal maximum
specimen temperature: **1000°C**

Mechanical Testing Division realizes:

- ***Tensile testing***
- ***Compression testing***
- ***Fracture toughness testing K_{IC}, critical CTOD, J_{IC} (CT25, SENB)***
- ***Determination of the rate of fatigue crack growth da/dN***
- ***Small Punch Test (SPT)***

All tests according to International Standards ISO, ASTM, BS…

SPT Small Punch Test:
Samples: ϕ3 x 0,25 mm discs
Punch: Ball ϕ = 1 mm
Temperature of test: ambient

Mechanical Testing Division

- Test samples miniaturization
- Testing of mm samples at HT with non-contact DIC extensometer !!!

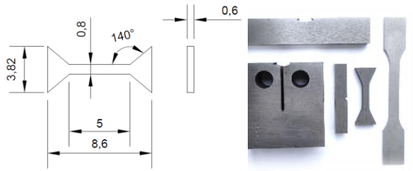
Mechanical Testing Division – Research Infrastructure

Materials hardness testing at micro- / nanoscale

Semi-automatic Zwick/Roell DuraVision G5 hardness tester

- Low-load hardness testing
- Load range 0.3-250 kg
- Brinell HB according to ISO 6506 (ASTM E10) 2.5/5 mm ball
- Vickers HV according to ISO 6507 (ASTM E-92)
- Rockwell HR.. according to ISO 6508 (ASTM E-18) - A,B,C,L,N,T scales

Miniaturized samples testing

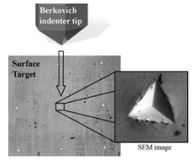


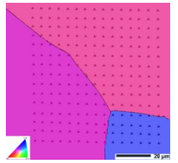
Dynamic testing machine (± 10-15 kN)

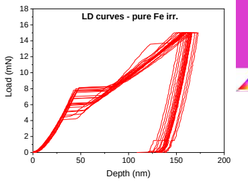
Resonance system
CT1/2", CT1/4" and SENB
<100 mm samples
Alignment Fixture

Nanohardness tester
NanoTest Vantage by Micro Materials Ltd., Wrexham UK

- **Berkovich, Vickers, Cube Corner and Conical** type indenters available for RT testing
- **HT measurements** with diamond (up to 450°C) and cBN (up to 750°C) indenter Measurements under **controlled argon atmosphere**
- **Humidity cell**
- Coupled **Atomic Force Microscope**
- Optical microscope (up to 40x mag.)
- Convers range forces from 0.1 mN to 20 N
- Load or depth-controlled mode
- **Single forces or Load Partial Unload**







Static testing machine (20 kN)

Electromechanical
0.5 class starting from 20 N
Furnace up to 1000 °C
Non-contact extensometer
DIC software
Sub-sized tensile specimens
Alignment Fixture

25J and 450J Pendulum Impact Testing Machines

Mechanical Testing Division realizes:

- ***Tensile testing***
- ***Compression testing***
- ***Fracture toughness testing K_{IC}, critical CTOD, J_{IC} (CT25, SENB)***
- ***Determination of the rate of fatigue crack growth da/dN***
- ***Small Punch Test (SPT)***

According to International Standards ISO, ASTM, BS…accredited tests !

Mechanical Testing Division – Expertise works

Mechanical testing of the high-speed railways in cooperation with Polish Railway Institute

70 years IK RAILWAY RESEARCH INSTITUTE

NATIONAL CENTRE FOR NUCLEAR RESEARCH ŚWIERK
NOMATEN Centre of Excellence in Multifunctional Materials for Industrial and Medical Applications

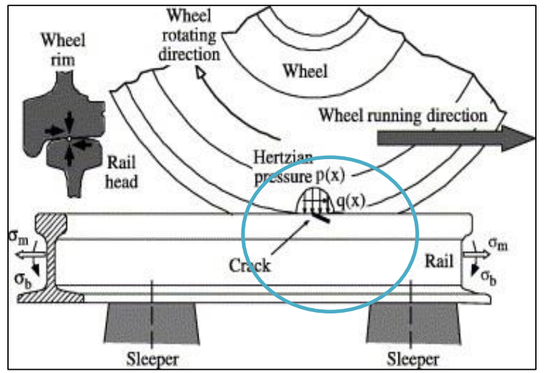
High-speed railways with speeds over 200 km/h, are one of the most demanding systems that must several requirements as: Safety, Durability and cost efficiency, Minimum acoustic impact

To achieve these objectives, the high-speed rail manufacturing process aims to meet the following requirements:

- Fracture mechanics – involves the initiation and growth of a crack, which can cause the material to break at a stress below its ultimate strength in the crack-free condition.
- Chemical, mechanical and structural homogeneity
- Uniformity of dimensions
- Absence of surface and internal defects
- Impact strength, wear and fatigue resistance
- Residual stresses
- Good Weldability

Accredited Mechanical Testing
Polish Centre for Accreditation
Accreditation number AB 025

ilac-MRA PCA Polskie Centrum Akredytacji BADANIA AB 025

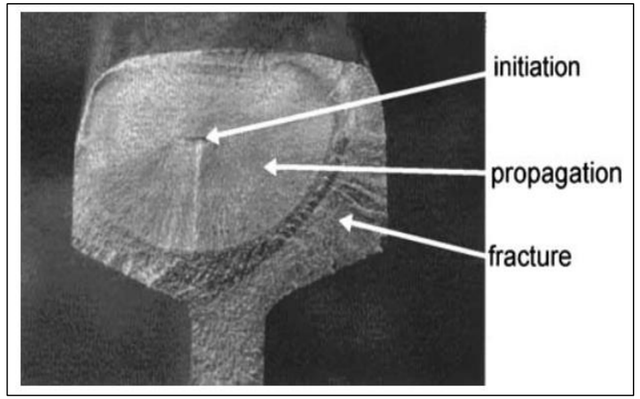


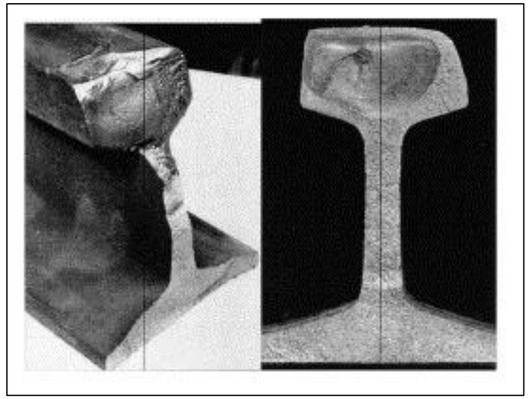
Cracking mechanism and testing of railways Stresses and Bielajew's point analysis

High-Speed ICE Pendolino train, max. speed 250 km/h

We realize the complex fracture mechanics accredited tests for railway systems since 2004…

- ✓ We measure the ***Rate of crack propagation (da/dN) – acc. ISO 12108***
- ✓ We evaluate the ***Critical stress intensity factor K_{IC} at lowered temperature – acc. ASTM E399***





