Utilization Status and Development Layout of RRs in Tsinghua University

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Contents

- Introduction to INET
- ESR and Nuclear Track-etched Membrane AntiCounterfeiting(NTMAC)
- HTR-10 and Overview of Nuclear Hydrogen Production

Introduction to INET

INET founded in 1960

Located in northern part of Beijing

Largest education Institute of NS in China

Introduction to INET

- **INET's main task is:**

  Help country meet the challenges in fields of energy, environment, as a leading nuclear research and experimental base in china

  Conducting R&D in science, technology, engineering and demonstration

  Promoting commercialization

  17 research divisions, 4 research centers and several workshops

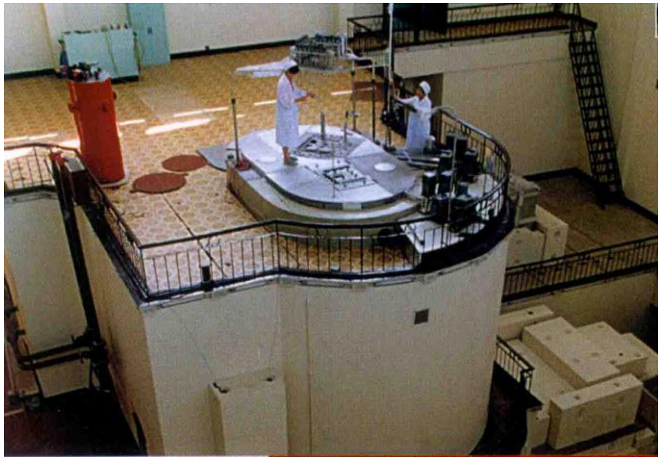
Introduction to INET

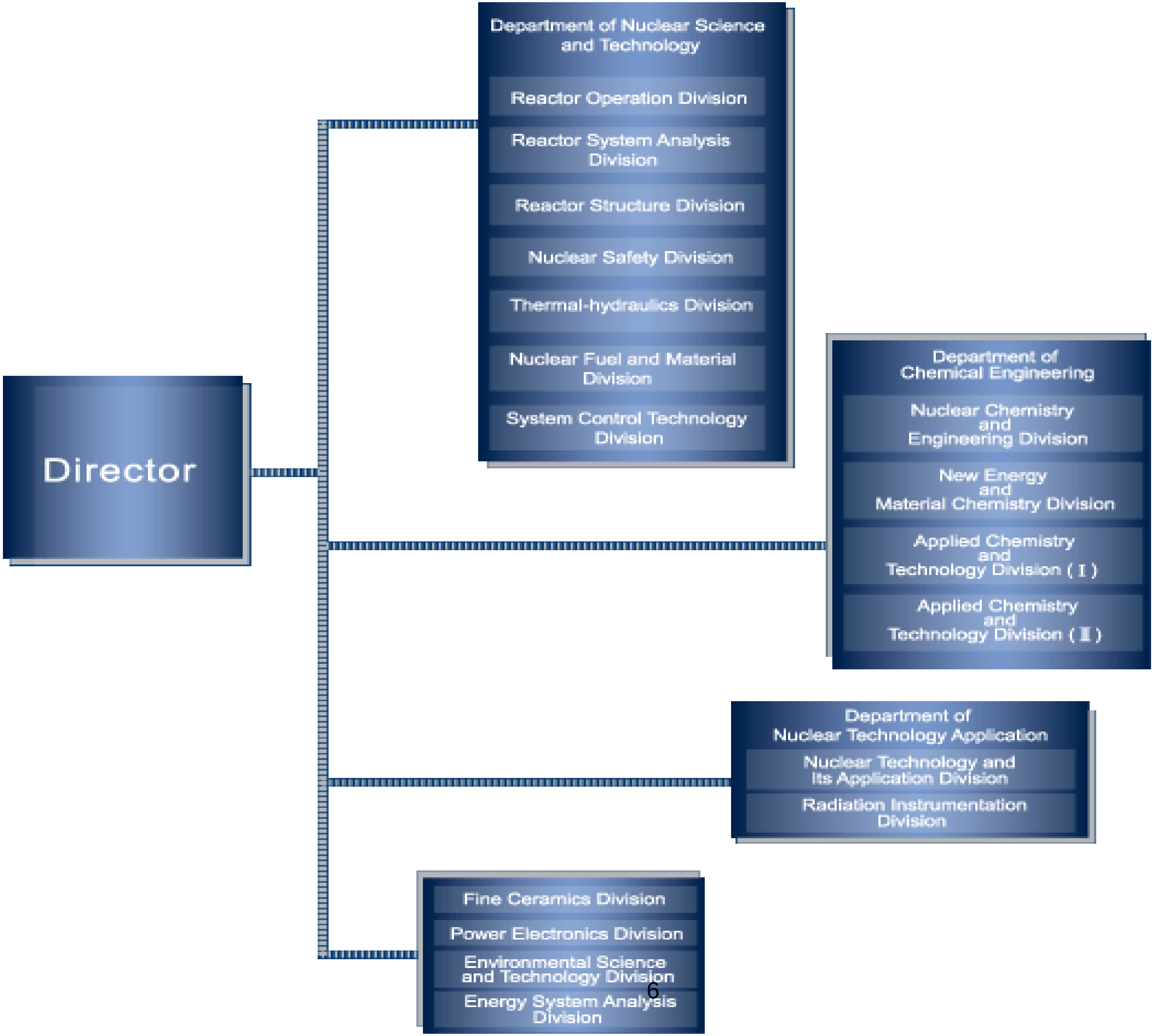
- Three RRs

  - HTR-10

  - NHR-5

  - ESR- twin core swimming-pool type




Director
Department of Nuclear Science and Technology
Reactor Operation Division
Reactor System Analysis Division
Reactor Structure Division
Nuclear Safety Division
Thermal-hydraulics Division
Nuclear Fuel and Material Division
System Control Technology Division
Department of Chemical Engineering
Nuclear Chemistry and Engineering Division
New Energy and Material Chemistry Division
