Current Status of Research Reactor Utilization Technology Development in KAERI

2014. 11. 17.

In-Cheol LIM
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RRs in KAERI
Characteristics

- **Type**: Open-tank-in-pool
- **Power**: 30 MW$_{th}$
- **Coolant**: Light Water
- **Reflector**: Heavy water
- **Fuel Materials enriched**: U$_3$Si, 19.75%
- **Absorber**: Hafnium
- **Reactor Building**: Confinement
- **Max Thermal Flux**: 5x10$^{14}$ n/cm$^2$s
- **Typical flux at port nose**: 2x10$^{14}$ n/cm$^2$s
- **7 horizontal ports & 36 vertical holes**
- **Vertical hole for cold neutron source**
- **Operation Cycle**: 28 days@5 weeks
Yearly Trend of Users in HANARO

![Yearly Trend of Users in HANARO](chart.png)
KiJang Research Reactor (KJRR) Project

Name

Period

Site

Site Area : 130,000 m²
Facility : Reactor, FM & RIPF, RWTF etc.

Objectives : RI Production and Research, Neutron Irradiation Services

Functional Requirements

- Power : 15 MW (Max. neutron flux > 3x10^{14} n/cm² s)
- Fuel : U-Mo plate type fuel (LEU)
- Fission Mo target : U-Al plate type (LEU)
Utilization of Neutron Beam
No. of Neutron Beam Instruments & Users

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Publications using HANARO Neutron Facility

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User Statistics

Proposals by user affiliations

Beam times by user type

Proposals by utilization type

Beam times by research area

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Statistics of Industry Users

- Industrial utilization: ~46 days (~5% of total)

Beam Time / Days / Instruments

Beam Time / Days / Topics

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Motivation

- Success stories from cooperation with large size enterprises in the area of fuel cell development and residual stress analysis
- Efforts of government institutes to help the growth of SMEs and job opportunity creation in them
  - An government theme: CREATIVE ECONOMY

Proposed Cooperation Area

- Wire production technology, bio-wires, cosmetics, secondary cell
- Precision glass, neutron detectors, thin film coating

Foundation of a Council in Nov. 2014

- Council for Industrial Application
- Participants
  - Industries
  - KAERI
  - HANARO users from universities
Open of New Instruments

Structural studies of Bio-macromolecules

Bio-C: Proteins, nucleic acids
up to more than \(~300,000\text{Å}^3\)

Bio-D: wide range of unit cell sizes
from \(~30\text{Å}^3\) to \(~30,000\text{Å}^3\)

Studies of membrane structure at the Bio-interface

Bio-REF: Lipid membranes, Protein adsorption.
from 1 nm ~ 200 nm for thickness measurable for membranes in liquids
DC-ToF
(Disk Chopper Time-of-Flight Spectrometer)
- Incident Neutron Energy: 0.8 meV ~ 20 meV
- Energy Resolution: 50 μeV ~ 2 meV
- Angular coverage: 8° ~ 83°
- 6 Disk choppers and focusing super-mirror guide
- Application
  - Low energy magnetic excitation and lattice dynamics
  - Low energy dynamics of liquid and solid molecules
  - Proton/Hydrogen dynamics in various materials

C-TAS
(Cold Neutron Triple-Axis Spectrometer)
- Incident Neutron Energy: 2 meV ~ 20 meV
- Energy Resolution: 0.1 meV
- Mono-chromater: Vertically focusing PG(002)
- Analyzer: Horizontally focusing PG(002)
- Sample environments; 10/4/2K CCR-type Low-temp cryostats 10T magnetic field
- Application: Inelastic neutron scattering
  - Low energy, high resolution dynamics study
  - Frustrated magnetic systems, superconductors, low dimensional magnetism, relaxors, quantum spin liquids, heavy fermions (strongly correlated electron system)...

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Activation Analysis using Cold Neutron
Cold Neutron Activation Station (CONAS)

- Three NAA instruments
  - PGAA (Prompt Gamma Activation Analysis)
  - NIPS (Neutron Induced Prompt Gamma Spectrometer)
  - NDP (Neutron Depth Profiling)
CONAS (2)

**PGAA & NIPS**
- **Principle**
- **Applications**
  - Nuclear structure and decay study
  - Material science, Biology
  - Environmental science, etc

**NDP**
- **Principle**
- **Applications**
  - Near surface depth profiling
  - Glass, Wafers, Li batteries and Semiconductors, etc

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Fission Mo Production Tech. Development
Fission-Mo Technology Development

**1st Phase (’12-’14)**
- Core Tech/Process Design/Demonstration
- Target Dissolution Tests
- Separation Tech and Process Design
- Hot Demonstration
  - FM Production (Min. 1Ci)
- 500 Ci/batch Process Test