Macroscopic observations of cracks and analysis of rails breakthrough

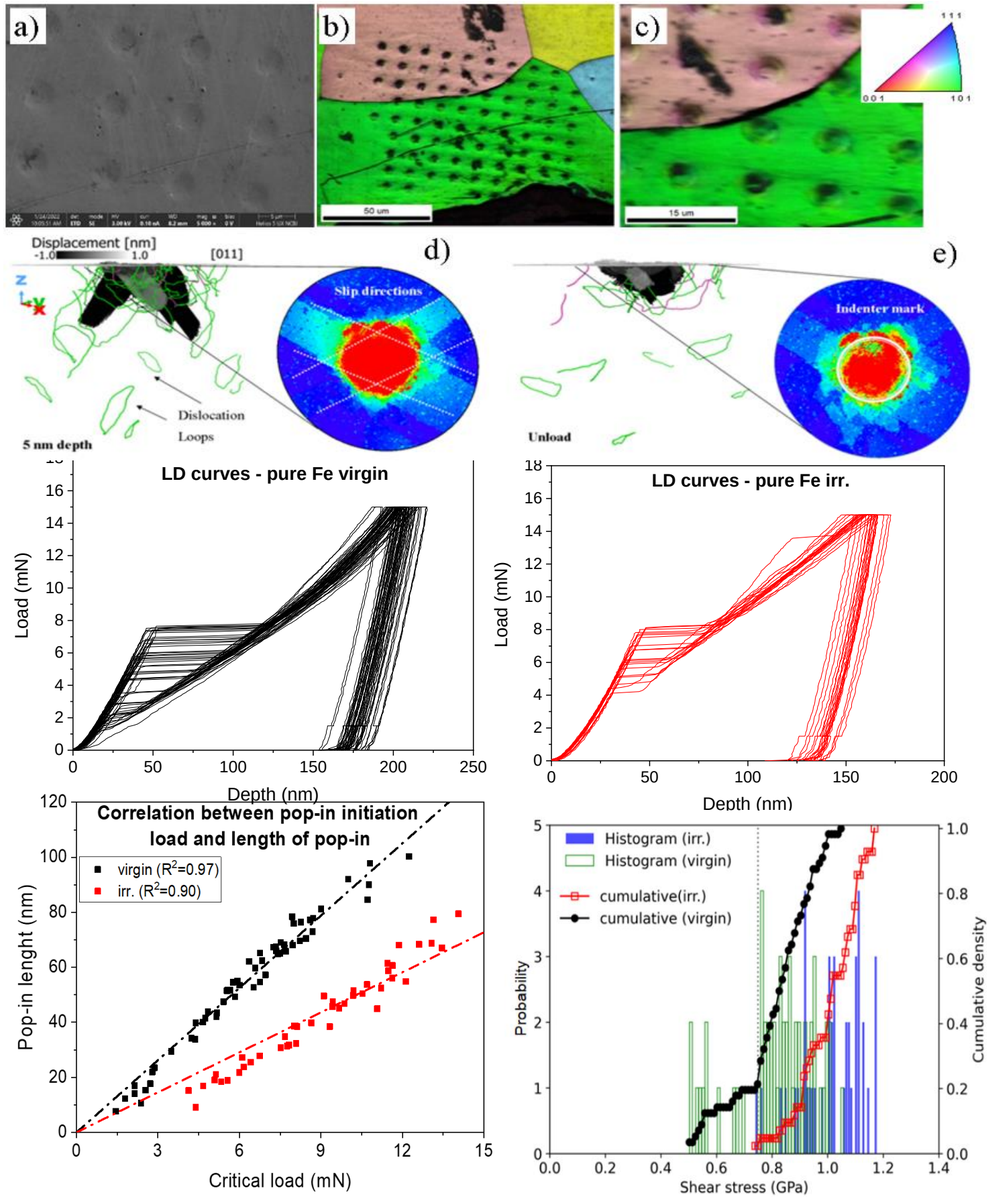
High-Speed ICE train disaster, Eschede, (Germany,1998)

Mechanical Testing Division – Research Activities

Studying effect of ion irradiation and temperature on the properties of Ferritic / Martensitic steels

NOMATEN Centre of Excellence in Multifunctional Materials for Industrial and Medical Applications

Spherical nanoindentation (R_i=25 µm)



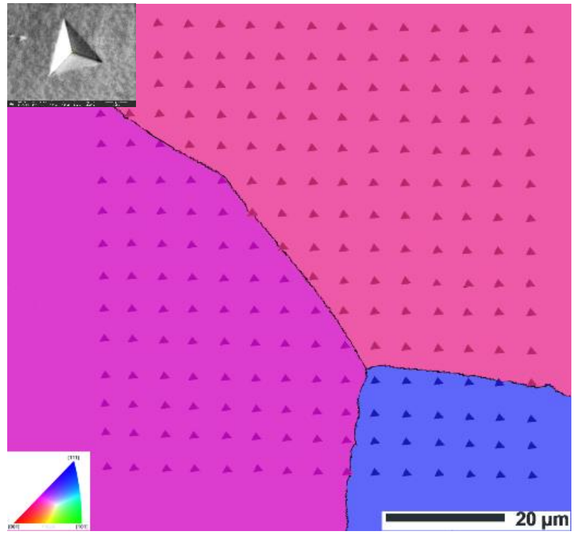
Samples: Pure Fe; Fe9%Cr; Fe9%Cr-NiSiP, Eurofer 97
Ion irradiation in HZDR up to 8MeV Fe ions, 5 dpa, temp. 300 (and 450°C)
Techniques: Nanoindentation at rT and HT; SEM+FIB/EBSD & TEM; XRD & MD simulations

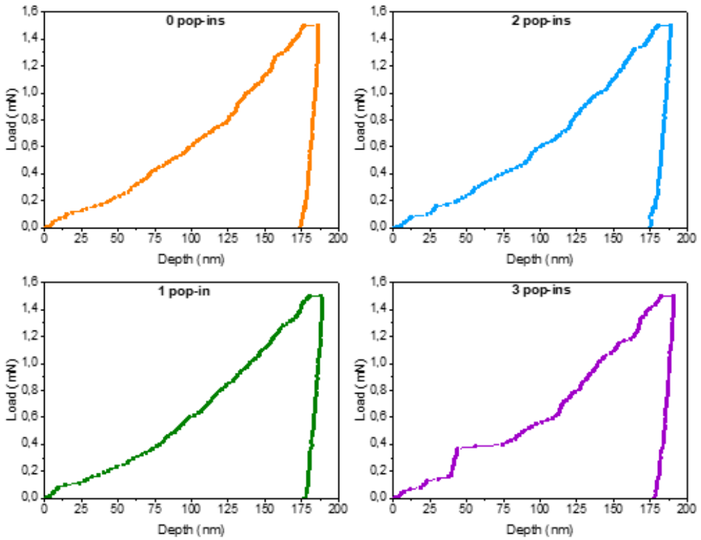
Results:

- Elastic analysis based on the Hertz revealed that the first pop-in is typically caused by plasticity initiation
- Calculated shear stress is about 3 GPa (theoretical strength)
- Interstitial atoms like C influence pop-in behaviour by blocking preexisting dislocations

Mechanisms to consider:

- Dislocation nucleation at neighboring grain, unlocking pinned by C atoms dislocations at grain boundaries, slip transfer?
- Do we see the impact of crystal orientation?