Applied Chemistry and Technology Division (I)
Applied Chemistry and Technology Division (II)
Department of Nuclear Technology Application
Nuclear Technology and Its Application Division
Radiation Instrumentation Division
Fine Ceramics Division
Power Electronics Division
Environmental Science and Technology Division
Energy System Analysis Division

Introduction to INET

- International Exchange activities

Agreements for bilateral exchanges and cooperation with dozens of universities worldwide .
Several hundred scholors and experts visit INET from the world

ESR and NTMAC

- **ESR- 901 Reactor**

- **Established in 1960**
- **Reached criticality in 1964**

- **The first reactor self-designed by P.R.China**
- **Twin-core all-purpose swimming-pool type experimental research shielding reactor**

- **29 irradiation channels total** (No.1 core 2MW with 9 H
- No.2 core 2.8MW with 20 V)

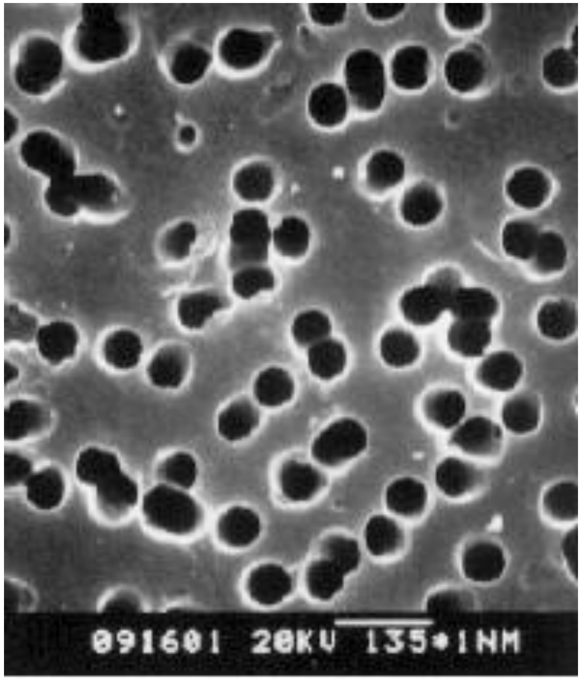
ESR and NTMAC

History of Utilization

- Shielding Experiments
- Seeds Irradiation
- NTM Production
- Neutron Radiography
- Anti-Irradiation Reinforcement Experiments
- Nuclear Measuring Apparatus Calibration
- Activation Analysis
- Chemical Sample Irradiation
- NTD
- Residual Heat Heating

ESR and NTMAC

- **Nuclear Track-Etched Membrane AntiCounterfeiting (NTMAC)**



NTMAC technology based on nuclear track technology.

