RATEN ICN PITEŞTI
INSTITUTUL DE CERCETĂRI NUCLEARE

RATEN ICN status on mechanical properties investigation of 316L generation IV candidate material

Alexandru NITU, Vasile RADU, Vorel IONESCU,
***RATEN ICN Pitești – Romania**
alexandru.nitu@nuclear.ro

IAEA
International Atomic Energy Agency
Atoms for Peace and Development

Technical Meeting on Structural Materials for Heavy Liquid Metal Cooled Fast Reactors

IAEA Headquarters
Vienna, Austria

15–17 October 2019

Outline

- **Develpoment of the testing facility in liquid lead**
  - **Experimental set-up *LILETIN***
  - **Results and discussion**
  - **Conclusions on the preliminary tests**

- **Overview on the key aspects in the experimental tasks performed in FP7 MatISSE Project**

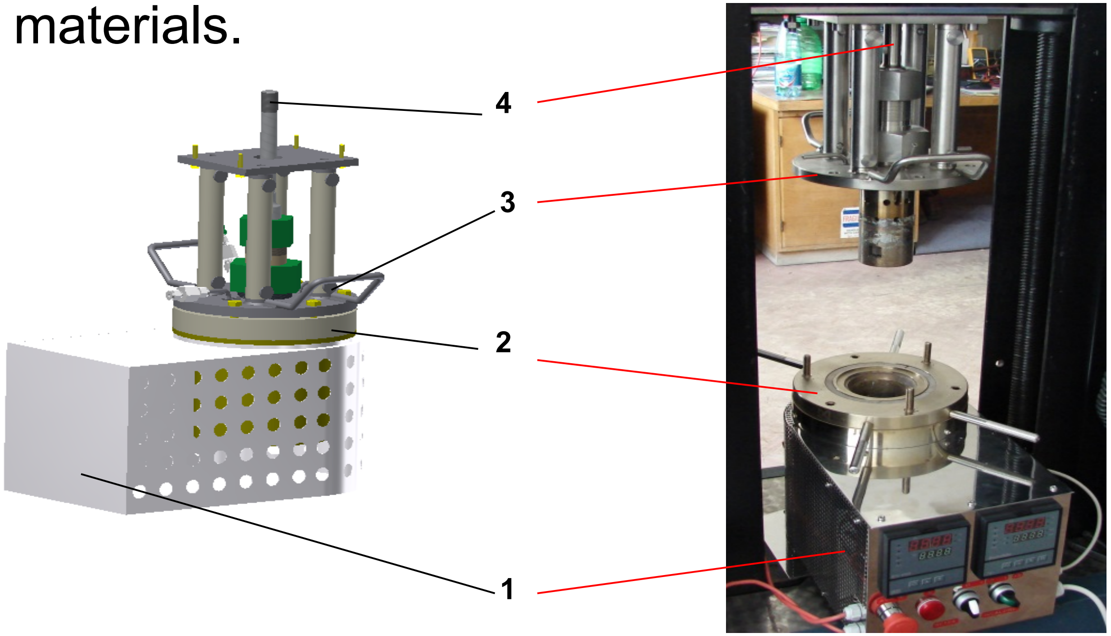
- **Good points and Issues**

- **Planned works**

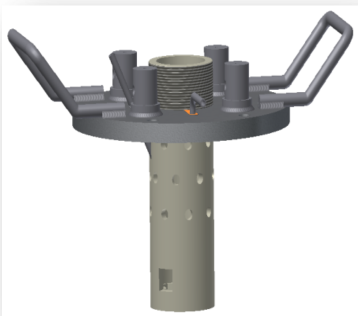
Experimental set-up

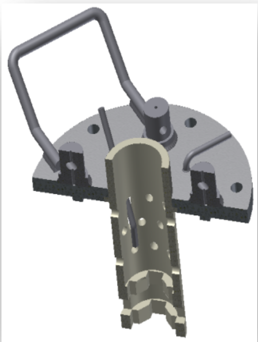
The testing facility LILETIN is designed and built to study the effects of Pb on the mechanical properties of structural materials.

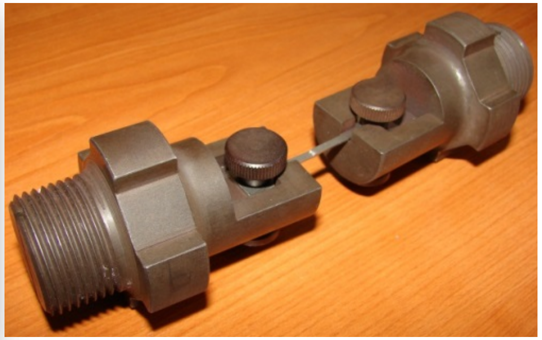
- maximum temperature: 500^{0}C,
- volume of Pb: 0.9 liter,
- strain rates controller,
- without Oxygen Control System (under development)



1-furnace, 2-liquid lead crucible, 3-specimen fixing assembly, 4-pooling rod.