NATIONAL CENTRE FOR NUCLEAR RESEARCH ŚWIERK

NOMATEN Centre of Excellence in Multifunctional Materials for Industrial and Medical Applications

CoE NOMATEN Materials Research Laboratory Structure Analysis and Corrosion Research Services

Structure and Corrosion Research Division – Research Infrastructure

Metallographic samples preparation and analysis

Metallographic sample prepartion section

- Cut-off machines (precision cutting)
- Manual or automatic grinder / polisher
- Manual or automatic, electrochemical (0-100V) and vibropolishing (60 - 120 Hz)
- Electrochemical polishing and etching (0-25V) / possibility of electrolytic polishing in cool temperature mode
- Hot Mounting Press

QATM Opal 410 press


QATM Saphir Vibro polisher

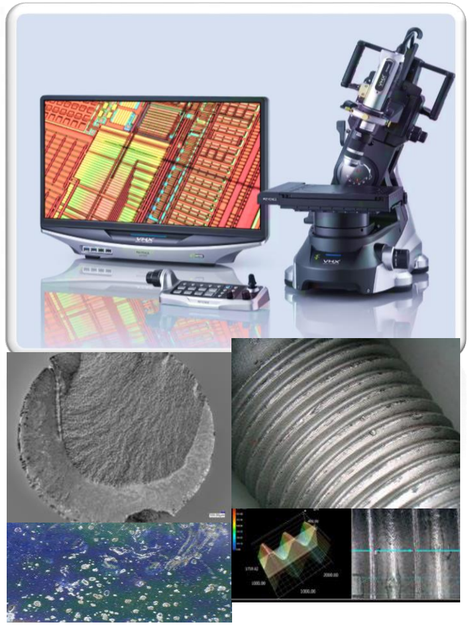
STRUERS – LectroPol electrochemical polishing / etching system


QATM Saphir 250 M2 automatic grinder / polisher

Microstructure characterization – Light Microscopy

- Leica DM IL Inverted Metallurgical Microscope
- Olympus BX53M Metallurgical Microscope
- Keyence VHX-7000 Optical Microscope
- ✓ Light microscopy contrast methods such as Brightfield BF, Darkfield DF, Polarized light POL, and Differential Interference Contrast DIC
- ✓ Olympus licensed software for determining average grain size according to international standards (i.a. ASTM E112, ISO 643) and phase analysis


Olympus BX53M Metallurgical Microscope


KEYENCE VHX-7000 Optical Microscope

Structure and Corrosion Research Division – Research Infrastructure

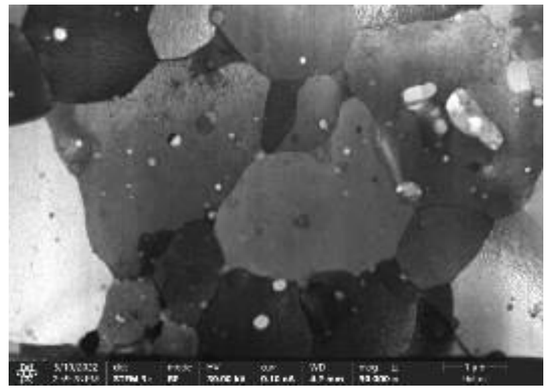
Samples preparation and microstructure analysis

SEM/TEM Laboratory financed by NOMATEN Centre of Excellence in Multifunctional Materials for Industrial and Medical Applications

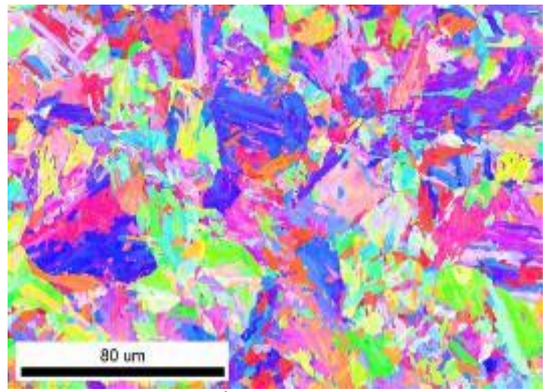
SEM microscope Helios 5 UX DualBeam (Thermo Fisher Scientific)

The Extreme High Resolution (XHR) Field Emission Scanning Electron Microscope (FE SEM) equipped with:

- ❑ FIB (Focused Ion Beam) technology
- ❑ EDS (Energy Dispersive X-ray Spectroscopy)
- ❑ EBSD (Electron Backscatter Diffraction)



STEM imaging
Recractable STEM 3+ detector

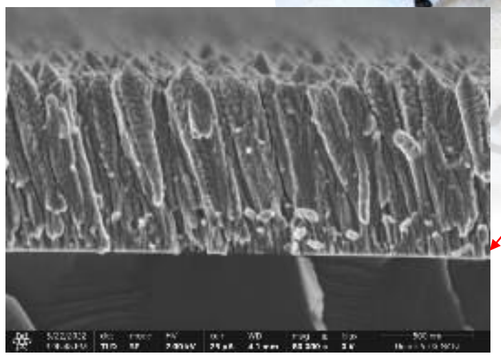


Crystal orientation mapping
Hikari Super EBSD Camera, 1400 fps
Operation down to 100 pA/5kV

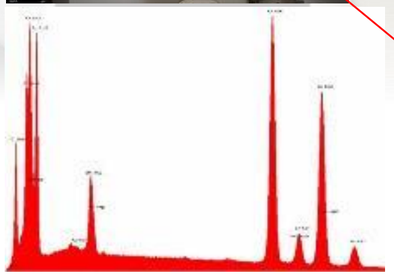
Ion Beam Precision Etching System

The PECS II and PIPS II (Gatan) is used to polish surfaces and remove without damage with two broad argon beams. This method is powerful for producing high-quality samples:

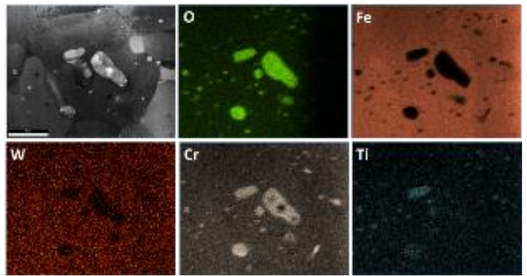
- ➢ for scanning electron microscope (SEM) observations
- ➢ for SEM imaging and EDS mapping
- ➢ for EBSD analysis,
- ➢ for STEM, TEM observation etc.