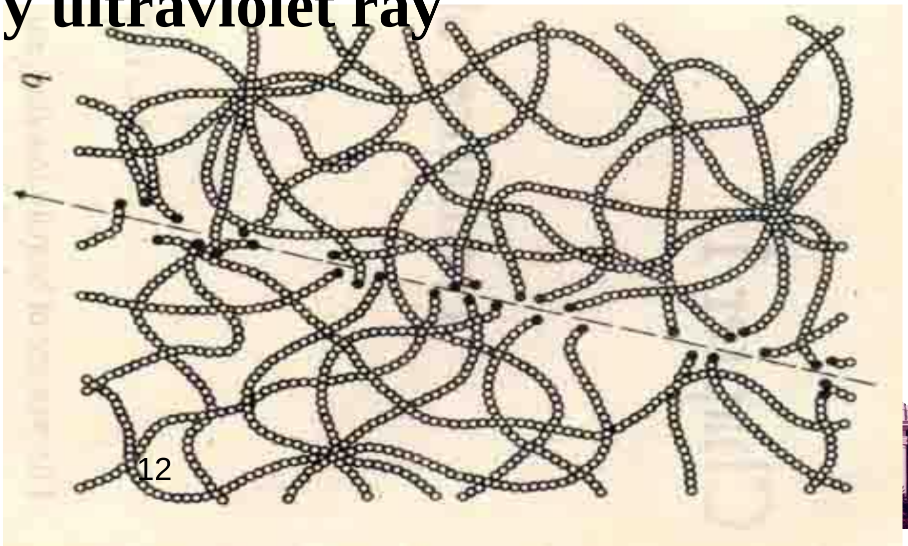
The polyester is irradiated by nuclear particles, through holes can be formed after the polyester is etched.

The polyester with uniform through hole is called nuclear track-etched membrane (NTM)

ESR and NTMAC

- **Production Flow of NTMAC**
  - Nuclear track generating
  - a) Reactor generating thermal neutron
  - b) Thermal neutron bombard U-235 target
  - c) Polyester is bombard by fission fragments
  - d) Polyester is damaged and tracks are generate

  - Sensitization of track by ultraviolet ray
  - Image shaping
  - Etch of track
  - After production



901 Reactor and NTMAC

- **Qualification**
- Material: Polyester
- Diameter of Micropore: 0.004~0.006mm
- Density of Micropore $4 \sim 8 \times 10^5 / cm^2$
- Slope Distribution: 0~50º
- Location Ditribution: Random
- Distribution of Micropore Direction: Random

901 Reactor and NTMAC

- **Characteristics**
  - High-tech, High-input, High-monopolistic
  - Almost impossible to be imitated
  - Simplification of general identification methods
  - Expert identification methods for judicial expertise

901 Reactor and NTMAC

- Identification methods for Two types of NTMAC label:

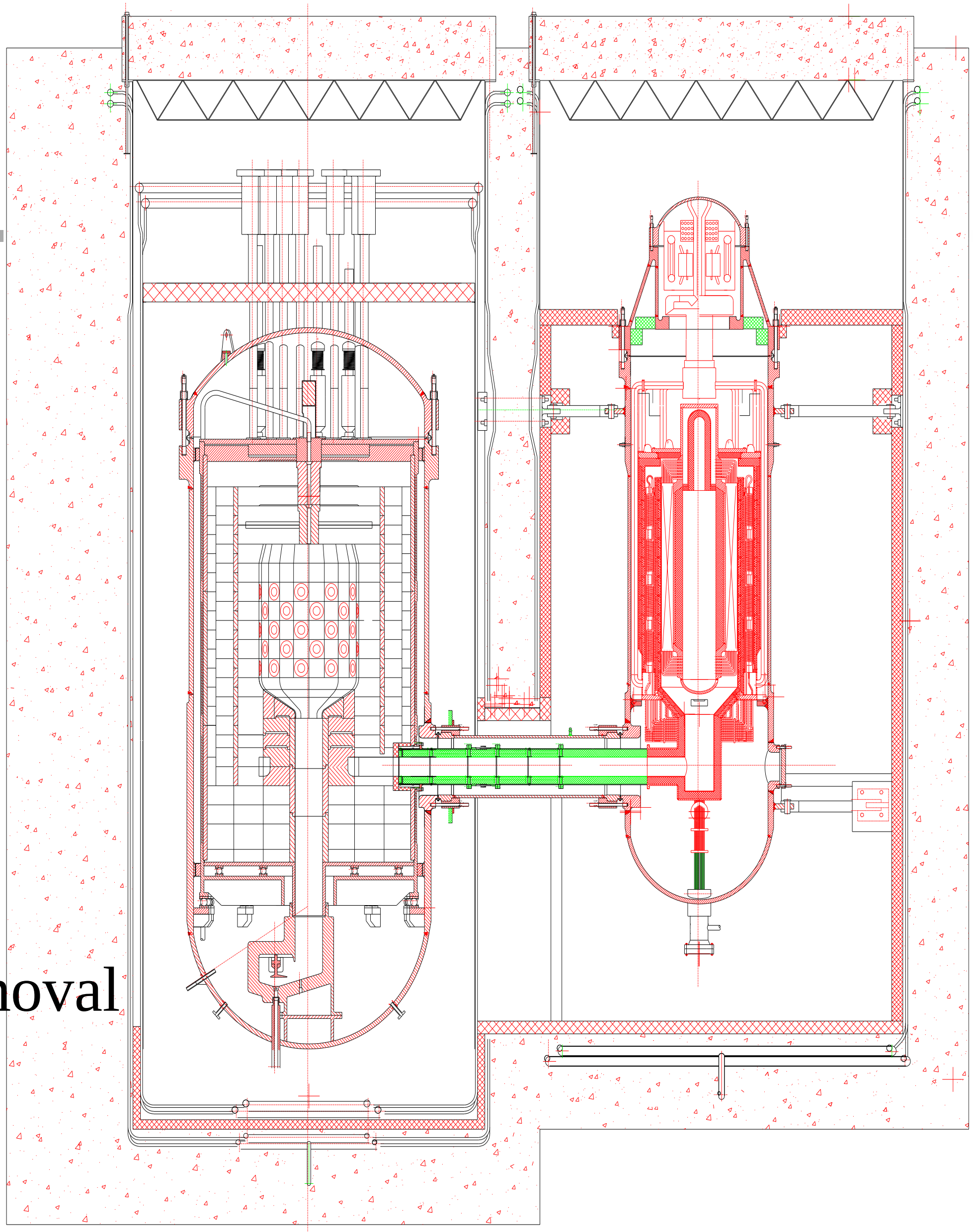
Drip-Disappear type:
Daubed the Drip-Disappear type label with transparent liquid such as water or alcohol. The figure on the label will disappear until the evaporation of the liquid

Color-Printing type:
Daubed the Color-Printing type label with color pen. Wipe away the color, the figure will appear.