**2nd (’15-’16)**
- Fission Mo Line Installation
- Manufacture of Full Scale Modules
- 1,000 Ci/batch Process Test
- 2,000 Ci/batch Process Test
- Fission Mo QC Protocol

**FM Production**
- Prod. Line Installation
- Prod. Test 200 Ci/w
- Kijang Research Reactor
Fission-Mo Production Process
Material Irradiation
Contribution to Key Projects

- **SFR/VHTR**: U-Zr/TRISO Nuclear Fuels 1st Generation
  - **2009.10~**
  - **2008.3**

- **SMART**: Steam Generator Materials
  - **2010.4**

- **JRTR/KJRR**: Core Materials
  - U-Mo Plate Fuel
  - **2012.9~**

- **IGRTR**: Control Rod Materials
  - for KNF/WEC AP1000 (U.S.)
  - **2007.11**

- **HANA**: Fuel Cladding
  - **2006.4~**

- **Kori-1 RPV**: Fuel Assembly Parts for KEPCO Nuclear Fuel Co.
  - **2002.4~**

- **2001.5~**

- **Korean-made RPV Steel for Doosan Heavy Inc.**
  - **2000.3**

- **NGNP (VHTR/SFR)**: Fuels & Core Materials
  - (TRISO/U-Zr, ODS, SiC)
  - **2013.8~**

- **Fusion**: Core Materials
  - (ARAA & Welds, Blanket...)
  - **2015~**
Irradiation Effects on Advanced Materials

Current density of MgB$_2$

Superconductor

- Neutron Irr. -NAA1 2nd-
  - 30 s (Si-29-S4a)
  - 75 s (Si-29-S4d)
  - 10 min (Si-29-S4f)
  - 30 min (Si-29-S4h)

- IP5 3rd-
  - 1min (Si-26-S3a)
  - 1min (Si-26-S3b)
  - 1min (Si-26-S3c)

 Resistivity & mobility of Si

T (K)

- Neutron Irr.
  - NAA1 2nd-
  - 30 s (Si-29-S4a)
  - 75 s (Si-29-S4d)
  - 10 min (Si-29-S4f)
  - 30 min (Si-29-S4h)

- IP5 3rd-
  - 1min (Si-26-S3a)
  - 1min (Si-26-S3b)
  - 1min (Si-26-S3c)

Multiferroics (Bi-Fe-Mn-O)

Multi-Functional Materials

Current density of MgB$_2$

Superconductor

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- IP5 3rd-
  - 1min (Si-26-S3a)
  - 1min (Si-26-S3b)
  - 1min (Si-26-S3c)

- Pristine

- Neutron Irr. -NAA1 2nd-
  - 30 s (Si-29-S4a)
  - 75 s (Si-29-S4d)
  - 10 min (Si-29-S4f)
  - 30 min (Si-29-S4h)

- IP5 3rd-
  - 1min (Si-26-S3a)
  - 1min (Si-26-S3b)
  - 1min (Si-26-S3c)
Remarks
The cold neutron beam instruments makes the HANARO contribute to the increase of users as well as the basic research.

Efforts are being made to increase the industrial application of neutron science and the spin-off technologies acquired during the construction and operation of the beam facilities.

The introduction of cold neutron NAA systems are expected to enlarge the application of activation analysis.

As for the development of fission Mo production technology, a hot demonstration of developed technology is expected to be made within this year.

The irradiation tests and the development of relevant technologies are contributing to the development of research reactor systems, the development of future nuclear energy systems and new advanced materials.
2015 International HANARO Symposium  
(Joint Events : KAERI-JAEA Seminar & IAEA-Workshop )

Call for papers

The 2015 International HANARO Symposium will be jointly held with the 4th KAERI-JAEA Joint Seminar on Advanced Irradiation and PIE Technologies. In addition, the IAEA Workshop on Research Reactor Coalition – Enhanced Networking in Asia-Pacific Region will be held as a satellite meeting. The events will be held at Daejeon Convention Center (DCC) in Korea from May 11 to 15 of 2015.

Welcome anyone who is interested in research reactors and their applications. Prospective authors are invited to submit abstracts for oral or poster presentations in all of the following area:

• Research Reactor General : Operation, Maintenance, Ageing Management and Modernization
• Neutron Scattering Science, Instrumentation and Cold Neutron System
• Nuclear Fuel/Material Irradiation & PIE and other Irradiation Services including NTD
• Radioisotope Production
• Neutron Activation Analysis
• Research Reactor Design, Construction and New Projects
• Any other contributions related to Research Reactor

Schedule
• 11-12 May : Int. HANARO Symposium, KAERI-JAEA Seminar
• 13 May : Technical Tour
• 14-15 May : IAEA Workshop

Important Dates
• Deadline for abstract submission : 14 Feb. 2015
• Notification of authors : 28 Mar. 2015
• Deadline for submission of PPT : 30 April 2015

Secretariat
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Gracias!