

Accident Tolerant Fuel R&D status in China

Nuclear Fuel R&D Center
China General Nuclear Power Corporation(CGN)

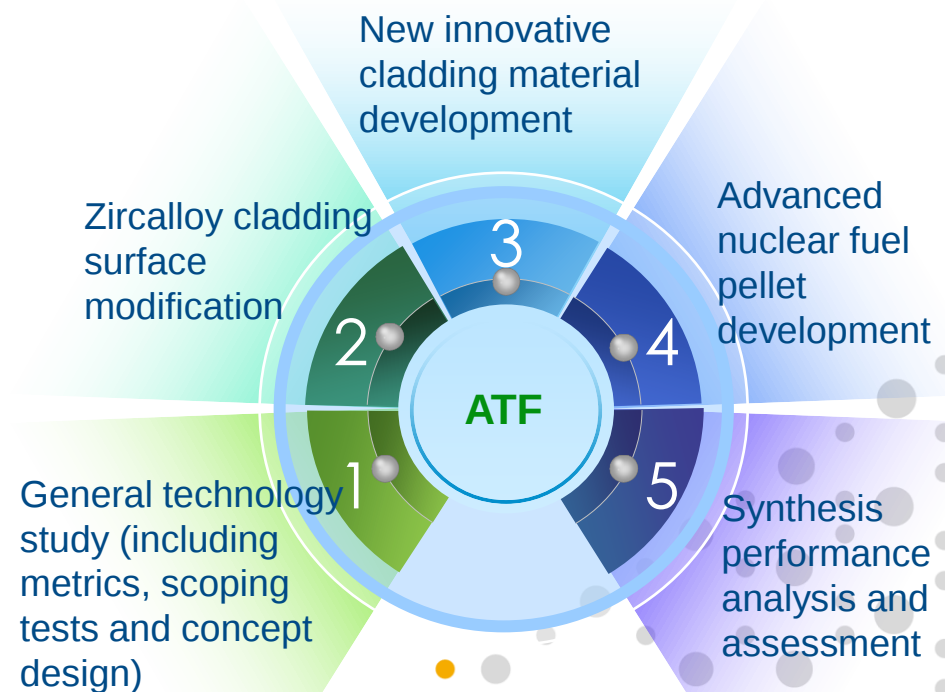
3-5 March, 2015
Third meeting of OECD/NEA EGATFL, Paris

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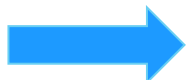
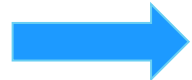
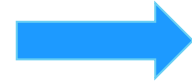
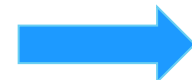
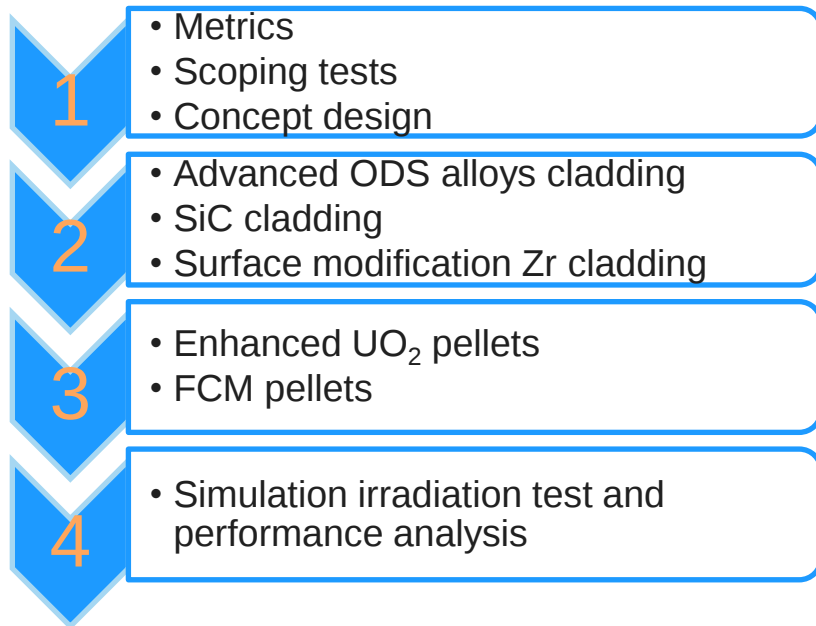
1. ATF development programs in China