HTR-10 and Nuclear Hydrogen Production

- 10 MW High Temperature Gas-Cooled Reactor (HTR-10)
  - Reach criticality in Dec, 2000
  - Advanced type reactor
  - Safety features, High efficiency, Wide application
  - Coated particle fuel
  - Helium used as coolant and graphite used as moderator

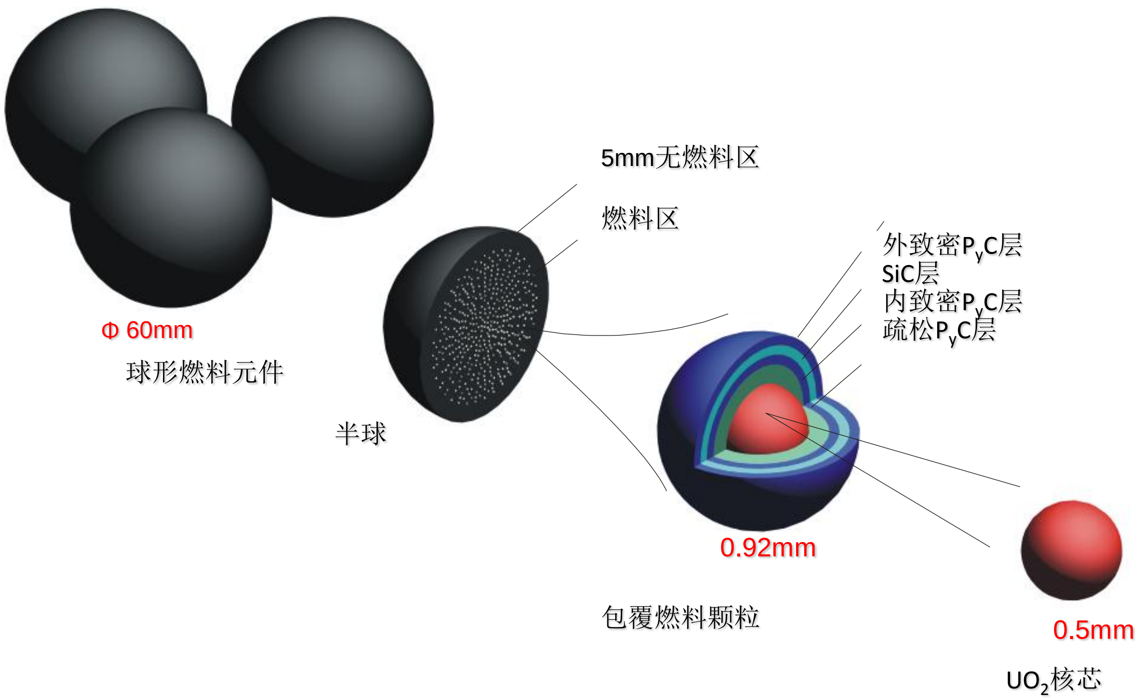
Reactor Power, MWth	***10***
Pressure, MPa	***3***
Reactor Inlet Temperature, ℃	***250***
Reactor Outlet Temperature, ℃	***750***
Fuel Elements Number	***27000***



Designed:
Completely passive decay heat removal of the HTR-10 under emergency conditions .
A surface cooling system.

Pebble-bed Fuel Elements

60 mm diameter



高温气冷堆球形燃料元件示意图

Background of INET Nuclear Hydrogen production programme

HTR-10 can:

- generates electricity,
- provides process heat with temperatures up to 950° C
- As an important application of high temperature heat, the nuclear hydrogen programme was initiated since 2004.

- Traditional hydrogen production methods:

Steam methane reform (CO_2 emission)

Electrolysis (expensive way)

Technical options for NH Production

INET is conducting preliminary studies on hydrogen production technologies:

- IS cycle
- High temperature steam electrolysis (HTSE)

IS cycle

$$2H_2O + I_2 + SO_2 \xrightarrow{\fallingdotseq 100℃} 2HI + H_2SO_4 \quad \text{(Exothermic)}$$