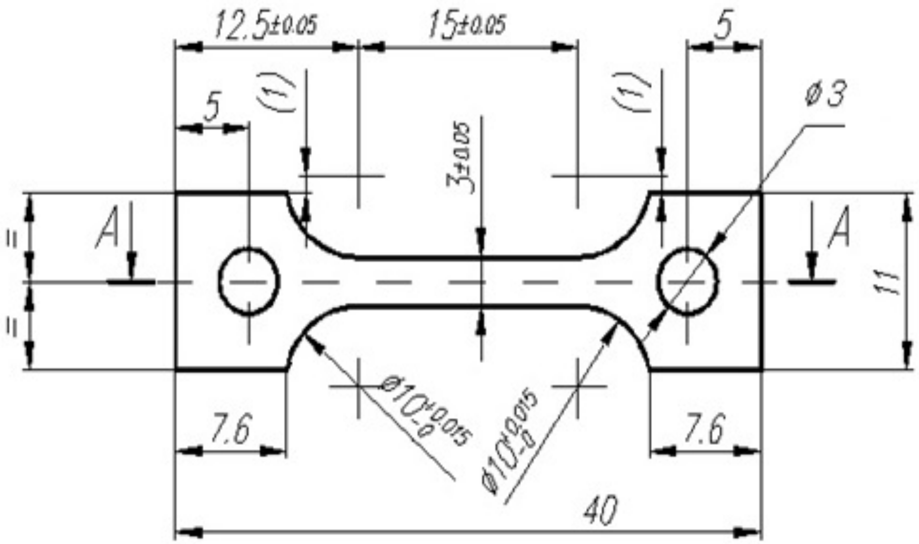


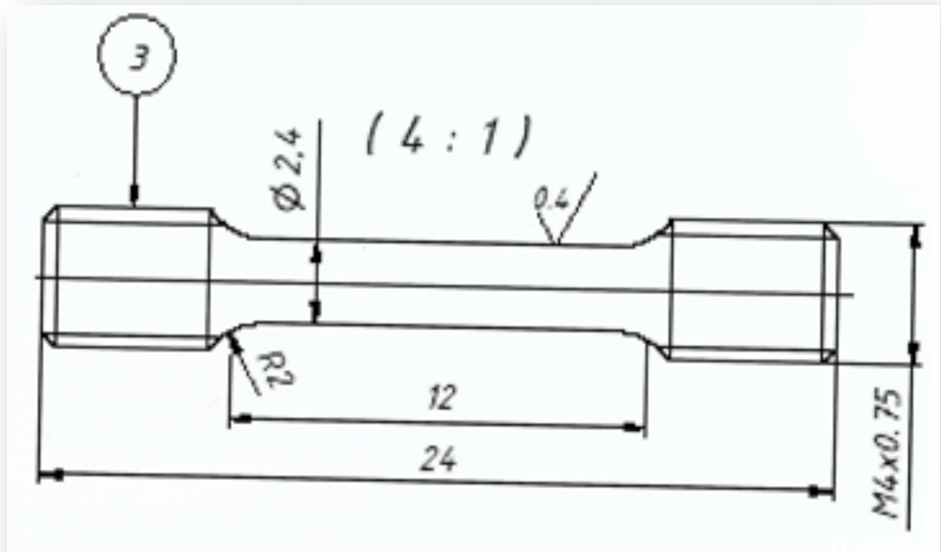


Experimental set-up

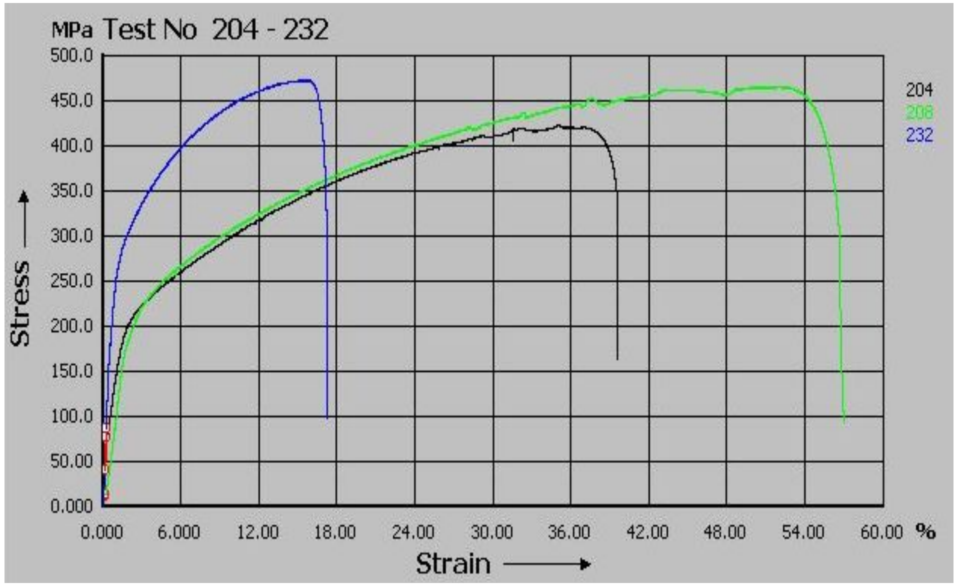
The characteristics of the preliminary tensile tests:

- small size flat and cylindrical 316L steel tensile specimens;
- in liquid lead at 400^0C, 450^0C and 500^0C;
- a constant strain rate of $5 \cdot 10^{-5} s^{-1}$ was applied.