- **Research on key technology of ATF, National Science and Technology Major Project, funded by Chinese government.**
 - Led by CGN, over 10 domestic organizations participate in.
 - Five sub-projects were included.



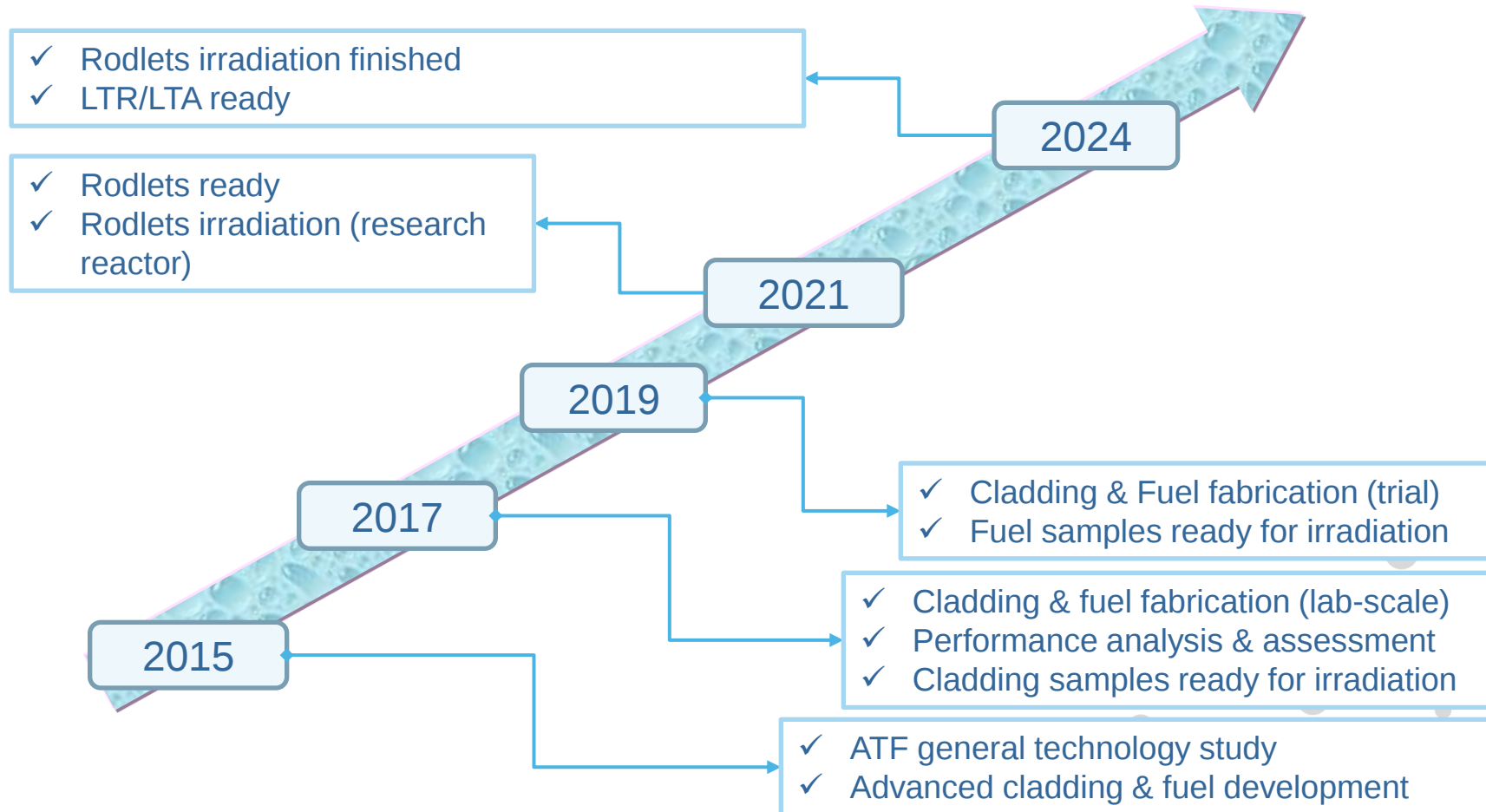
1. ATF development programs in China

- **Research on base properties of ATF**, *the Strategic Research Project of CGN*.
 - Financial supported by CGN, over 10 research group members in the project.
 - Four sub-projects are included.



1. ATF development programs in China

■ ATF R&D Strategy



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2. ATF research facilities in CGN

□ Research facilities of CGN



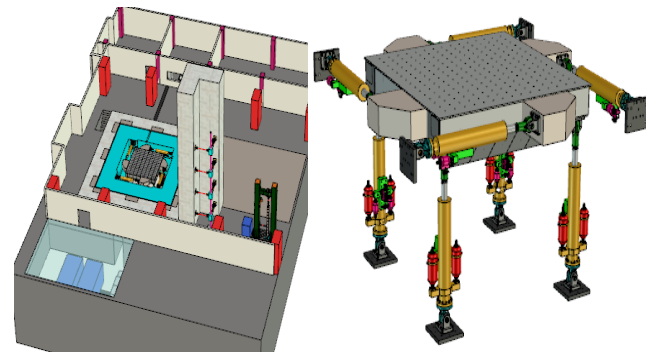
Large-scale Hydraulic Test Facility



Large thermal hydraulic test facility, LATHY



