Recent Development of Pyrochemical Processing and Metal Fuel Cycle Technology in CRIEPI

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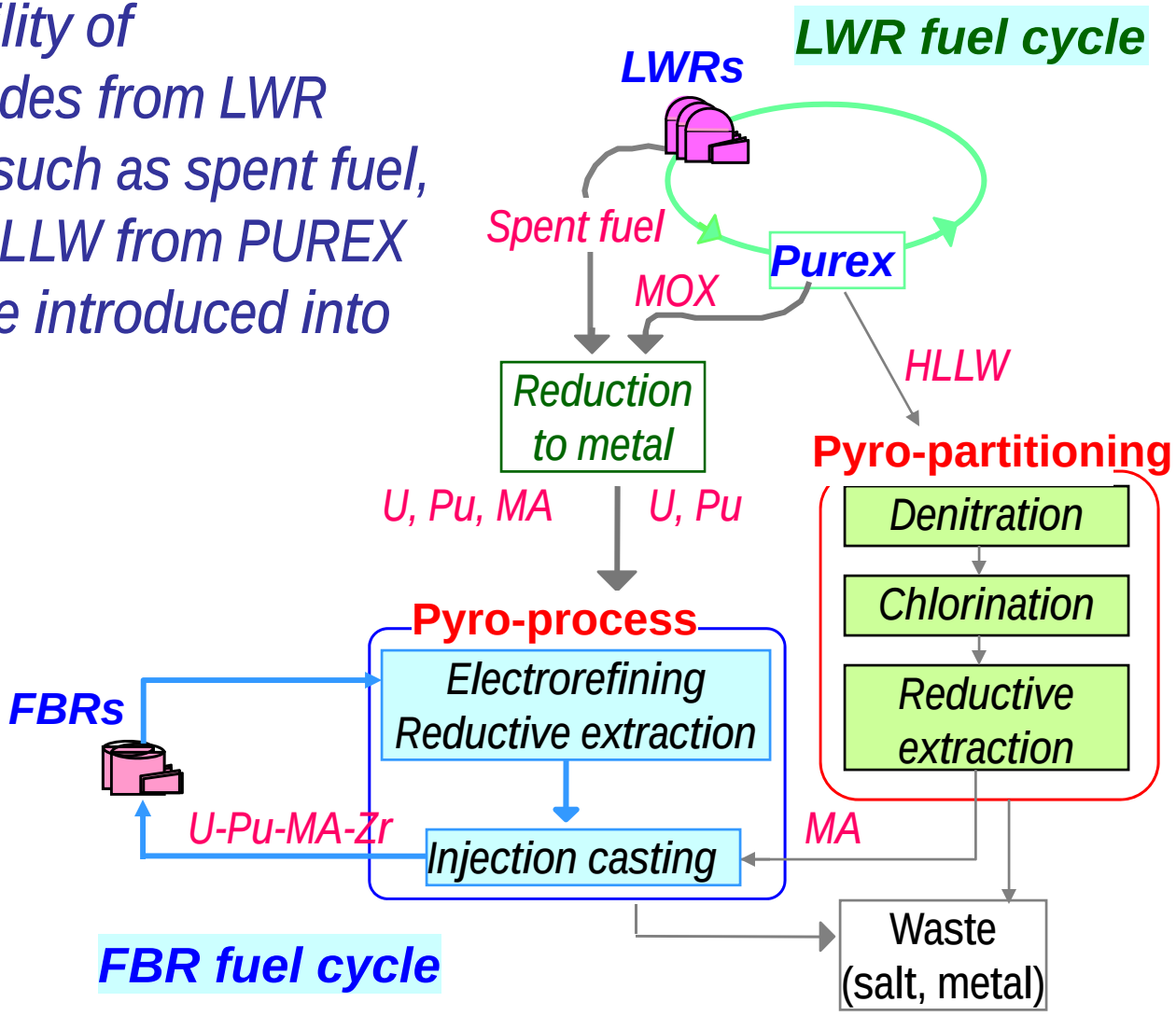
Metal Fuel & Pyroprocess Characteristics

- ***Metal fuel enhances the performance of SFR core, e.g. a higher breeding ratio, less fissile inventory, higher fuel burn-up.***
- ***The nature of metal fuel enables to employ pyrometallurgical reprocessing which has an intrinsic proliferation-resistant feature due to inherent difficulty of extracting weapon-usable Pu.***
- ***Long-lived transuranium elements are recovered together with Pu in electrorefining step, and are served for fuel fabrication to be transmuted in the fast reactor. Reduction of waste heat load will reduce disposal site area.***
- ***Combination of the pyrometallurgical reprocessing and the injection fuel casting offers substantial reduction of fuel cycle cost compared with the conventional aqueous reprocessing - pellet fabrication system.***