High resolution SEM imaging
Acceleration voltage: 350V – 30kV
Resolution: 0.6 nm (2 - 15kV), 0.7 nm (1 kV)
Detectors: ETD, TLD, ICD, MD, ICE



EDS Chemical composition analysis
Octane Elite Plus EDS System
SSD detector, area: 30mm2, resolution: 125eV, Si3N4



Structure and Corrosion Research Division – Research Infrastructure

Samples preparation and microstructure analysis

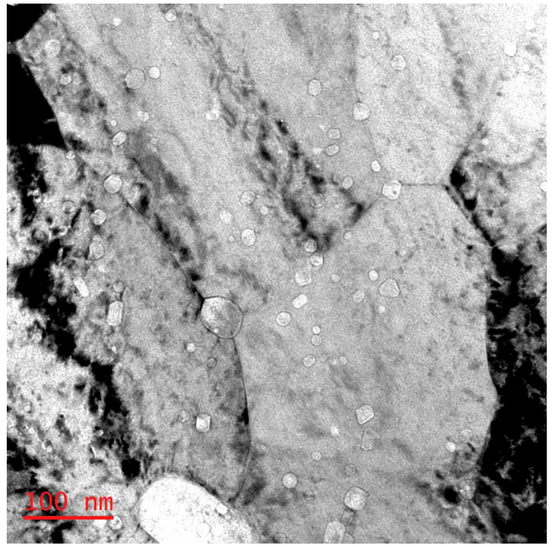
SEM/TEM Laboratory financed by
NOMATEN Centre of Excellence in Multifunctional Materials for Industrial and Medical Applications

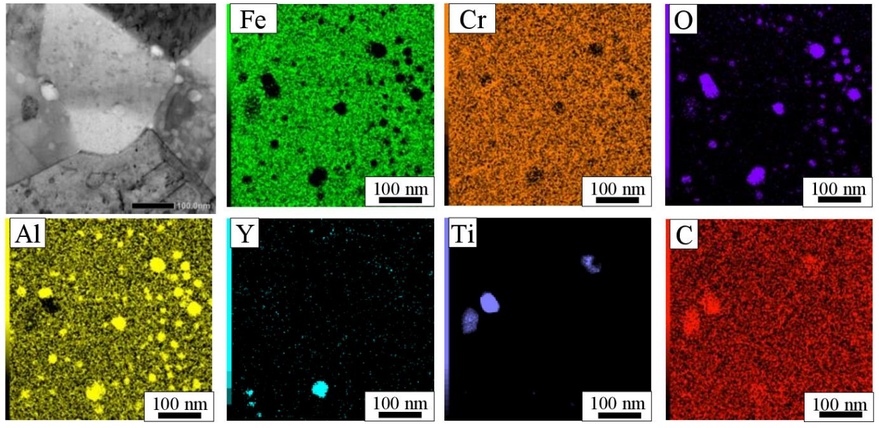
TEM Microscopy

Transmission Electron Microscopy TEM – JOEL F200 Microscope

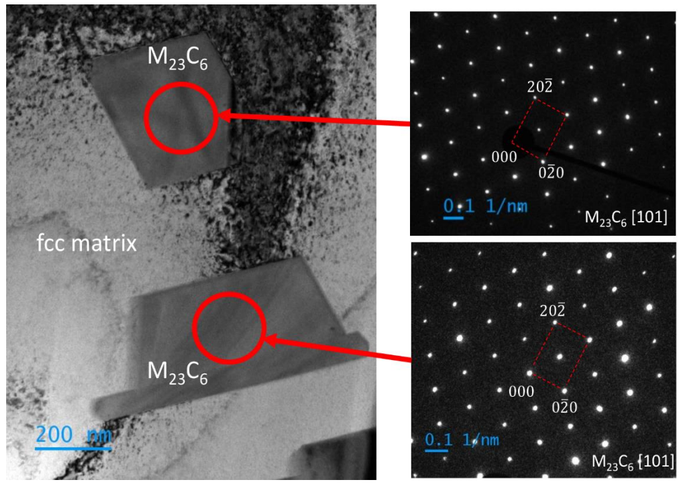
TEM with STEM, HAADF, EDS, BEI, BF and ABF detectors
Equipped with in-situ tensile and HT annealing up to 1000°C holders

STEM-EDS chemical composition analyses of nanometric precipitates in FeCrAl-Y2O3-Ti ODS alloy





SafeG Project
Inconel produced in collaboration with the University of Sheffield - Nuclear Advanced Manufacturing Research Centre)



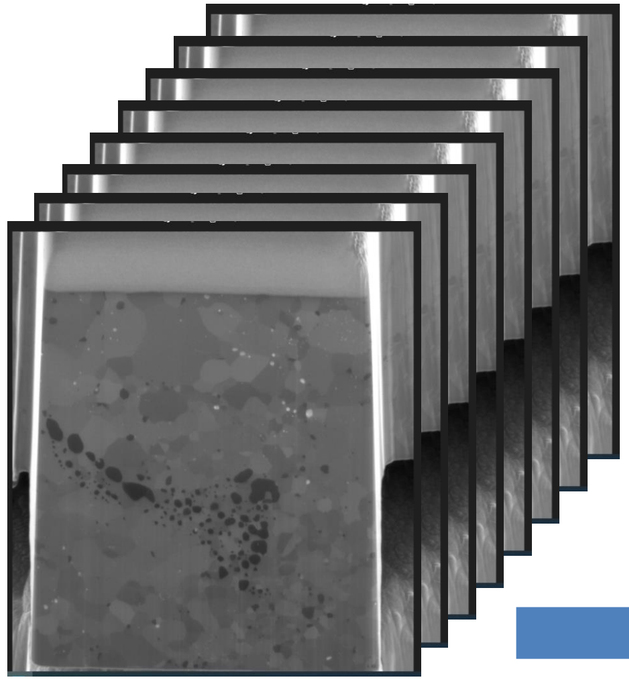
TEM image and SAED patterns of M23C6 carbide in additively manufactured Inconel 617 alloy