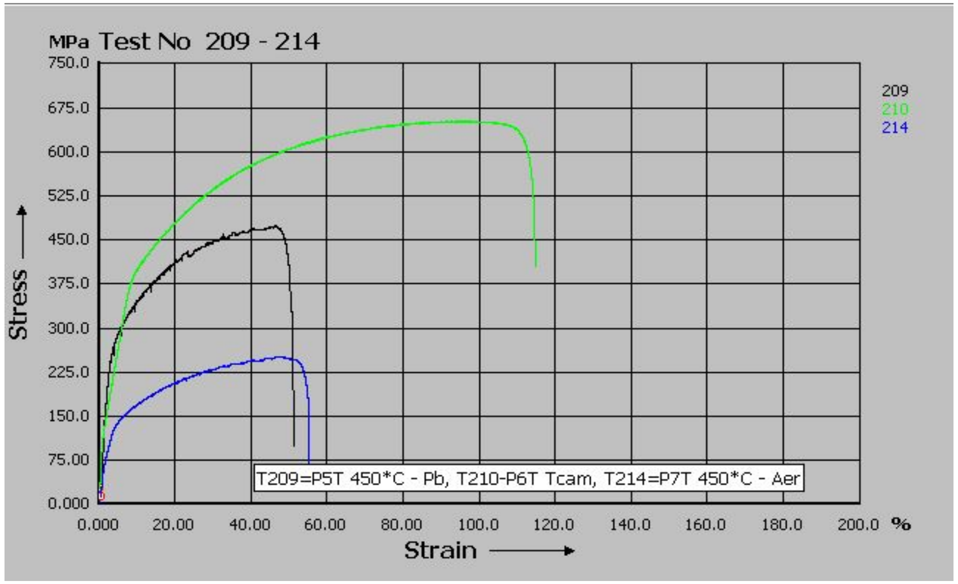




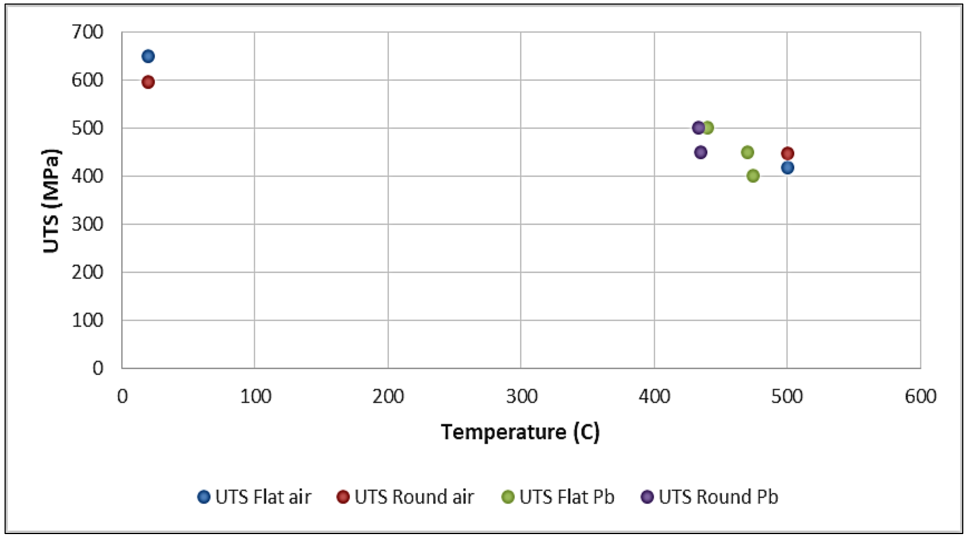
Results and discussion (1/2)



*Tensile test diagram on flat specimen in **liquid lead***
(204 at 500°C, 208 at 450°C, 232 at 400°C)

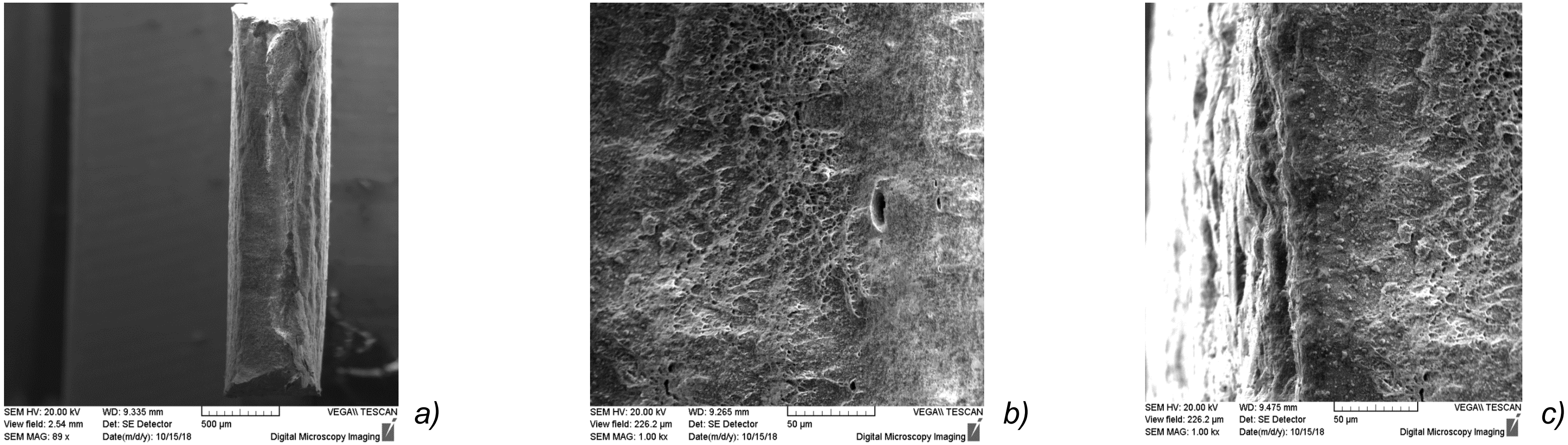


*Tensile test diagram on cylindrical specimen in **liquid lead***
*(209 at 450°C) and in **air** (Test 210 at RT, Test 214 at 450^{0}C)*