CRIEPI's Fuel Cycle Concept

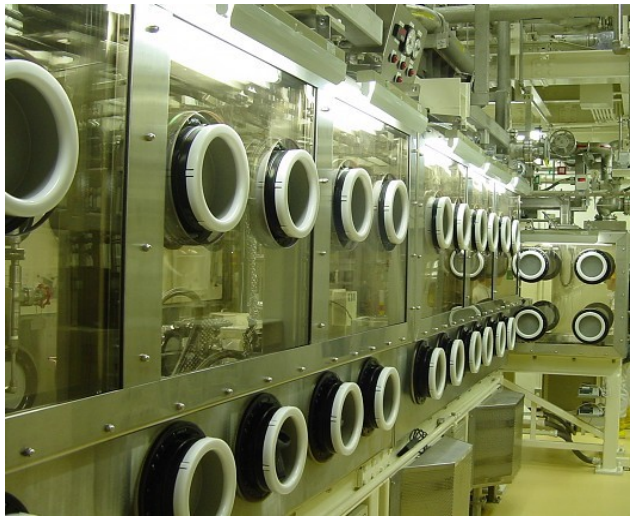
Applying the flexibility of pyroprocess, actinides from LWR fuel cycle streams such as spent fuel, MOX powder and HLLW from PUREX reprocessing will be introduced into fast reactor cycle.



1. Development of Metal Fuel Cycle Technology

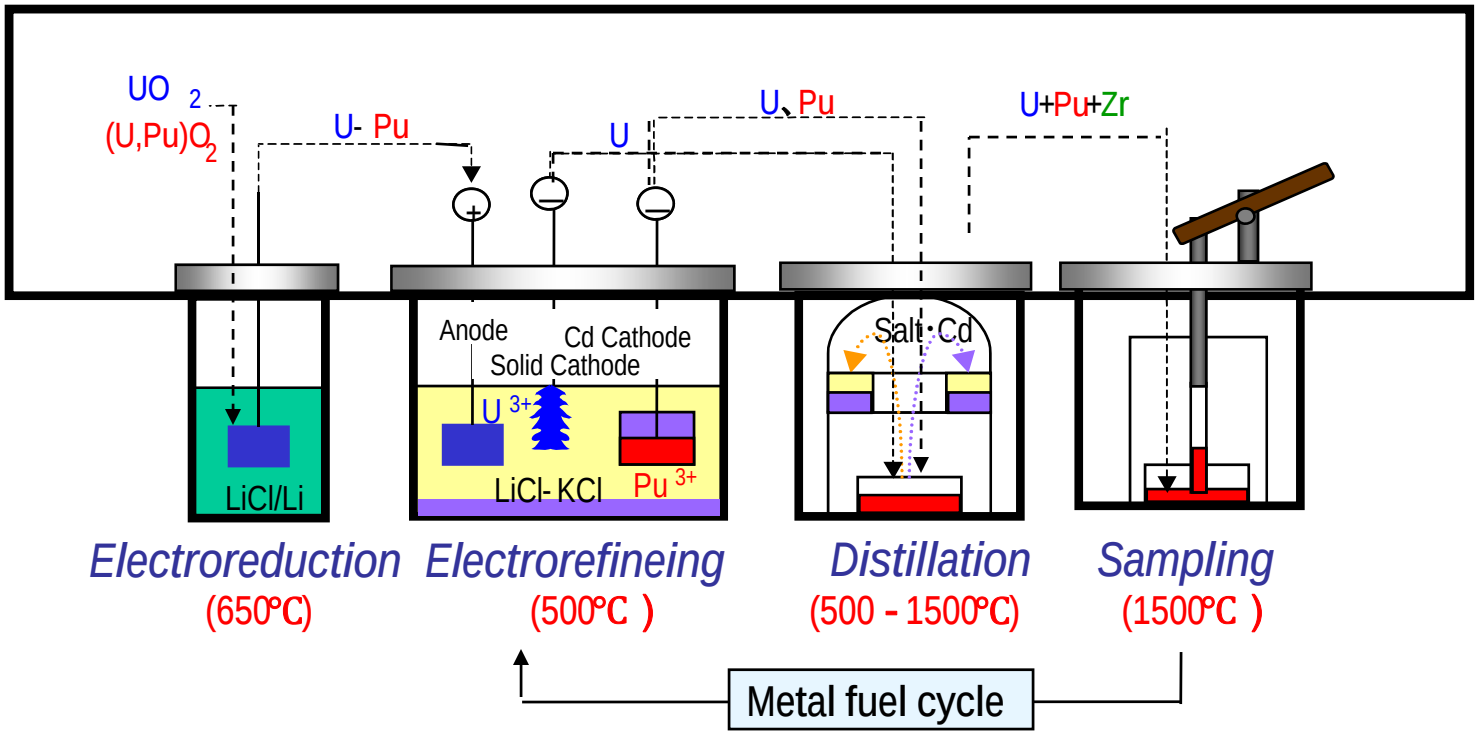
Pyroprocess Development with Un-irradiated Fuels

(CRIEPI /JAEA joint program)



Integrated tests with cold U,Pu for metal and oxide fuel reprocessing

Process Optimization for high recovery ratio



Pyroprocess Development with Irradiated Fuels

(CRIEPI / JRC-ITU joint program)

Ar atmosphere Hot Cell dedicated for pyroprocess installed in JRC-ITU.