Structure and Corrosion Research Division – Research Infrastructure

Samples preparation and microstructure analysis

SEM/TEM Laboratory financed by

SEM-FIB 3D Reconstruction



Presentation

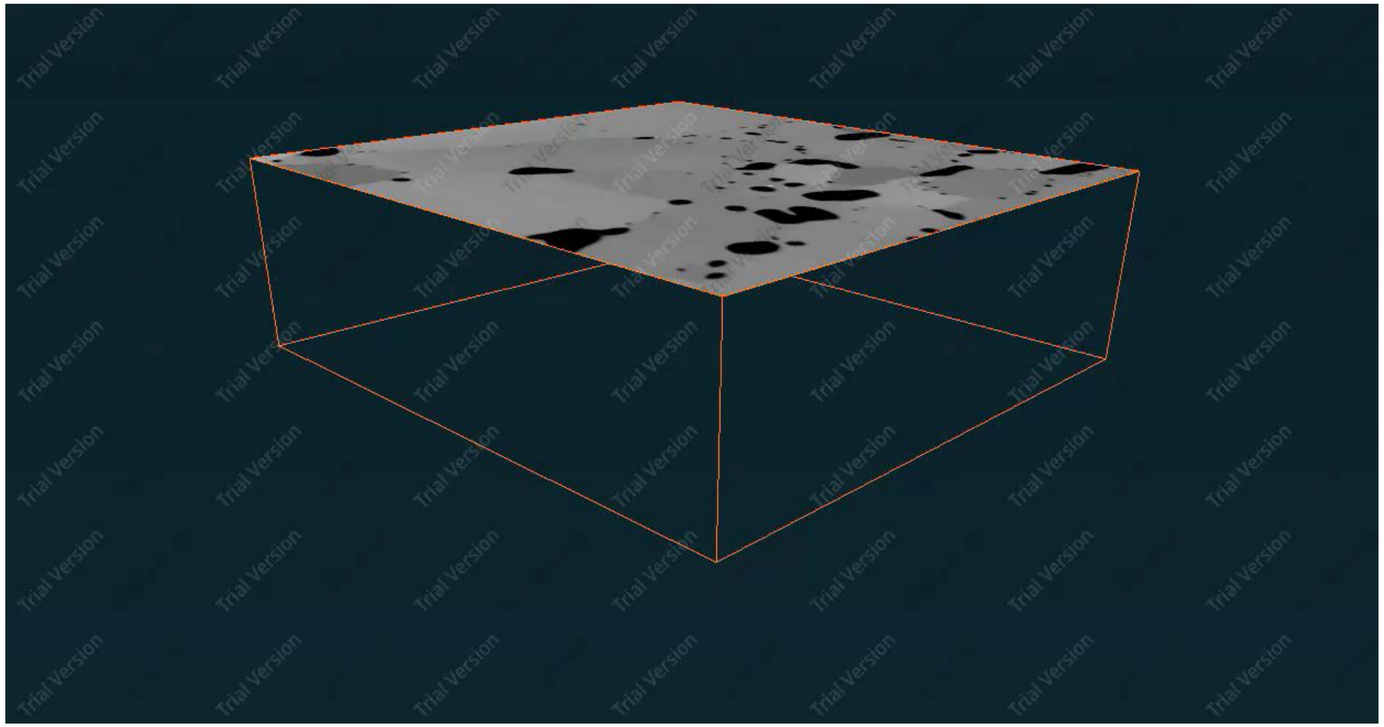
Visualization

Measurements and analysis

Segmentation

FIB slicing & SEM imaging

Reconstructed Material Microstructure in volume mode



Structure and Corrosion Research Division – Expertise works for automotive

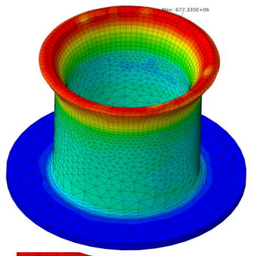
Materials fatigue analysis for Automotive Indsutry

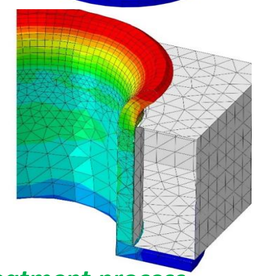
Problem to solve: Cracking of tubular rivets for clamping Knee-Airbag modules

Production losses: 1 Airbag module cost ca. 200 EUR…ca. 60 losses / 24h 24h lost: 12 000 EUR
10 days until decision to stop the production line Total lost: 120 000 EUR + production downtime

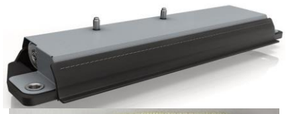
- We realized metallographic analysis of the low-carbon steel, macroscopic, LM and SEM observations and EDS analysis
- We showed that material cooling after heat treatment was realized wrongly – tertiary cementite in the grain boundaries
- We finally selected the proper heat treatment parameters of the rivets and estimated the optimal clamping force with FEM analysis

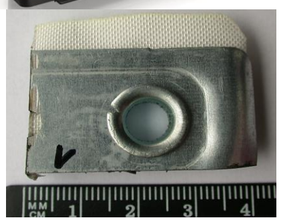
FEM analysis of riveting process – clamping force

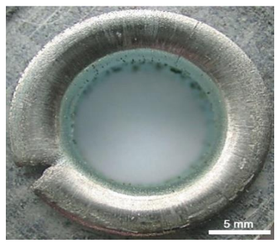


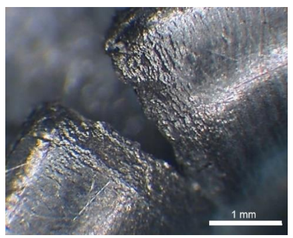


Knee – Airbag module



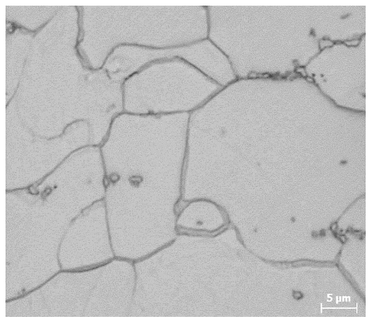


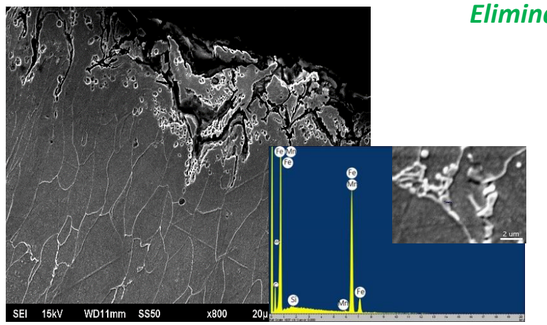




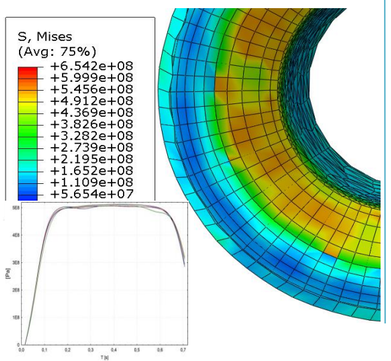
Macroscopic observation of the cracking area of the rivets

Result: Heat treatment process improvement
Elimination of production losses





Microstructure analysis of the low-carbon steel – tertiary cementite in the grain boundaries



Problem to solve: Induction hardening optimization
Cracking of the drive shafts during straightening at quality control stage

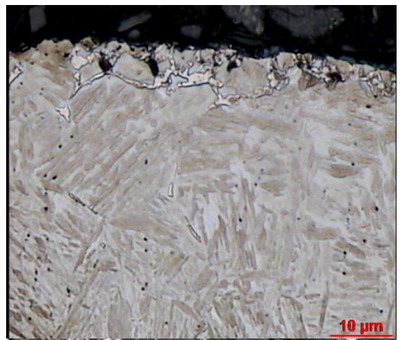
- We analyzed the material after each production stage (rod delivery state > machining > induction hardening)
- We realized metallographic analysis of the low-alloy steel (macroscopic observations of breakthrough, LM and SEM observations, hardened case depth analysis)
- We showed that material after induction hardening tends to crack at the surface
- We optimzed heat treatment with adding stress relief stage after machining and set proper induction hardening parameters incl. low-tempering after hardening

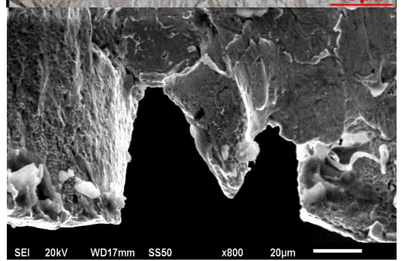
Macroscopic observation of the cracking area in the drive shaft

Macroscopic observation of breakthrough

Microstructure analysis of low-alloy steel – surface ckracking effects after induction hardening

Result: Full eilimination of the cracks
Quality control report:
100% Drive shafts OK
10 000 pieces





NATIONAL CENTRE FOR NUCLEAR RESEARCH ŚWIERK

NOMATEN Centre of Excellence in Multifunctional Materials for Industrial and Medical Applications