Integral Scale Hydraulic Test Facility, ISHY



Seismic Effect Test Facility

2. ATF research facilities in CGN

□ Research facilities of CGN



New fuel assembly mechanical and hydraulic test facilities



Material mechanical test machine



LOCA high temperature oxidation and quenching simulation test facility

2. ATF research facilities in CGN

□ Research facilities of CGN



Materials internal pressure creep and fatigue test facilities



SEM



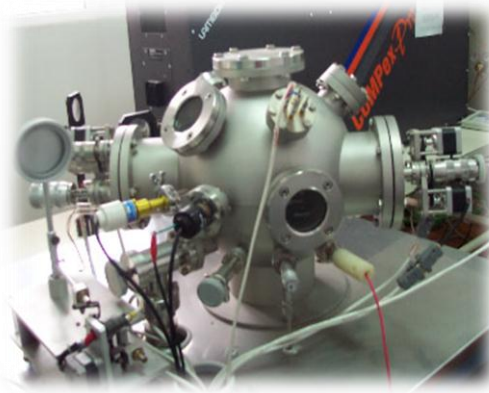
XRD

2. ATF research facilities in CGN

□ Research equipments of CGN-CAEP Joint Laboratory



FEI TITAN TEM



Pulsed laser sputtering deposit system



Ion beam deposit system

2. ATF research facilities in CGN

□ The new laboratory of CGN in Shenzhen is under construction

CGN would launch the experiments as following at the end of 2016:

Materials mechanical test

- strength, creep and fatigue

Materials corrosion test

- static and dynamic coolant corrosion

Materials oxidation test

- high temperature steam oxidation

LOCA simulating test

- high temperature steam oxidation and quenching

RIA simulating test

- high speed temperature and pressure increasing

Materials microstructure analyzing

- analysis with TEM, SEM and so on

Thermo physics property analyzing

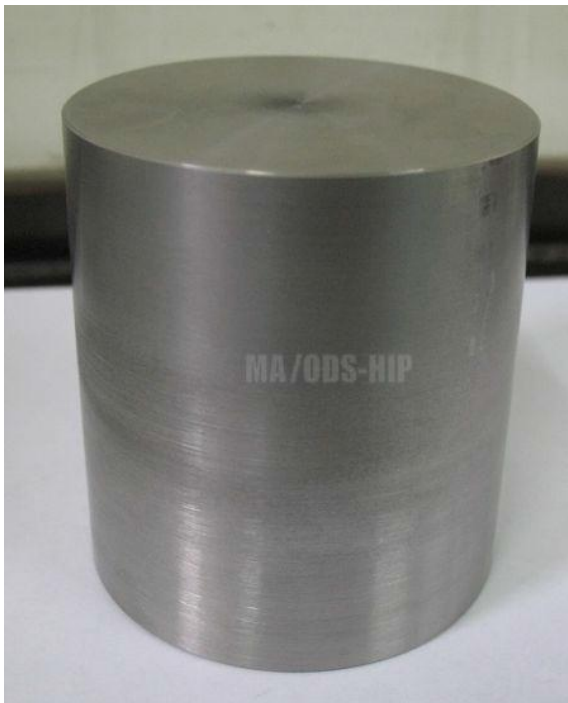
- thermal expansion, heat conductivity and so on

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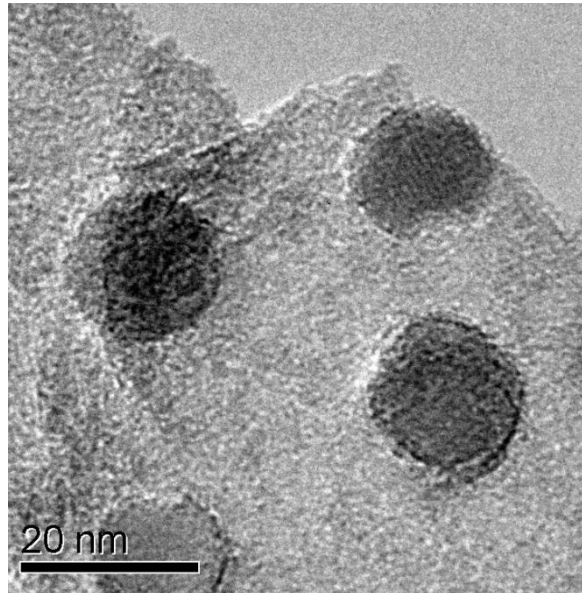
3. Updated research activities

□ ODS-FeCrAl cladding development



■ ODS steels ingot and tube fabricated in China

Supplied by University of Science and Technology Beijing



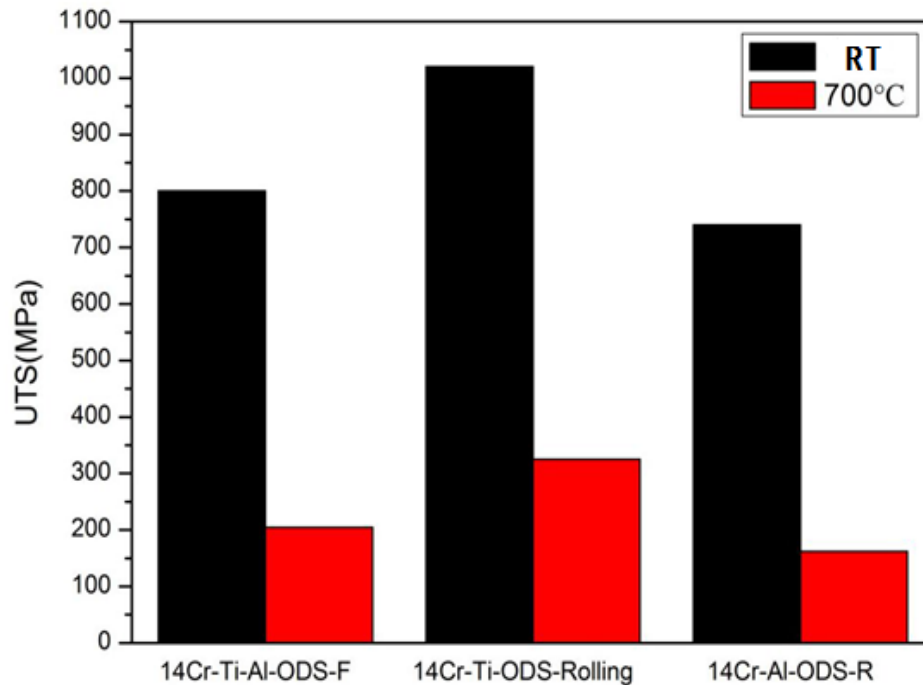
■ TEM photo of ODS steels microstructure