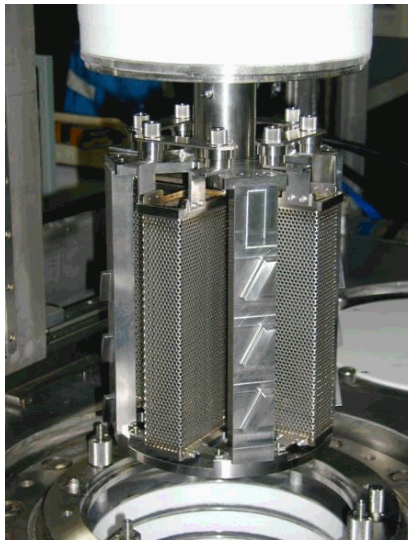
- ✓*Electroreduction test of irradiated oxide fuel*
- ✓*Electrorefining test of U-Pu-Zr fuel irradiated at Phenix*

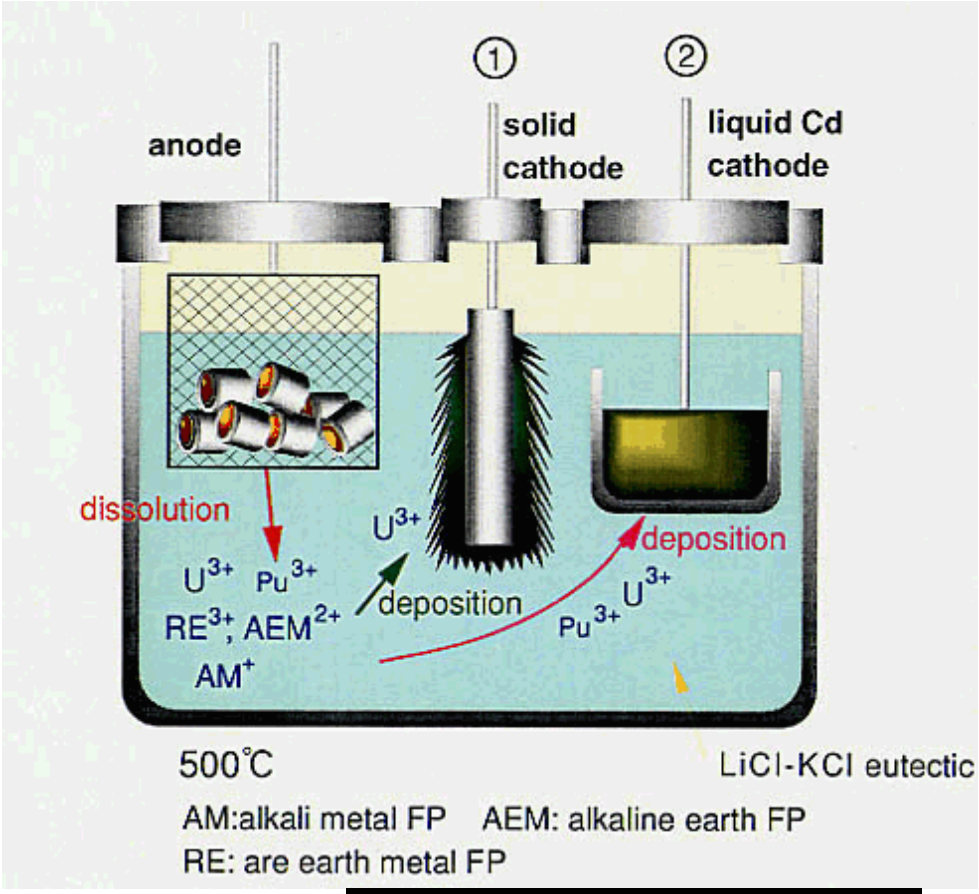
⇒ *Material Balances of actinides and FPs*

Process Equipments Development / Electrorefiner

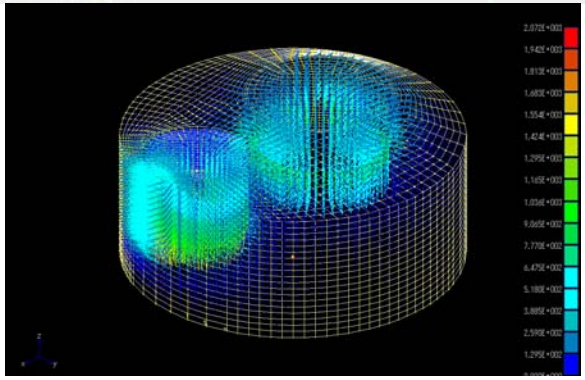
Anode/solid cathode

Test with U





Calculation for scale-up



Liquid Cd cathode

Test with simulants

Metal Fuel Development – JOYO Irradiation Program

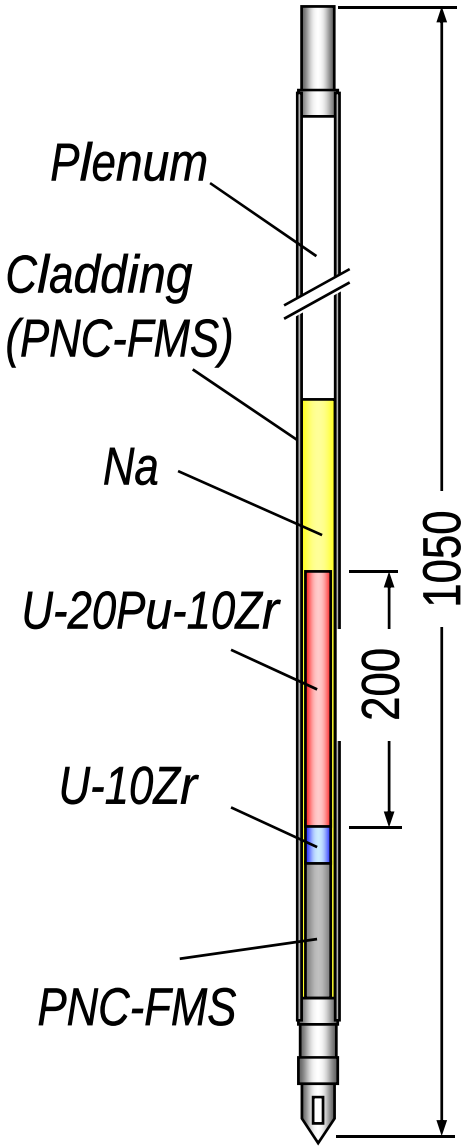
(CRIEPI /JAEA joint program)