CoE NOMATEN Materials Research Laboratory Phase Analysis and Chemical Composition Research Services

Phase analysis Laboratory NOMATEN XRAYLAB – Research Infrastructure

X-Ray Laboratory financed by
NOMATEN Centre of Excellence in Multifunctional Materials for Industrial and Medical Applications

X-ray diffraction phase analysis

Key X-ray research abilities:

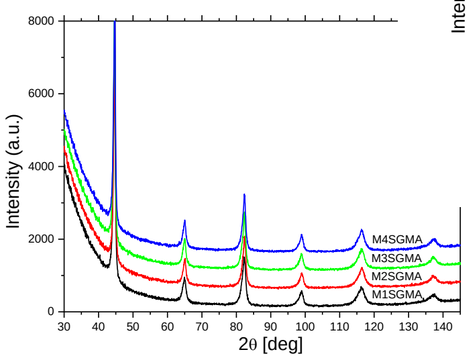
X-ray powder diffraction (XRPD)
- Identification of crystalline and amorphous phases and determination of specimen purity
- Quantitative analysis of both crystalline and amorphous phases in multi-phase mixtures
- Microstructure analysis (crystallite size, microstrain, disorder…)
- Bulk residual stress resulting from thermal treatment or machining in manufactured components
- Texture (preferred orientation) analysis
- Indexing, ab-initio crystal structure determination and crystal structure refinement

Analysis of amorphous, poorly crystalline, nano-crystalline or nano-structured materials
- Phase identification
- Structure determination and refinement
- Nano particle size and shape

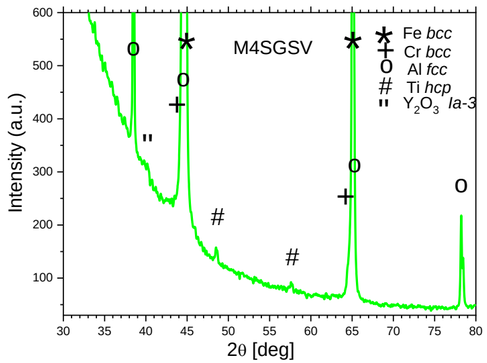
Thin Films and Coatings high quality analyses
- Grazing incidence diffraction
- X-Ray Reflectometry
- High resolution X-ray diffraction
- Reciprocal space mapping

BRUKER **D8 ADVANCE**
- equipped with a sealed Cu X-Ray tube, TWIN-TWIN optics and LYNXEYE XE-T strip detector
- Cu radiation, $\lambda_{K\alpha1}$ = 1.540562 Å
- Energy Resolution < 380 eV at 8 keV
- B-B/GID geometries

High-temperature stage - Anton Paar HTK 1200 N
- temperature up to 1200°C
- operates Under Vacuum or Selected Gas Environment
- specimen Stage with Rotation (Rocking)



FeCrAl-ODS alloys powders analysis



Sample	Fe-rich solid solution (bcc)				Cr-rich solid solution (bcc)		
	Lattice constant [Å]	Crystallite Size [nm]	Strain parameter	Phase content	Lattice constant [Å]	Crystallite Size [nm]	Strain parameter
M1SGMA	2.868	28	0.0049	74	2.891	14	0.0057
M2SGMA	2.866	23	0.0048	87	2.889	11	0.0051
M3SGMA	2.869	23	0.0047	79	2.891	14	0.0053
M4SGMA	2.868	23	0.0047	87	2.891	14	0.0057

Structure and Corrosion Research Division – Research Infrastructure

Spectroscopic phase and chemical composition analysis

Raman Spectroscopy

Research Features

- Obtaining qualitative to semi-quantitative information on material phase composition (Raman imaging)
- Determination of stress distribution
- Examination of phase transition and corrosion of materials
- Observations of structural changes after ion implantation - defects type and amount determination

WITec focus innovations

Alpha 300R
Raman Spectrometer

Ultra-high throughput spectrometer (UHTS), for high speed and high resolution Raman imaging.

High temperature stage (up to 1000 C)

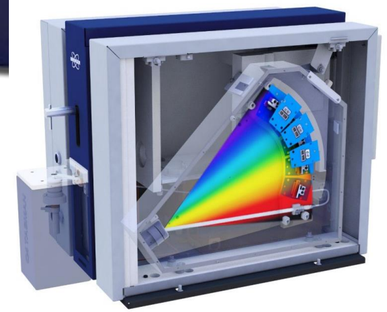
Optical microscope:
Zeiss Neofluar objectives
magnification x10, x50, x100

Spark Optical Emission Spectroscopy OES

BRUKER Q4 TASMAN Series 2

Research features:

- Quantitative elemental analysis
- Improved precision and stability
- High accuracy and sensitivity levels, full capabilities including C, P, S, Sb, Te
- Digital Spark Source delivers improved analytical precision and shorter time-to-result.
- Dual optics concept with robust Paschen Runge mount, multi-chip systems with temperature stabilization



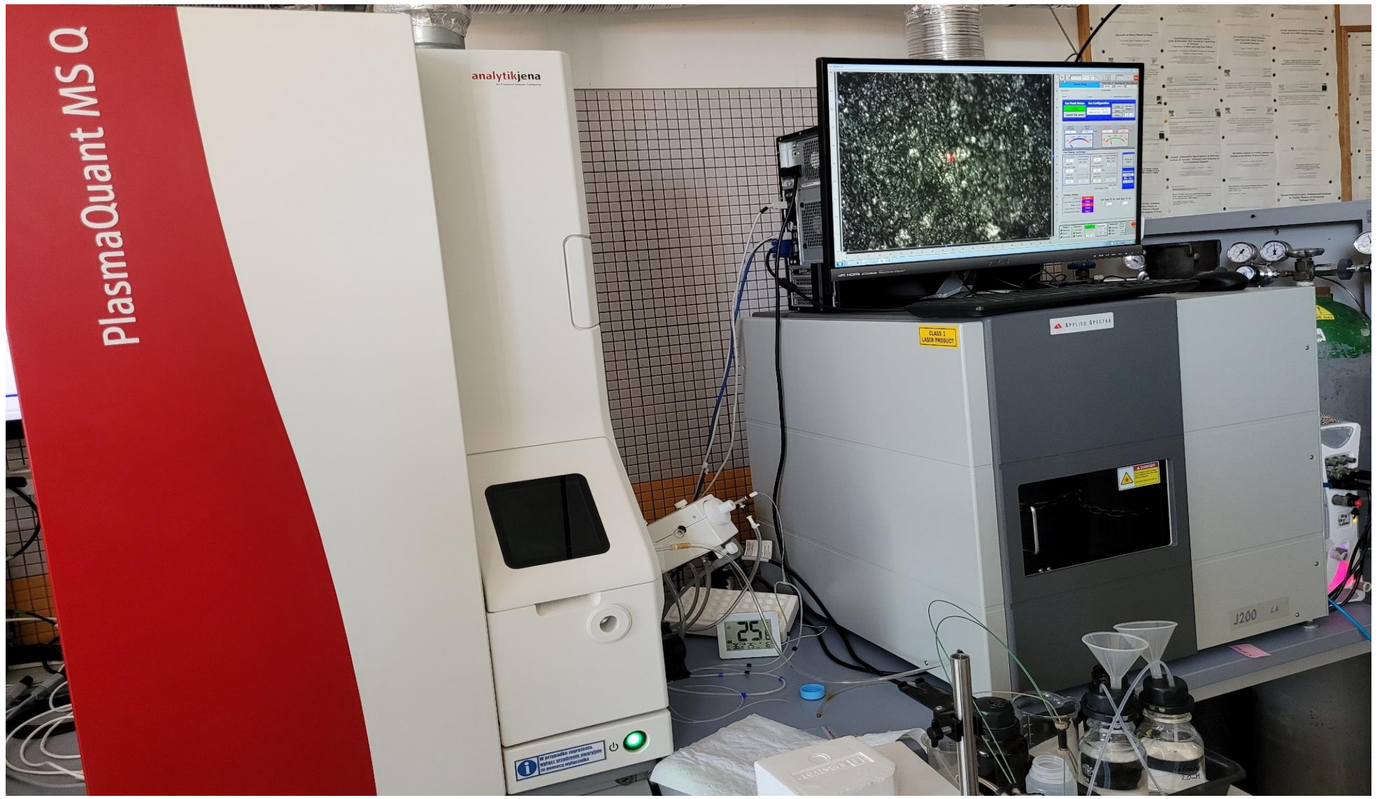
4 Analytical Bases Fe, Al, Ni and Ti alloys