Supplied by University of Science and Technology Beijing

- The ODS-alloy powder is manufactured by mechanical alloying (MA)
- The ingot is manufactured by hot isostatic pressing

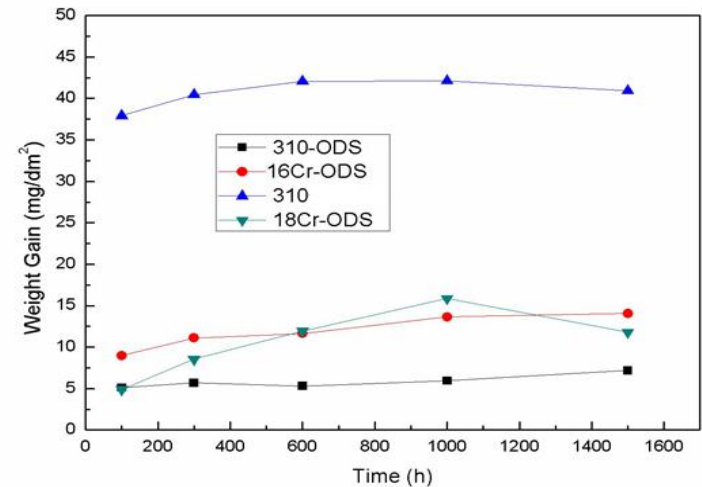
3. Updated research activities

□ ODS-FeCrAl cladding development



- The mechanical properties of ODS-FeCrAl at RT and 700°C

Supplied by University of Science and Technology Beijing



- The corrosion of ODS-steel and other steel in water, 600°C, 25MPa

Supplied by University of Science and Technology Beijing



- The corrosion samples of ODS-steel

Supplied by University of Science and Technology Beijing

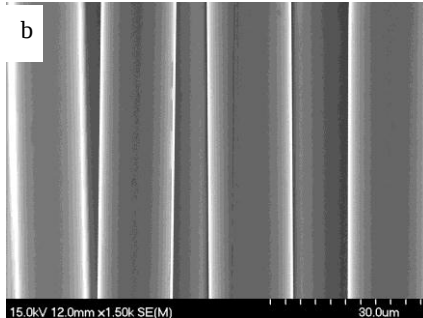
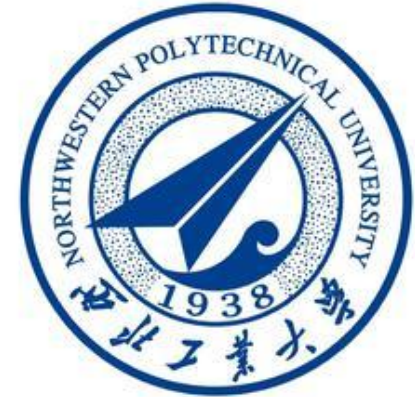
3. Updated research activities