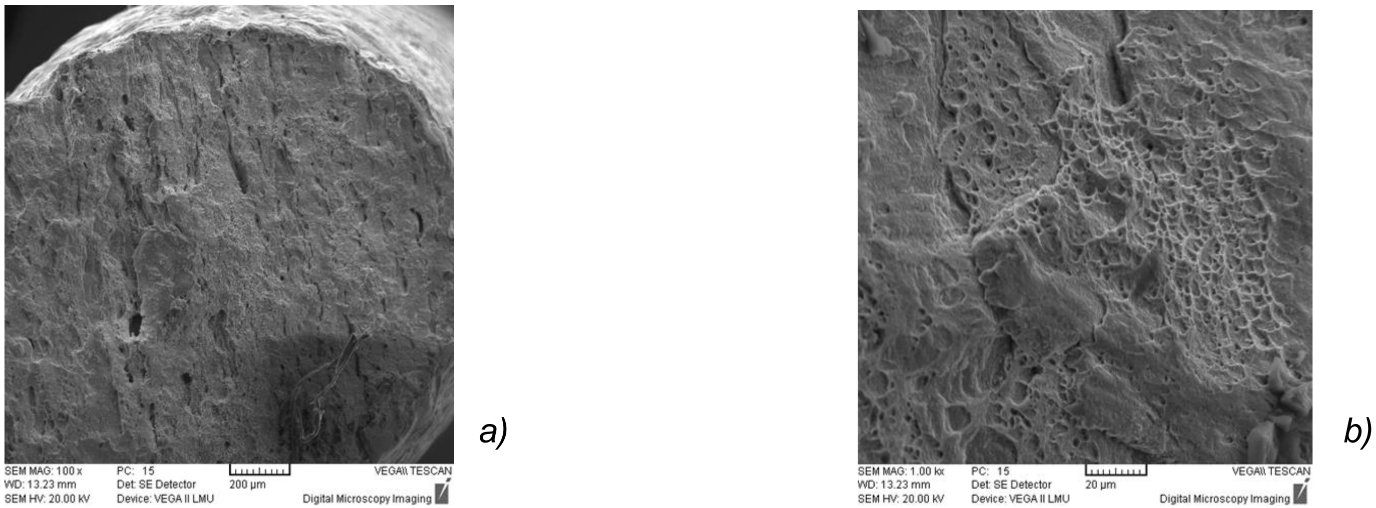


Values of UTS in liquid lead environment and air

Results and discussion (2/2)



SEM aspects of 316L flat specimen fracture surfaces tested at 400⁰C: a) x100 magnification; b) x1000 magnification; c) x1000 magnification



SEM aspects of 316L cylindrical specimen fracture surfaces tested at 450⁰C: a) x100 magnification; b) x1000 magnification

Conclusions on the preliminary tests

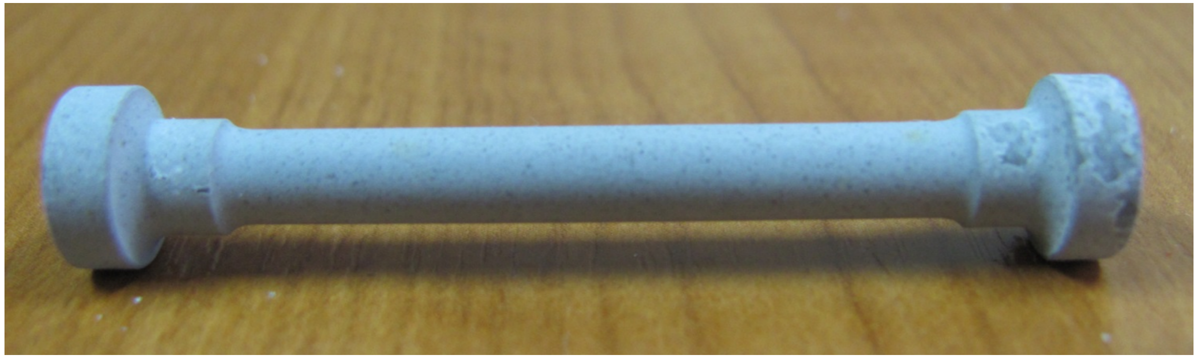
At this early stage, *the LILETIN facility is able to perform tensile tests in the liquid metal crucible configuration, with temperatures up to 500^{0}C in static lead conditions, and without any oxygen monitoring system.*

Few conclusions from works performed on the 316L steel specimens tested in the liquid lead environment at different temperatures are:

- *In order to examine the mechanical properties of the 316L steel tested in the liquid lead environment, the specimens are tested under tensile loading at a constant strain rate of 5x10^{-5} s^{-1};*
- *SEM pictures highlight the ductile behavior of the fracture surface for the 316L material and it is observed that the rupture begins at the surface of the sample and evolves inwards;*
- *The results show the need to perform more tests in the liquid lead environment to establish the environment influences on the mechanical properties.*

Overview on the key aspects in the experimental tasks performed in FP7 MatISSE Project