➢ *Test fuel pins & objectives*

✓ *Total 6 test pins will be fabricated and irradiated.*

Smear density	Peak clad. temp.	Peak burnup	Objective
77%	640℃	3 at.%	To confirm no liquefaction at ~650C at the fuel-clad. interface
74%			
77%	620℃	8 at.%	To obtain FCCI data at a high clad. temp. >600 C
74 %			
77%	610℃	15 at.%	To obtain FCMI data at a high burnup >15at.%
74%			

✓ *Linear power rate: ~500 W/cm*



Metal Fuel Development – Fuel Fabrication for JOYO

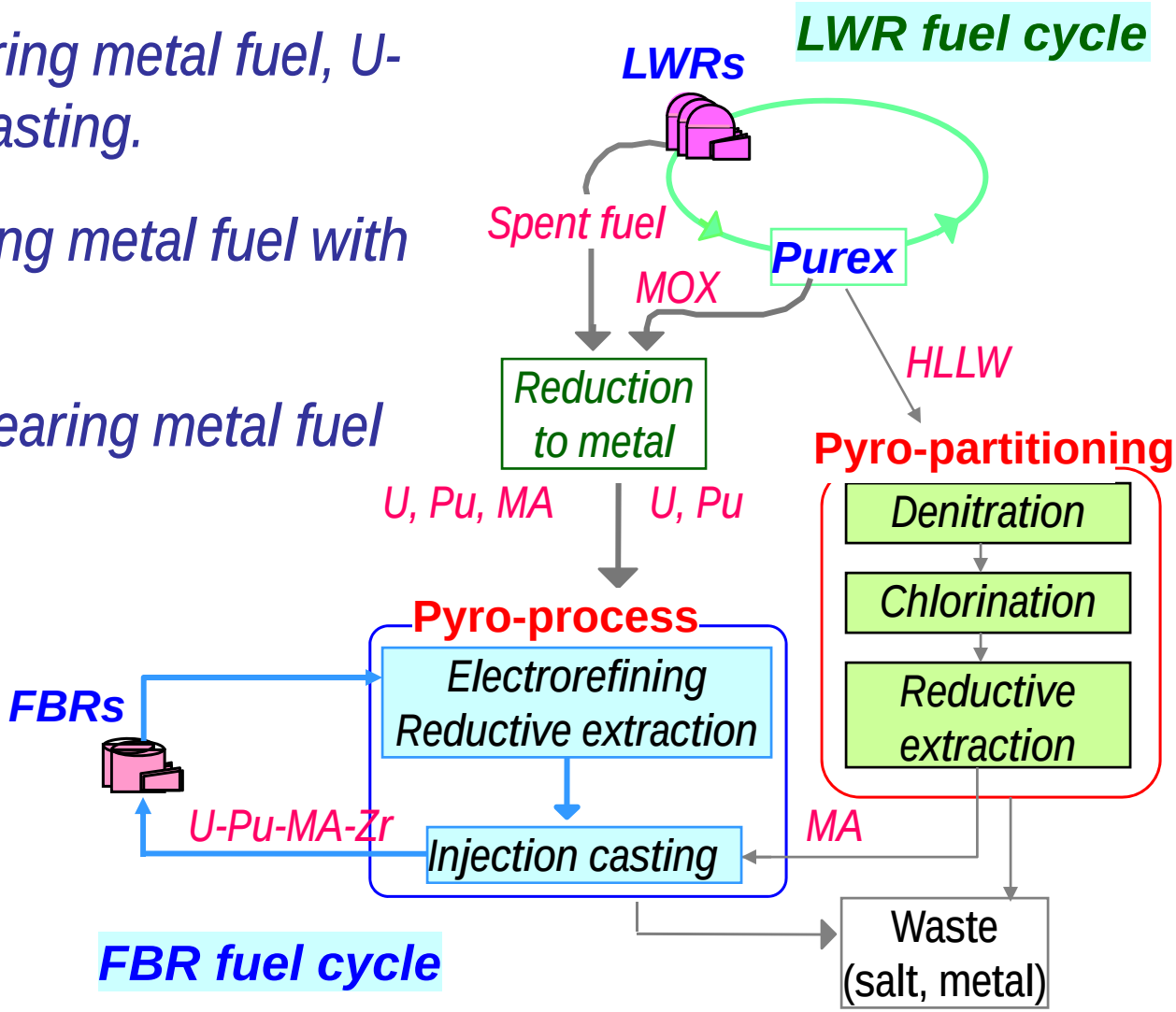
(CRIEPI /JAEA joint program)

- ***The fuel pin design has been completed and approved by the regulatory authority.***
- ***Fabrication of 6 Metal Fuel pins are underway for JOYO irradiation test.***
- ***U-Pu metal was prepared by electroreduction of MOX, and injection casted with Zr and U.***

2. Partitioning & Transmutation Study

Pyro-partitioning Process & Transmutation

- ✓MAs recovery from HLLW of purex process by pyro-partitioning.
- ✓Fabrication of MA bearing metal fuel, U-Pu-MA-Zr, by injection casting.
- ✓Irradiation of MA bearing metal fuel with Fast Reactor.
- ✓Reprocessing of MA bearing metal fuel by pyro-processing.