□ SiC ceramic cladding development



■ SiC/SiC_f composite tube

Supplied by Northwestern Polytechnical University



■ SiC fibers

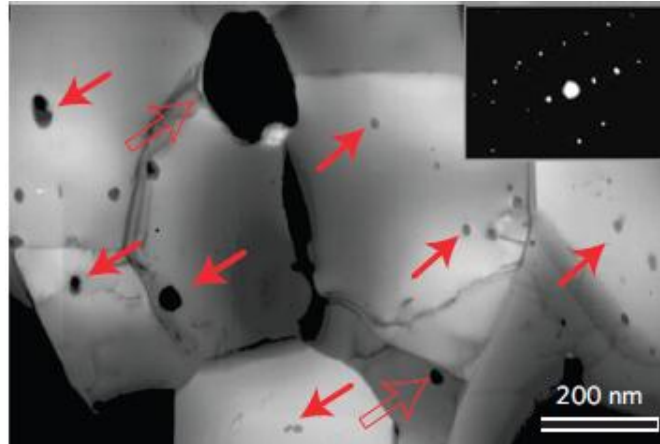
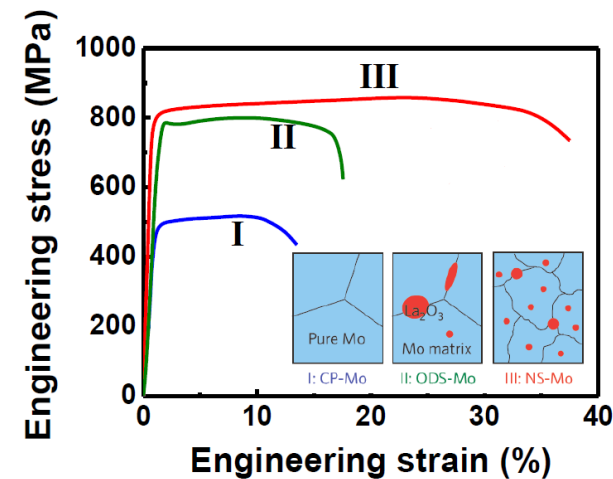
Supplied by Xiamen University



- Three layers SiC/SiC tube
- Inner tube is manufactured by CVD
- The fiber layer is densified by CVI

3. Updated research activities

Mo-alloy cladding development



- The microstructure and mechanical properties of NS-Mo

Supplied by Xi'an Jiaotong University

Alloys	Properties			
	Tensile strength (MPa)/elongation (%)			
	1,000 °C	1,200 °C	1,300 °C	1,400 °C
CP-Mo	120/8.6*	102/6.4	88/7.2	72/5.8
ODS-Mo	382/10.7*	205/8.7	184/11.4	167/9.6
NS-Mo	368/23.7*	224/28.8	211/25.4	185/22.7
TZM-Mo (ref. 17)	520/3.6	414/5.6	-	172/26
LCAC-Mo (ref. 17)	260/2.7	-	-	-
ODS-Mo (ref. 17)	313/4.9	-	-	-

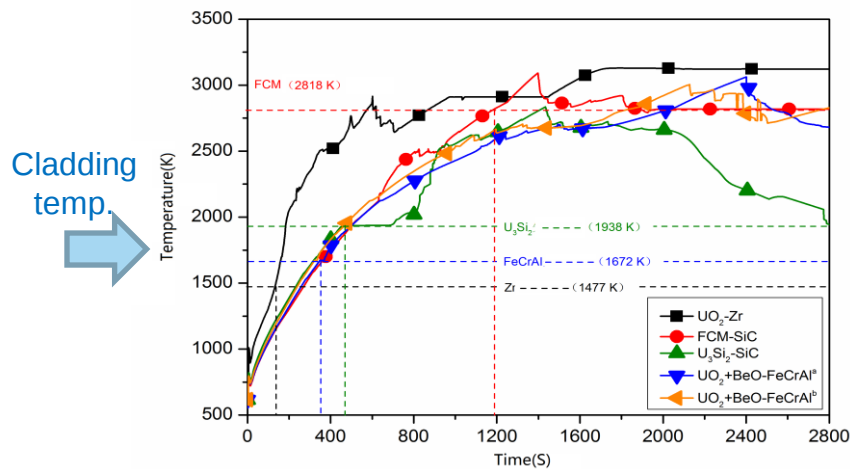
*Measured at 1,050 °C.