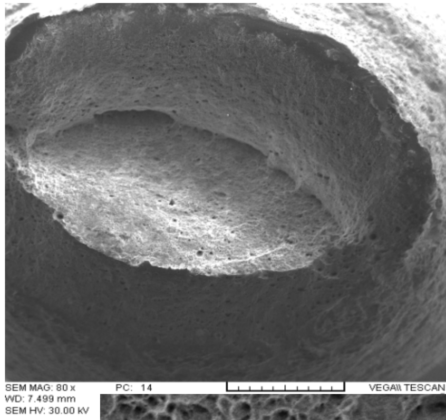
316L coated



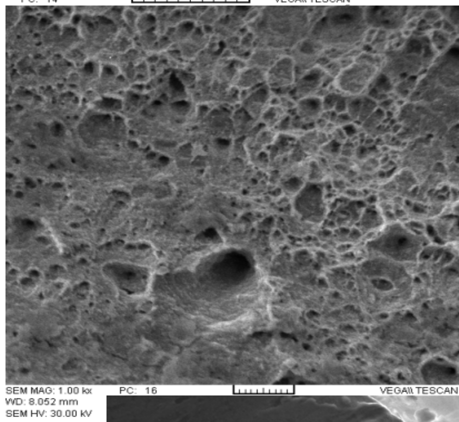
The stress-strain tensile curves for the coated 316L specimens

constant strain rate of $5 \cdot 10^{-5}\ s^{-1}$

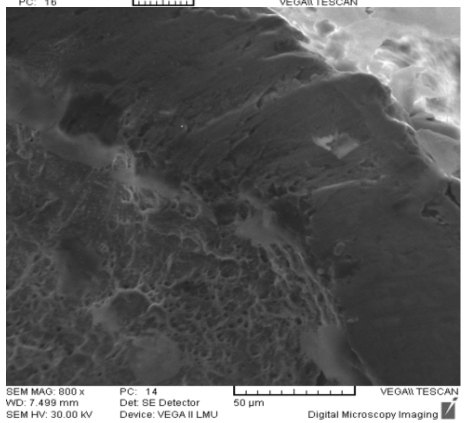
a)



b)

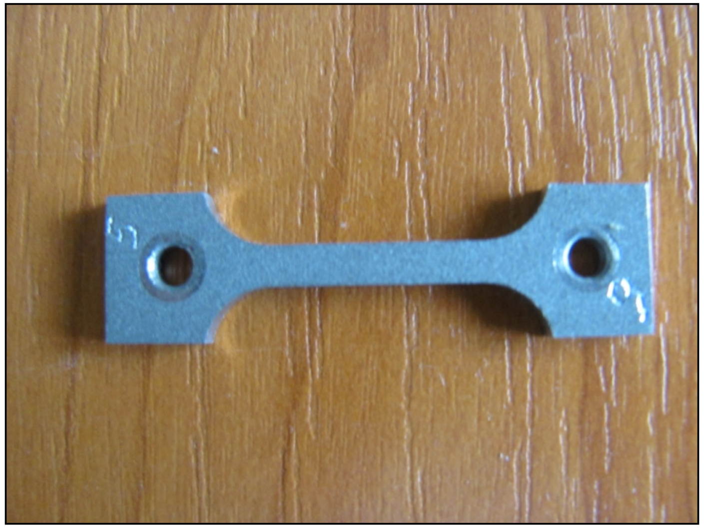


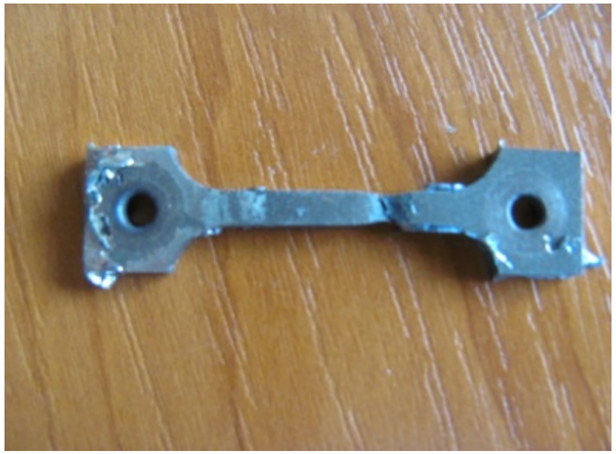
c)

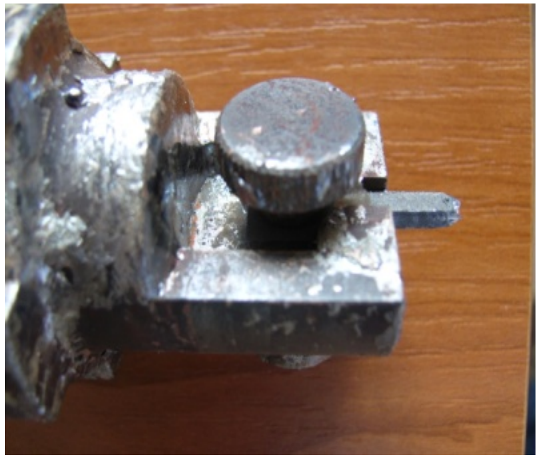


SEM aspects of tested specimen: a) fracture surface (x80), b) base material (x1000), c) the coating layer (x800)