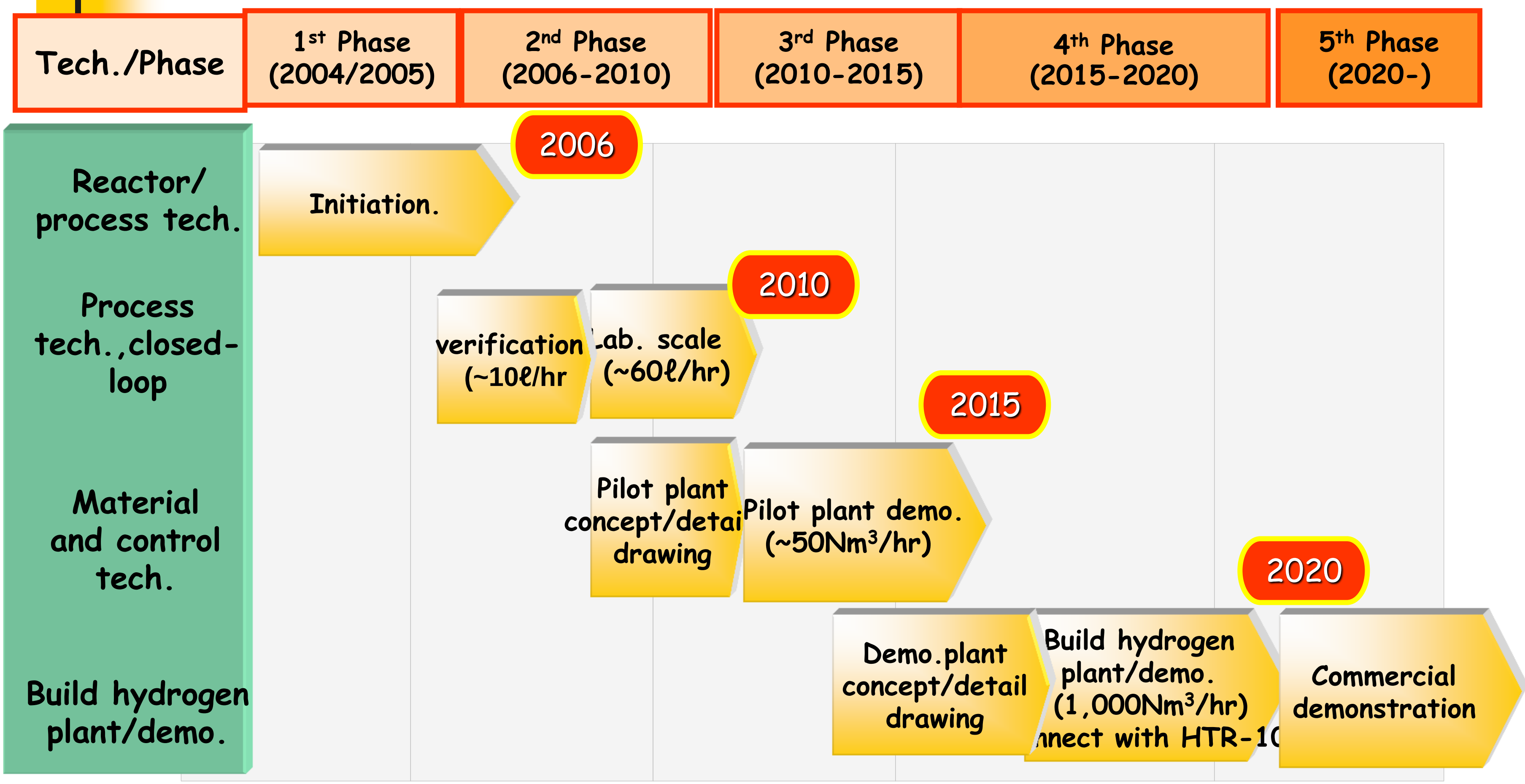
$$2HI \xrightarrow{400 \sim 500\ ℃} H_2 + I_2 \quad \text{(Endothermic)}$$

$$H_2SO_4 \xrightarrow{\fallingdotseq 850℃} H_2O + SO_2 + (1/2)\ O_2 \quad \text{(Endothermic)}$$