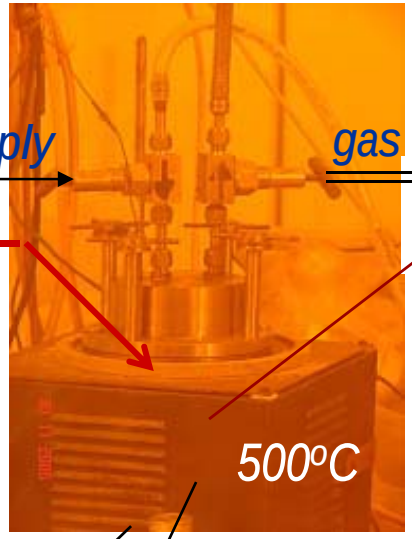


Denitration Test of Real HLLW

(CRIEPI / JRC-ITU joint program)

- 520 g of TRU concentrated real HLLW was heated at 500°C under air flow.
-Volatile material and NOx were trapped at scrubbers

Calcinated products (7.3 g)



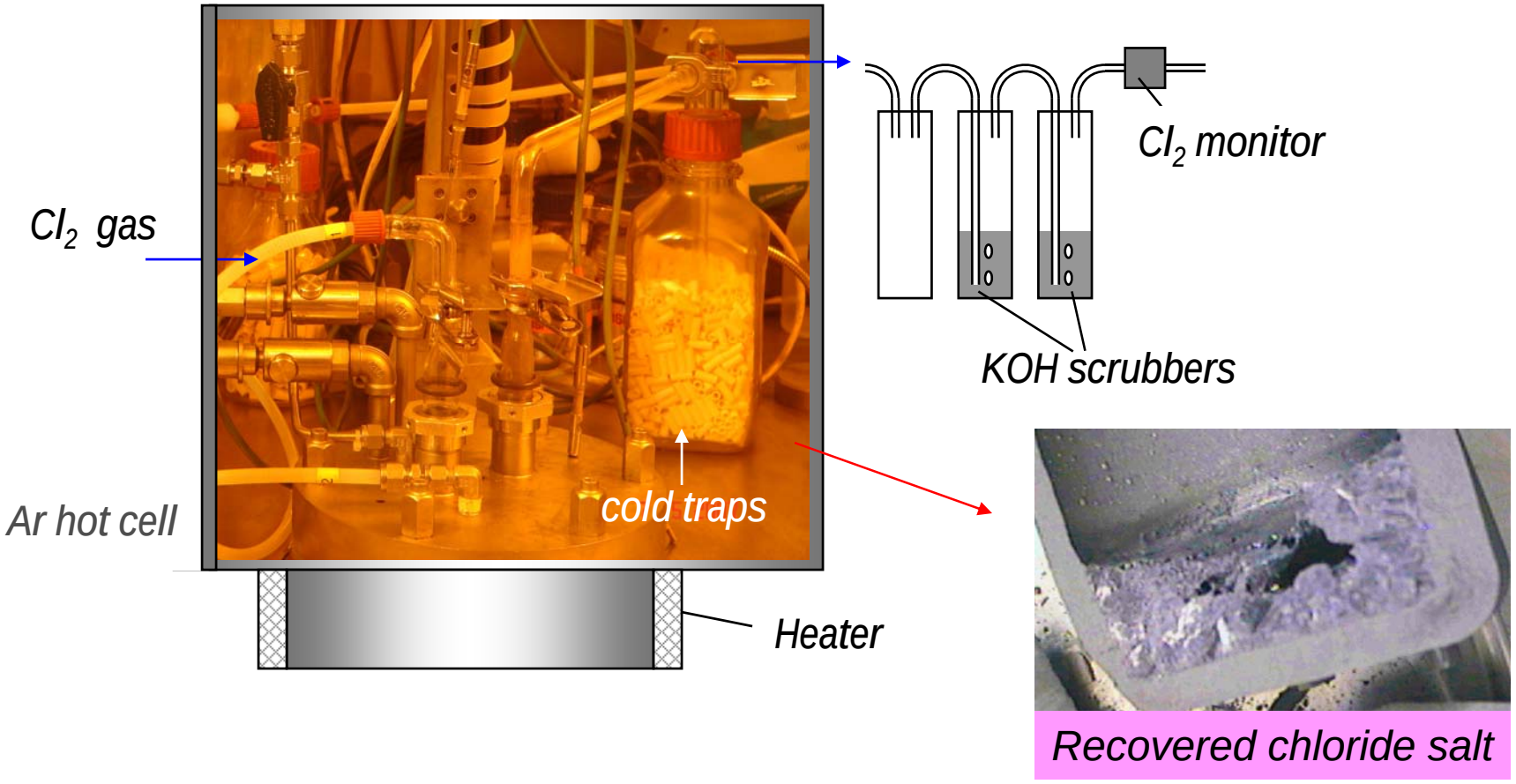
520g of HLLW
U: 8400 µg/g
TRU: 600 µg/g
FP: 2000 µg/g

Only 0.2 – 0.3 % of Ru was detected

Chlorination Test of Denitration Products

(CRIEPI / JRC-ITU joint program)

- The denitration product (7.3g) was charged with 97.5g of LiCl-KCl salt in a graphite crucible.
- The crucible was heated at 650°C, and reacted with chlorine gas for 32.2 hours.