T91 coated

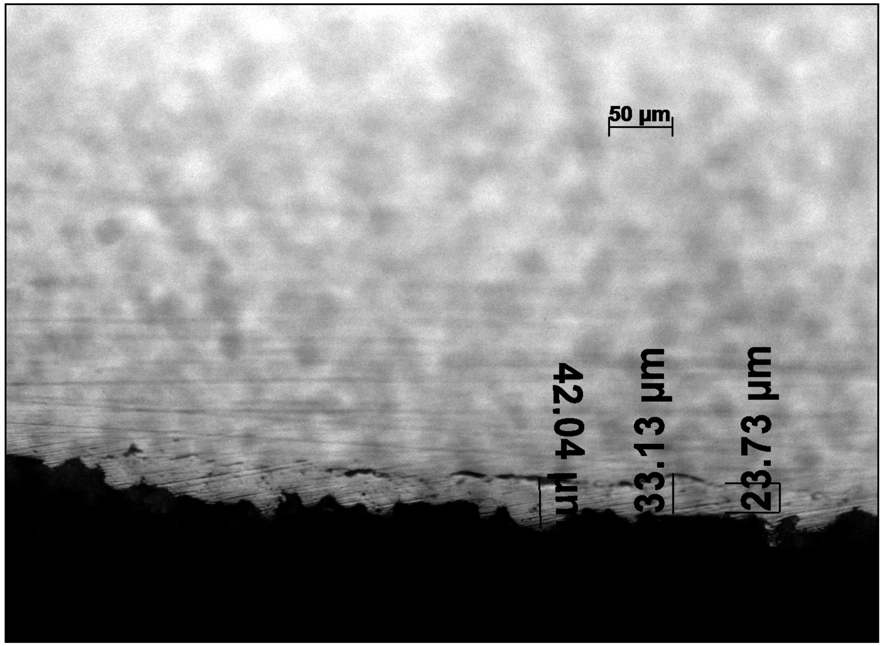






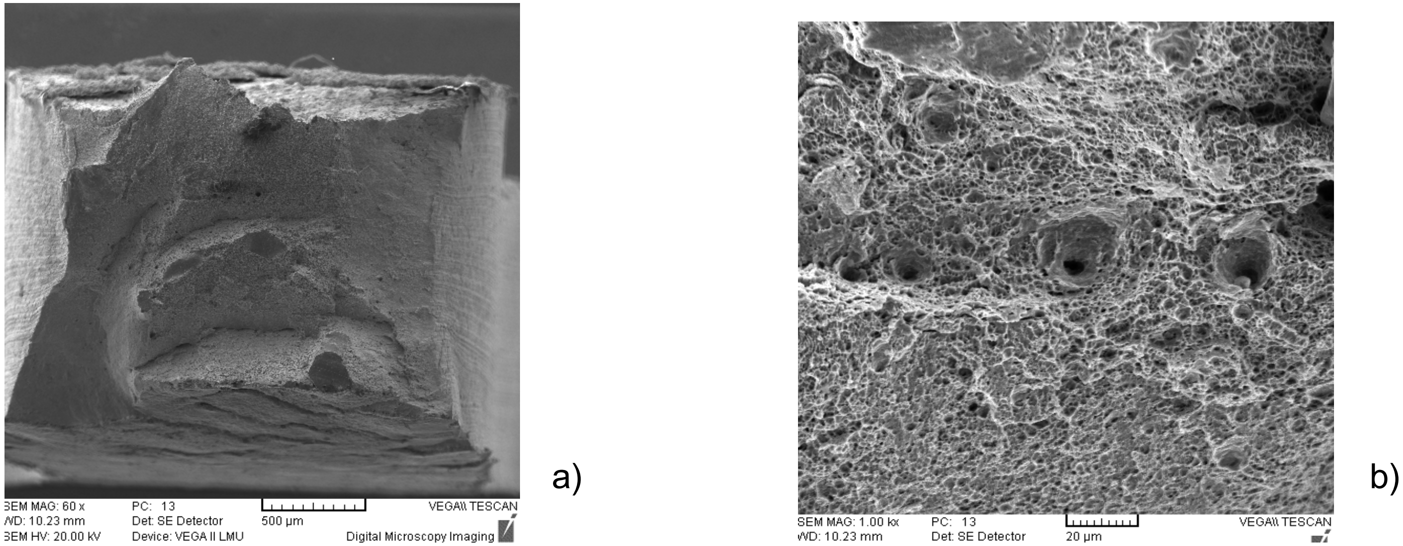
Aspect of specimens extracted from the testing crucible