Advantages

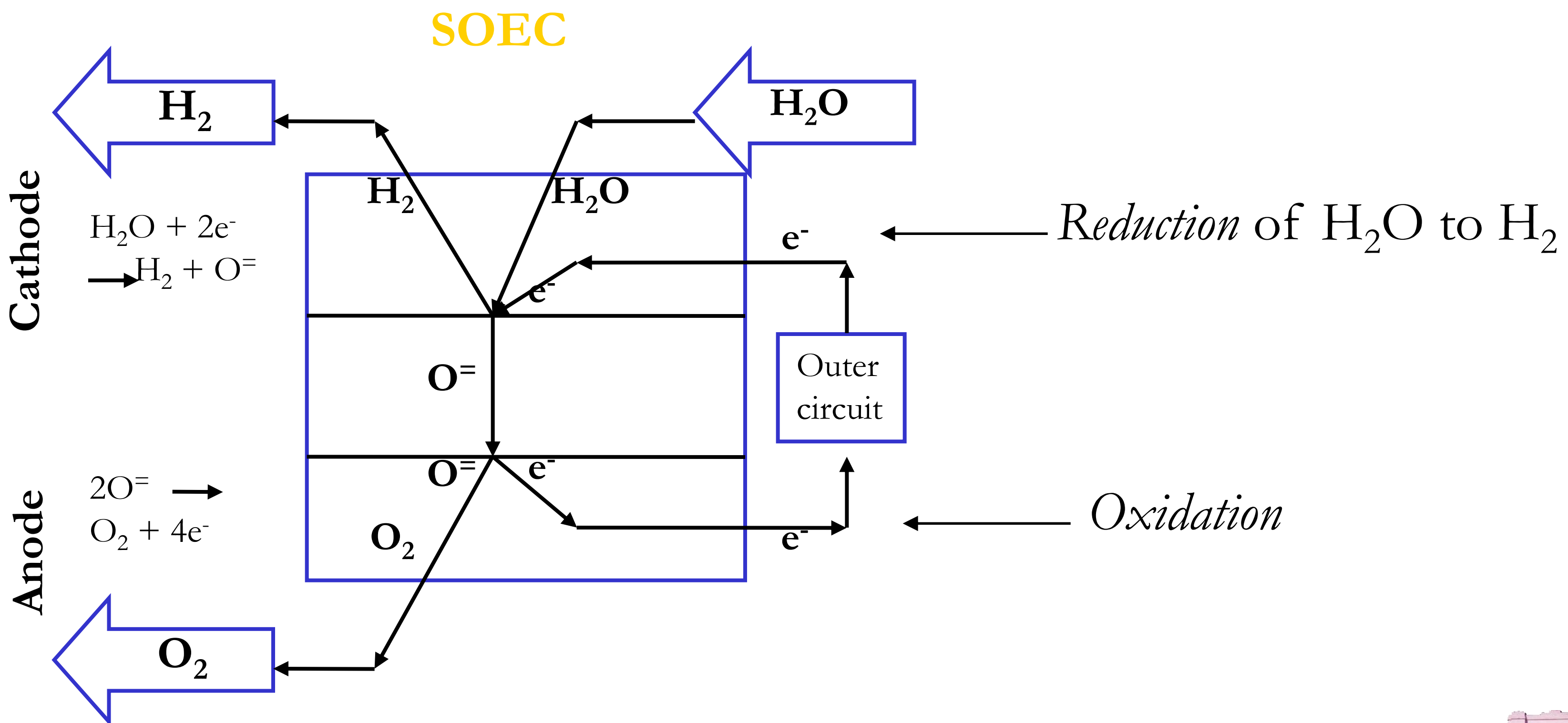
- **Good matching of heat needed and heat delivered by HTR**
- **High efficiency (> 50%)**
- **All fluid and closed-cycle (no by-product)**
- **Large scale hydrogen production**

Research plan of IS cycle



System Principal for HTSE

- $H_2O_{(g)} \rightarrow H_{2(g)} + \frac{1}{2} O_{2(g)}$



Advantages of HTSE

- Using nuclear heat and electricity would allow hydrogen production with no associated greenhouse gas emissions
- High efficiency, with a thermal-to-hydrogen conversion efficiency of 45 ~ 55 %.
- Rapid hydrogen production in a small unit
- Technological Feasibility
  - *Lower operating temperatures than thermochemical cycles*
  - *Less corrosive operating conditions*
  - *Builds on existing Solid Oxide Fuel Cell technology*

A HTSE bench and testing system

A evaluation instrument for electrochemical performance of material at high temperature

Thanks for your attention!!