3. Updated research activities

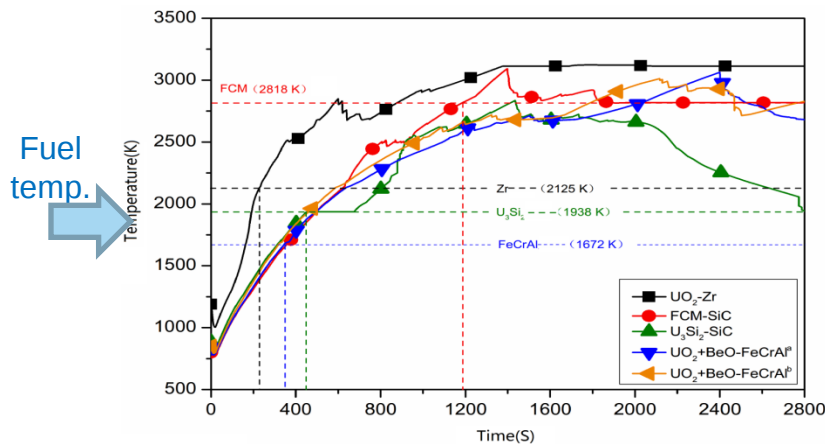
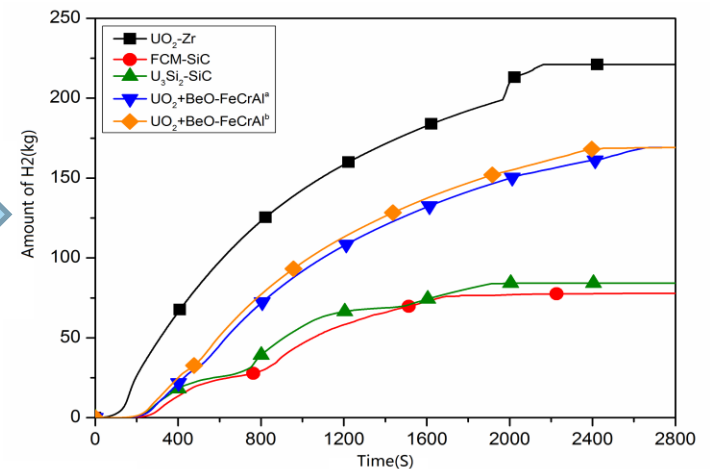
□ ATF conceptual design and preliminary analysis