The stress-strain tensile curves for coated T91 specimens

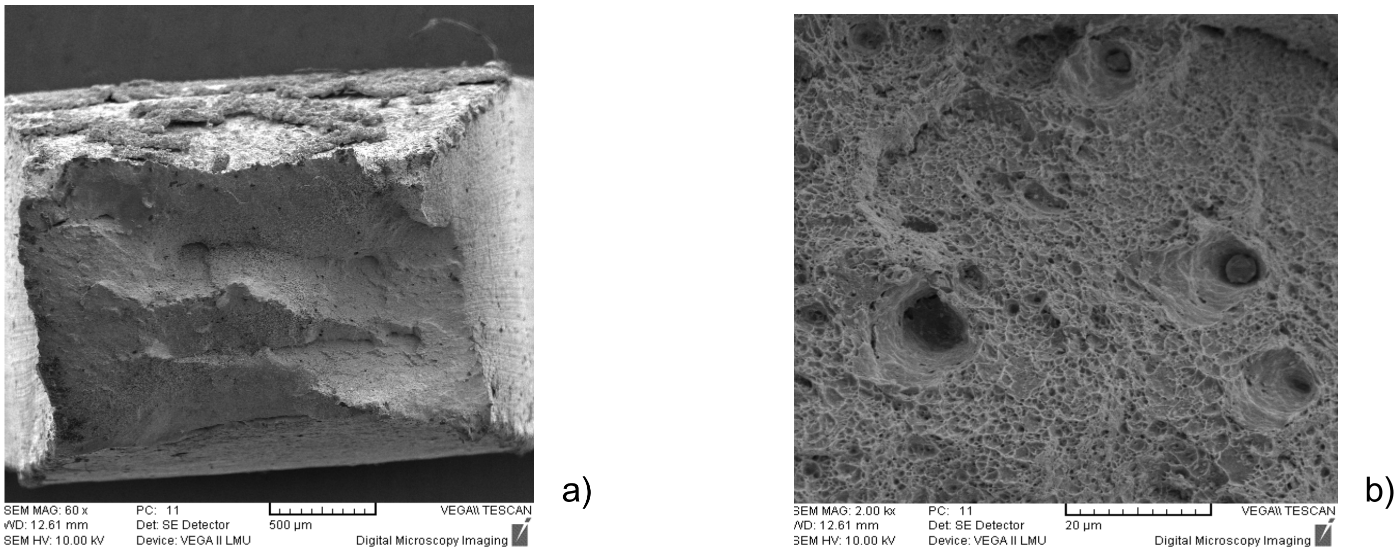


Metallographic aspect of coating layer

constant strain rate of $5 \cdot 10^{-5}\ s^{-1}$



SEM aspects of tested specimen #2: a)fracture surface (x60), b) base material (x1000)



SEM aspects of tested specimen #3: a) fracture surface (x60), b) base material (x2000)

Good points and Issues

The good points for LILETIN facility:

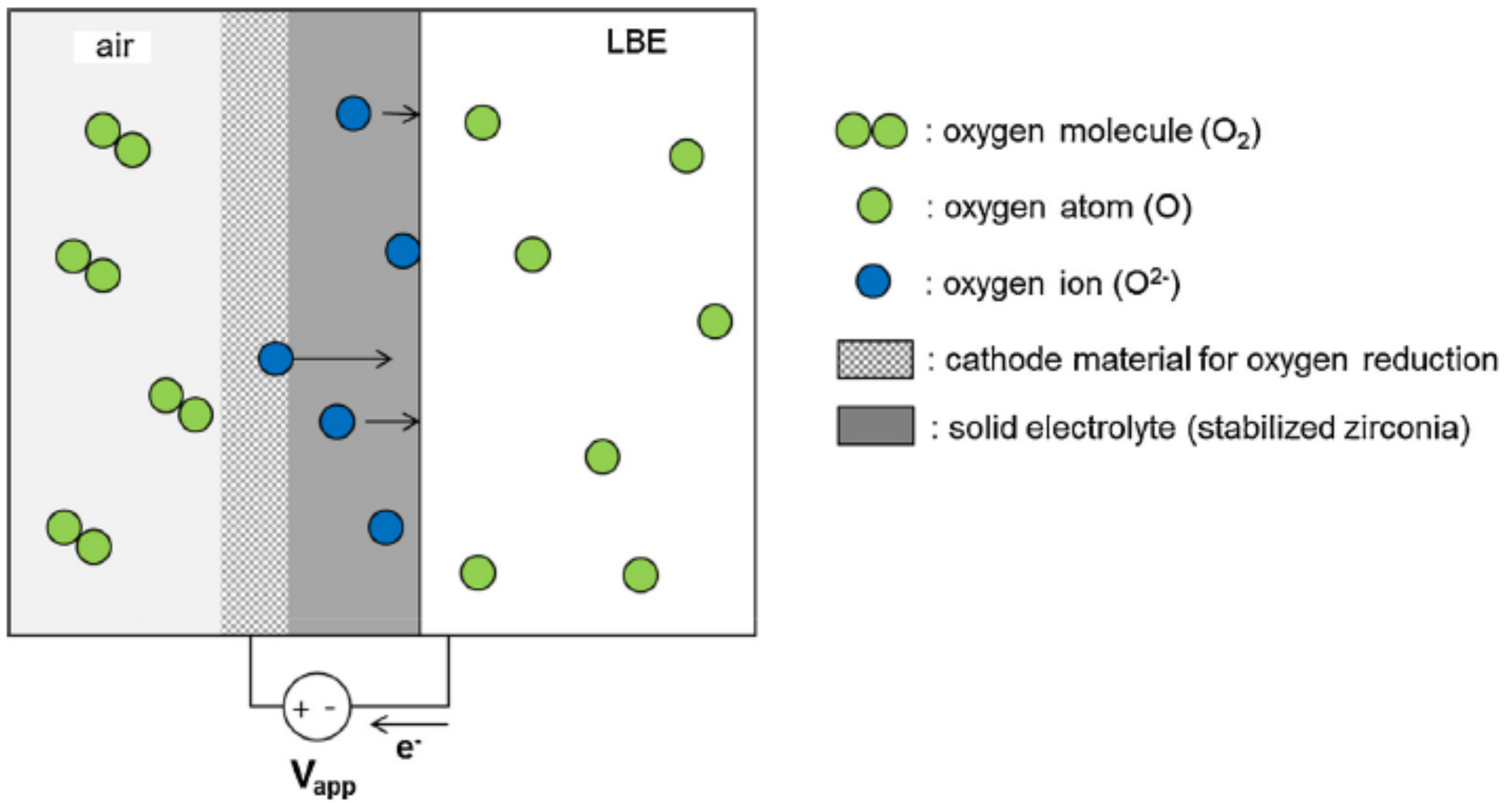
- The use of the facility is relatively easy for the operator;
- The ultimate tensile strength (UTS) can be precisely determined;
- For the tests performed under the same conditions, the reproducible results are obtained;

The issues need to be solved:

- ✓ Because of the time interval to achieve the testing temperatures above 450°C, it is necessary to reduce the loss of heat through the facility components;
- ✓ Because is not possible to use the normal extensometers for measurements in the liquid lead, it is necessary to find a practical solution to measure the sample elongation during the tensile tests.
- ✓ *The system for the measuring and controlling the concentration of oxygen in the liquid lead is under development*.