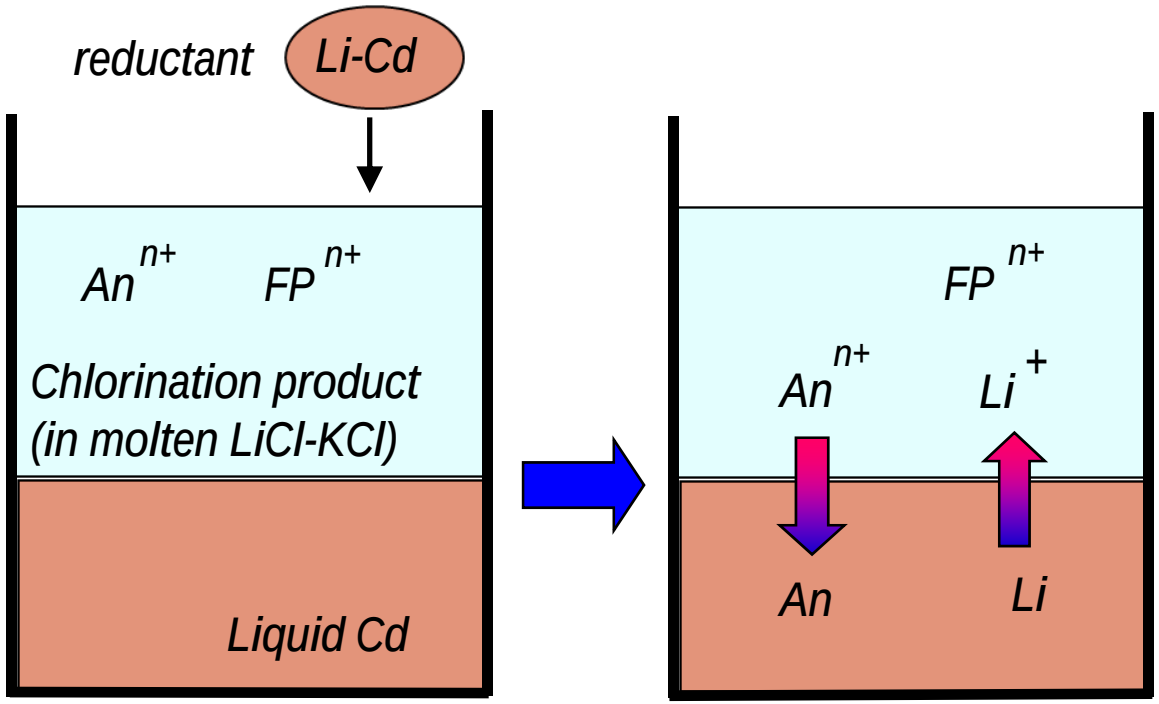


Recovered chloride salt

Analytical Results and Next Step

(CRIEPI / JRC-ITU joint program)

- The contents of actinide chlorides in LiCl-KCl were analysed for obtaining recovery ratios from the amounts in HLLW.
- The obtained recovery ratios of actinides as chlorides were 94 - 111%, respectively.
- The chloride is being contacted with liquid Cd-Li alloy for recovering actinides into liquid Cd phase.