CGN & Xi'an Jiaotong University

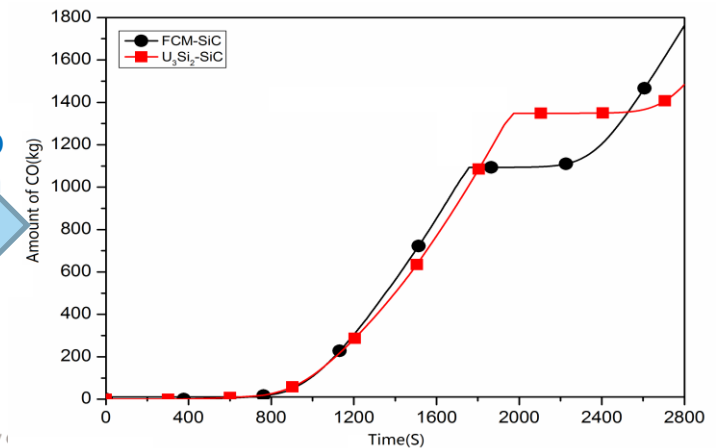
■ LOCA performance



In-core hydrogen generation →



In-core CO generation →

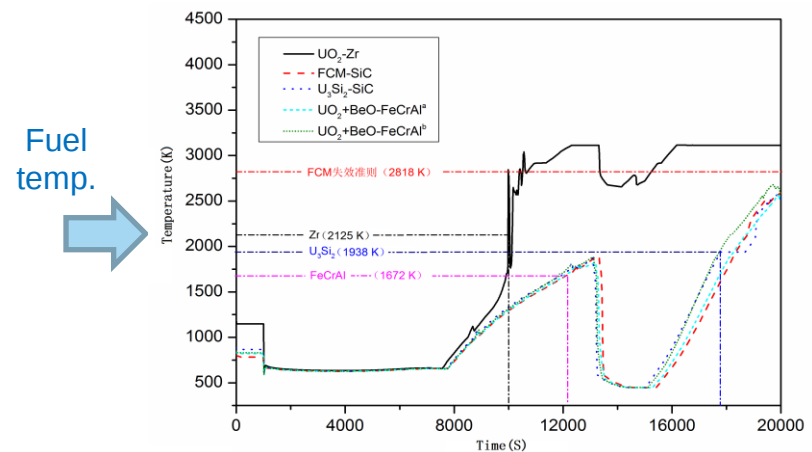
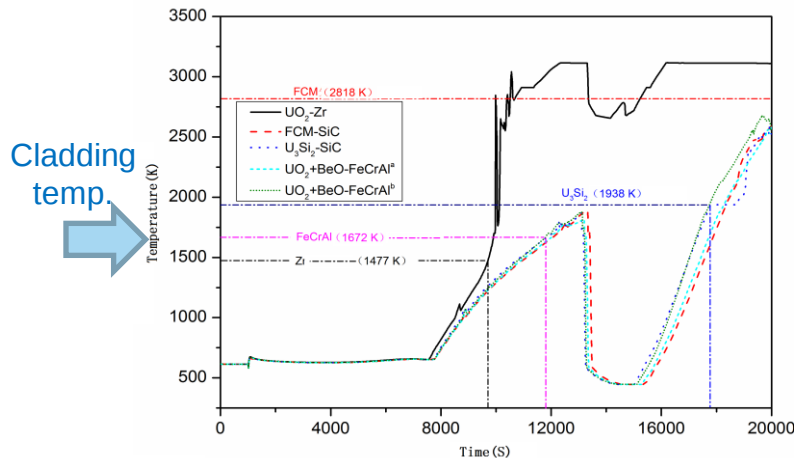


3. Updated research activities

□ ATF conceptual design and preliminary analysis

CGN & Xi'an Jiaotong University

■ SBO performance



Failure time

	UO ₂ -Zr	FCM-SiC	U ₃ Si ₂ -SiC	UO ₂ +BeO-FeCrAl ^a	UO ₂ +BeO-FeCrAl ^b
Event	Time(S)				
Cladding temp. to 1477K	8716.0*	9982.0	9756.0	9925.0	9811.0
Cladding temp. to 1672K	8907.0	11074.0	10887.0	11048.0*	10843.0*
Pellet temp. to 1938K	8987.0	17194.0	16916.0*	17269.0	16744.0
Pellet temp. to 2818K	8987.0	>19000.0*	>19000.0	>19000.0	>19000.0

a:cladding thickness is 0.57mm, b:cladding thickness is 0.45mm

*failure time

The first failure ATF system (UO₂+BeO-FeCrAl^b) is 2000s later than the standard UO₂-Zr system.

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4. Summary

- ❑ ATF R&D projects have been approved and formally launched by China government and CGN, the funding is over 400 million RMB (60 million US dollar).
- ❑ Existing research facilities and abilities in CGN and Chinese ATF research groups will contribute to the implementation of ATF R&D activities, and much more advanced facilities are under construction or in plan.
- ❑ The research group has obtained some achievements on ODS-steel, SiC/SiC cladding, ATF conceptual design and preliminary analysis.

Thank you for your attention