30 CRM Materials with ISO 17034 Standard

Structure and Corrosion Research Division – Research Infrastructure

ICP-MS integrated with Laser Ablation LA and LIBS spectrometer

Analytik Jena Plasma Quant MS Q <> Applied Spectra J200 LA system with LIBS



Financed by
PROJECT HTGR

Chemical analysis at .ppm and .ppb level of high purity graphite in accordance with IAEA regulations

Other research plans:

- solid samples inpurities analysis
- C,H,O,N detection in materials (LIBS)
- MARIA reactor water analysis

TOYO TANSO

■ Impurity Analysis Example

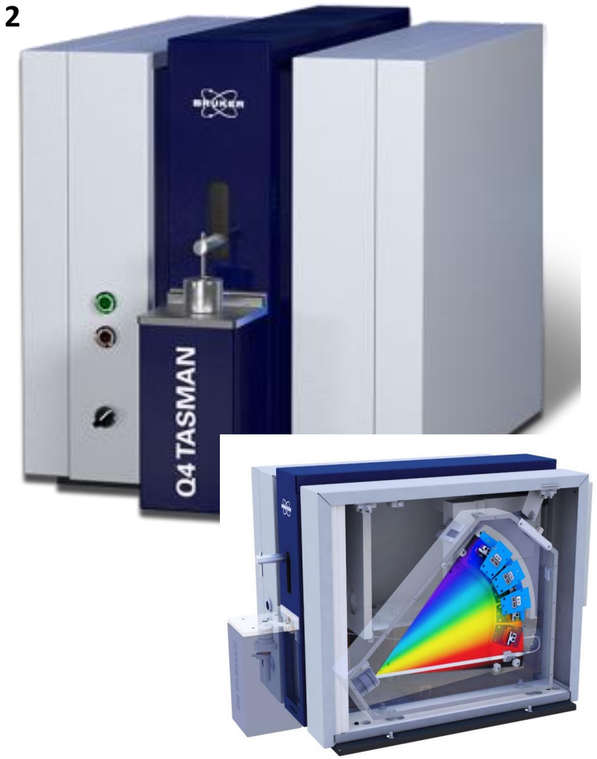
Unit: mass ppm

Element	Content			Measurement Method
	Ultra High Purity Graphite	High Purity Graphite	Regular Graphite	
Li	<0.001	<0.001	<0.03	ICP-MS
B	0.10	0.15	3	ICP-MS
Na	<0.002	<0.002	<0.5	ICP-MS
Mg	<0.001	0.004	0.2	ICP-MS
Al	<0.001	0.012	14	ICP-MS
Si	<0.1	<0.1	2	UV
K	<0.03	0.04	2	FL-AAS
Ca	<0.01	0.08	6	FL-AAS
Ti	<0.001	<0.001	33	ICP-MS

Element	Content			Measurement Method
	Ultra High Purity Graphite	High Purity Graphite	Regular Graphite	
V	<0.001	0.018	40	ICP-MS
Cr	<0.004	0.006	<0.3	ICP-MS
Mn	<0.001	<0.001	<0.2	ICP-MS
Fe	<0.02	0.06	26	ICP-MS
Co	<0.001	<0.001	<0.3	ICP-MS
Ni	<0.001	0.006	4	ICP-MS
Cu	<0.002	<0.002	<1	ICP-MS
Zn	<0.002	<0.002	<0.6	ICP-MS
Pb	<0.001	<0.001	<1	ICP-MS

Spark Optical Emission Spectroscopy OES

SMAN Series 2



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4 Analytical Bases Fe, Al, Ni and Ti alloys

30 CRM materials with ISO 17034 Standard

Structure and Corrosion Research Division – Research Activities

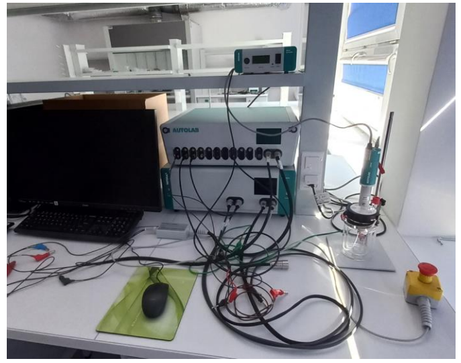
NOMATEN Centre of Excellence in Multifunctional Materials for Industrial and Medical Applications