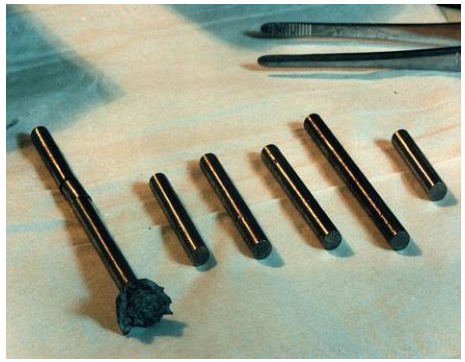
reductive extraction test crucible

Transmutation – Phenix Irradiation

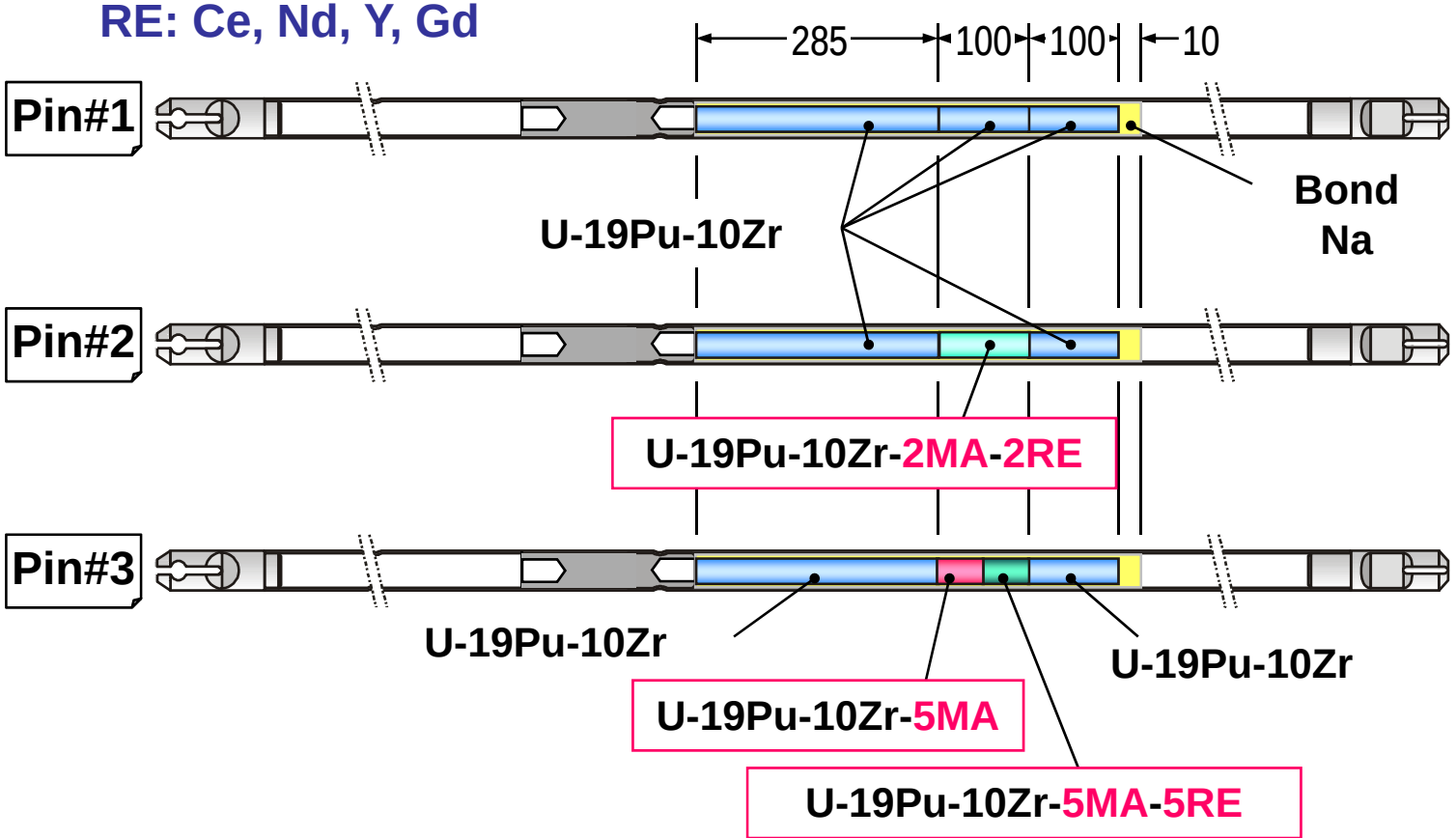
(CRIEPI / JRC-ITU joint program)

➢ Fabrication of fuel alloy rods

- ✓20 ~ 50 mm-long, 4.9 mm dia. fuel rods
- ✓U-Pu-Zr, U-Pu-Zr-MA, U-Pu-Zr-MA-RE
- ✓Arc melting and gravity casting at ITU