Planned works (1/2)

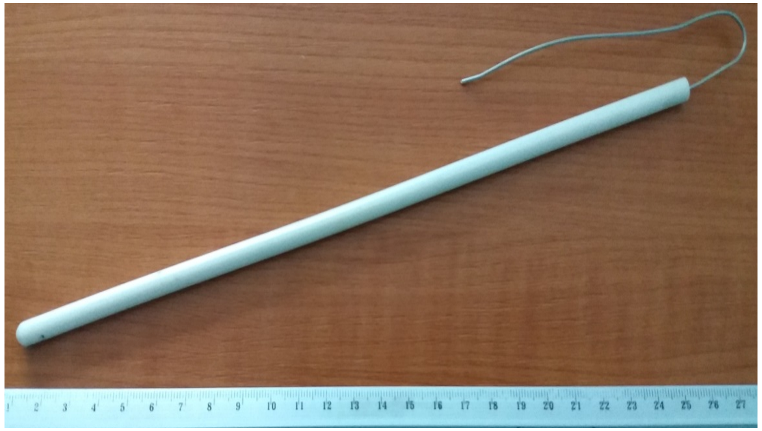
Working priciple of an electrochemical oxygen pump*



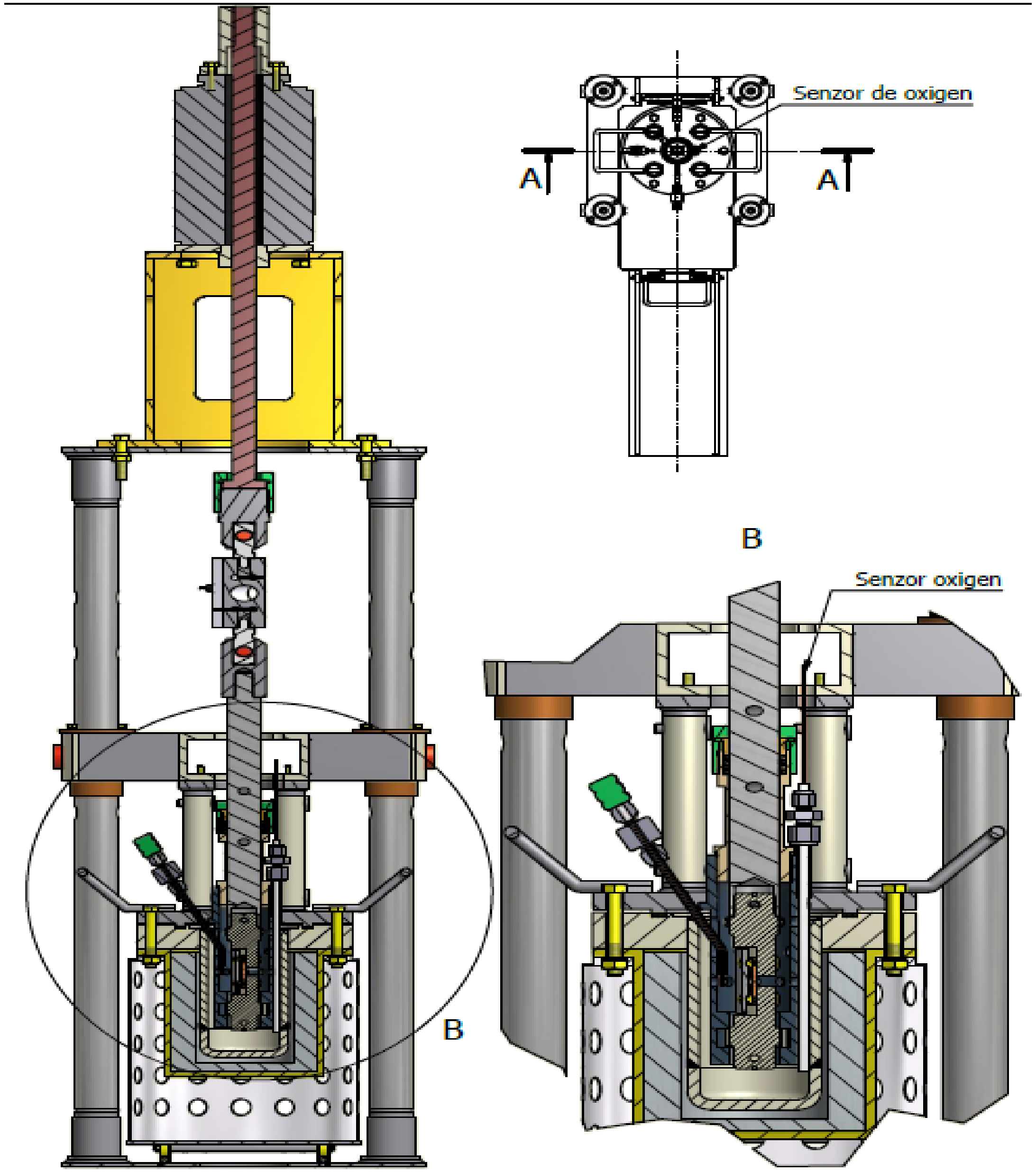
*J. Lim et all, Control of dissolved oxygen in liquid LBE by electrochemical oxygen pumping, Sensors and Actuators B 204 (2014) 388-392

Planned works (2/2)

Facility upgrade by including an oxygen sensor



YPSZ – yttria partially stabilized zirconia
Lenght – 250mm
Outer diameter – 6,15mm



Thank you for your attention!

alexandru.nitu@nuclear.ro