Corrosion and Electrochemistry Laboratory

Workplace 1: Setup for standard and long-term corrosion monitoring

Potentiostat/galvanostat
a Metrohm VIONIC

Potentiostat/galvanostat
a Metrohm AUTOLAB 302N



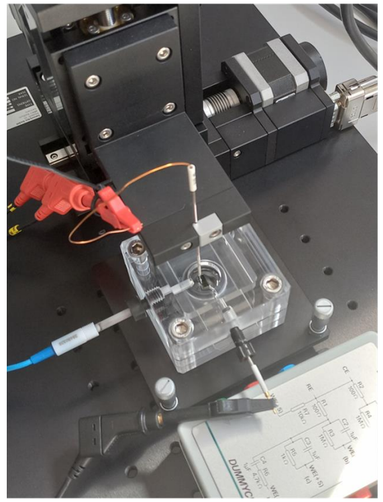
Raman electrochemical cell
Redox me

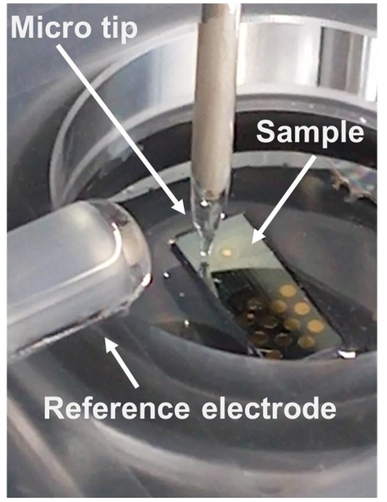
Selected capabilities*:*

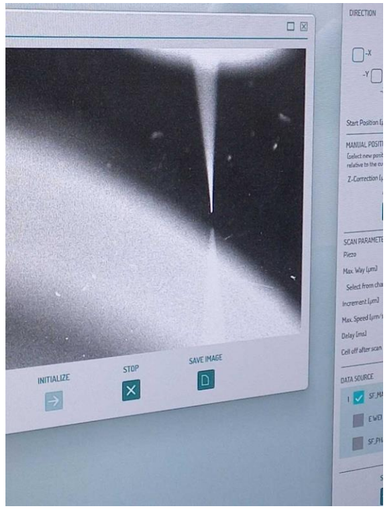
- **Polarization (LSV, CV)** tests according to the **ASTM** regulations *(corrosion rate [mm/year], tendency to pitting corrosion)*
- **Electrochemical Impedance Spectroscopy (EIS)** tests *(testing coatings/paint systems, /oxide layers, corrosion monitoring)*
- All electrochemical tests can be performed in controlled temperature/flowing rate of the electrolyte
- ***Monitoring of the surface changes and corrosion resistance simultaneously – in situ Raman spectroscopy***

Workplace 2: Setup for corrosion tests in microscale

Scanning electrochemical microscope (SECM)
equipped with the Shear-Force and High-Res modules
Sensolytics







Local, separate corrosion response from:

- Particularly oriented grains in materials
- Different phases of materials
- Interfaces: precipitates/grain boundaries
- Parts of the welded joints (welded metal/HAZ)
- Surface features

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NOMATEN Centre of Excellence in Multifunctional Materials for Industrial and Medical Applications

CoE NOMATEN Materials Research Laboratory
Thermal Properties Analysis Services

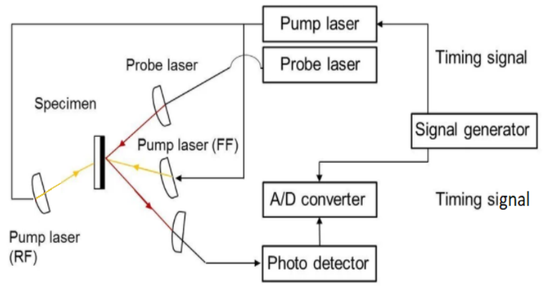
Thermal Properties Testing Laboratory – Research Infrastructure

Thermal Research Laboratory
Financed by Project HTGR
PROJECT HTGR

The Thermal Laboratory enables full characterization of the thermal properties of advanced materials

The laboratory equipment includes:

(I) high-temperature dilatometer
(II) device for measuring of thermal diffusivity of volumetric materials,
(III) device for measuring of thermal diffusivity of thin films,
(IV) a set for simultaneous thermal analysis
(V) a thermal mass spectrometer.

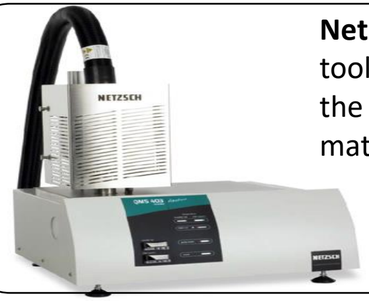


NanoTR enables measurements of thermal diffusivity of metallic, ceramic and composite layers in the range from 0.01 to 1000 mm^2/s with an accuracy of 5%.

High-temperature Dilatometer Netzsch DIL402
Operates in horizontal mode within the temperature range from RT to 1600°C.
The load on the sample is in the range from 50mN to 3N, with measurement of cylindrical samples and cuboidal samples with an accuracy of 1 nm and in the range of measuring 10 mm.

Netzsch LFA 467 *HT HyperFlash*® allows for measurement of **thermal diffusivity and thermal conductivity between RT and 1250°C with Xenon Flash**

Netzsch STA 449 F3 Jupiter®
STA instrument combines two measuring techniques: Thermogravimetry (TG) and Differential Scanning Calorimetry (DSC) for a single sample.
The device includes two high-temperature furnaces:
- High-temperature furnace enabling operation in a protective atmosphere (in the range of RT to 1600°C)
- High-temperature furnace enabling operation in a water vapour atmosphere (in the RT to 1250°C range, at a relative humidity in the range of 5-90%.).



Netzsch Mass Spectrometer QMS 403 Aëolos Quadro useful tool for obtaining the chemical and analytical information about the products causing the weight changes of the different materials during heat treatment.

NATIONAL CENTRE FOR NUCLEAR RESEARCH ŚWIERK

NOMATEN Centre of Excellence in Multifunctional Materials for Industrial and Medical Applications

We invite you to cooperate with us…!!!

- ***We have a research laboratories with high-end infrastructure,*** *which is fully equipped and operational*
- ***We have a management system*** *under PN-EN ISO/IEC 17025 norm and we can realize* ***accredited testing*** *in line with* ***international research and materials standards ISO, ASTM, BS****…*
- ***We have a young Staff of Engineers*** *who continue to expand and develop their competencies…*

Save the Date for 2nd Edition of NOMATEN Innovation Days 2024!

Date: *22th Ocotber 2024*

Session and Lectures:
Industrial Cooperation Session
Nuclear Materials Session
Non-nuclear Materials Session
Materials Research Examples

Technical Visists to:
MARIA Reactor
NOMATEN Laboratories
POLATOM Company
CERAD Cyclotrone
CentriX Laboratory

For more info please visit our website:
https://nomaten.ncbj.gov.pl/

MARIA Reactor hall

CERAD Cyclotrone Infrastracture

Over 120 Participants in 2023!

Acknowledgements

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European Commission | Horizon 2020 European Union funding for Research & Innovation

FNP Foundation for Polish Science

Ministerstwo Aktywów Państwowych
Ministry of State Assets

Mazovia Marshall Office
Mazovia. heart of Poland

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Project HTGR High-Temperature Gas Cooled Reactor

Ministry of Education and Science

Ministry of Climate and Environment

Ministerstwo Nauki i Szkolnictwa Wyższego

"Funding from the undertaking of the Minister of Science and Higher Education "Support for the activities of Centers of Excellence established under Horizon 2020"

THANK YOU FOR YOUR INTEREST

Contact Persons:

Professor Jacek Jagielski
Head of the NOMATEN TEAMING for Excellence Project
Director of Material Physics Department
National Centre for Nuclear Research
e-mail: Jacek.Jagielski@ncbj.gov.pl
phone: +48 22 273 1443

Łukasz Kurpaska, D.Sc., Assoc. Prof.
Director of NOMATEN CoE
Materials Research Laboratory
National Centre for Nuclear Research
e-mail: Lukasz.Kurpaska@ncbj.gov.pl
Phone: +48 22 273 10 61 / Mobile: +48 796 768 038

Jarosław Jasiński, D.Sc., Assoc. Prof.
NOMATEN CoE Industry Liason Group Member
Materials Research Laboratory
National Centre for Nuclear Research
e-mail: Jaroslaw.Jasinski@ncbj.gov.pl
Phone +48 22 273 10 62 / Mobile: +48 507 941 657