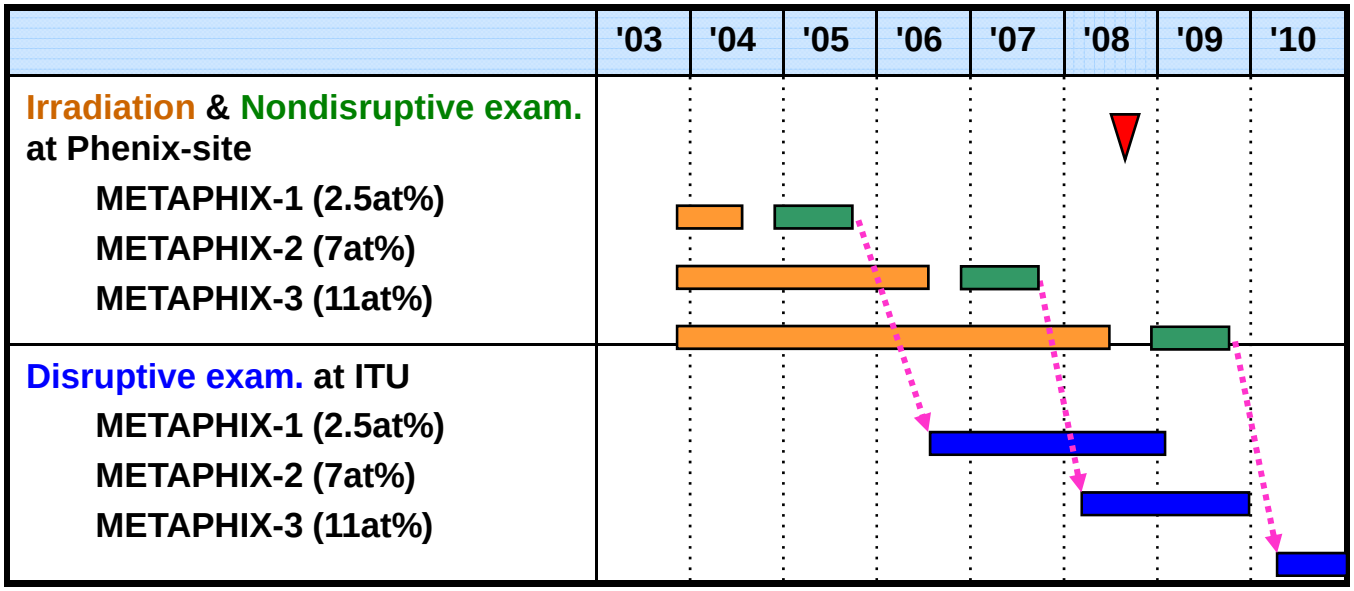


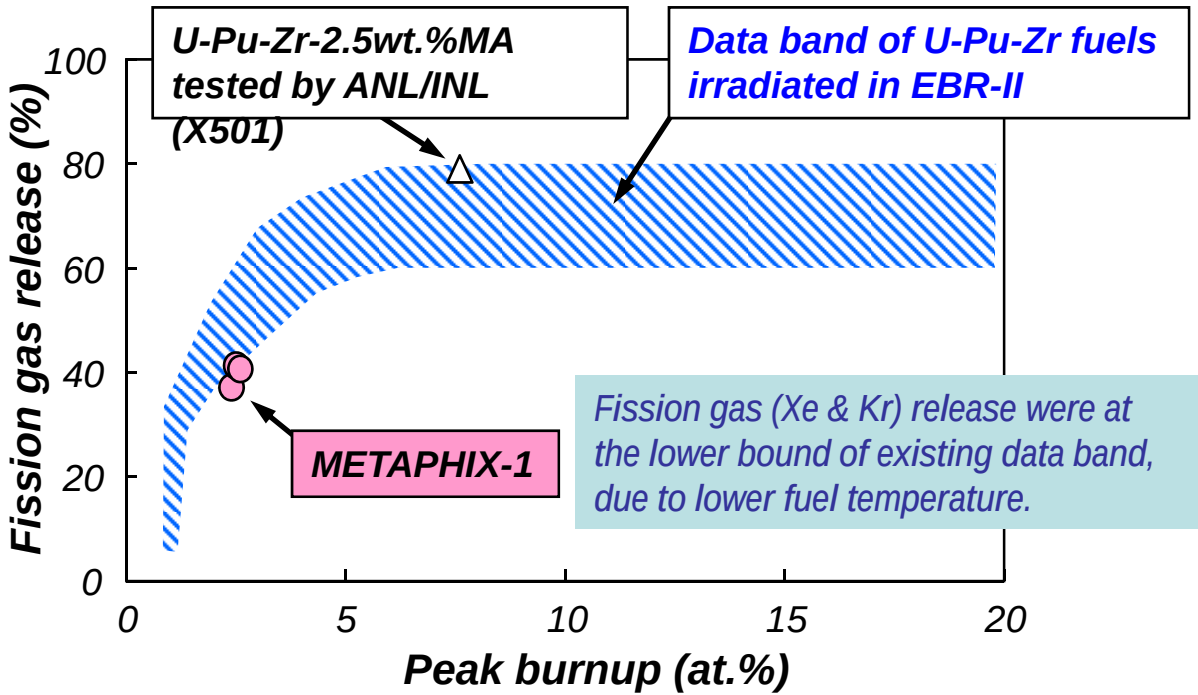
MA: Np, Am, Cm
RE: Ce, Nd, Y, Gd

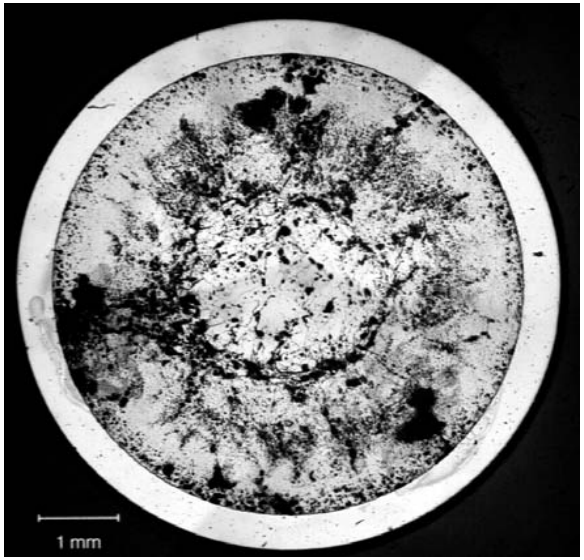


Transmutation – Phenix Post-Irradiation Exam.

(CRIEPI /JRC-ITU joint program)







Cross section of Pin#3, U-19wt.%Pu-10wt.%Zr-5wt.%MA

Summary and Future Work

- *CRIEPI's current developments on pyrochemical processing and metal fuel cycle technology are summarized.*

- *As for FBR fuel cycle technology, engineering model of process equipments will be developed based on the detailed material balance obtained by hot examination.*

- *As for P&T study, tests of pyro-partitioning of actinides from real HLLW will be finished, and electrorefining of irradiated MA bearing metal fuel will be carried out.*