Materials and Innovations for Fusion Energy
Room Ballroom A - Session FUS-ThP

Materials and Innovations for Fusion Energy Poster Session

FUS-ThP-1 Experiment Setup of a Testbed Facility to Characterize Tritium Storage Materials, ***Simon Niemes***, *David Beisiegel, Nicolas Bekris, Noah Ellenbogen, Robin Größle, Ralph Lietzow, Immanuel Müller, Florian Priester,* Karlsruhe Institute of Technology (KIT), Germany*; Tim Teichmann,* Kyoto Fusioneering (KF), Germany

A key requirement for the transportation, storage and processing of tritium is the availability of storage devices compatible with tritium. Metal hydride storage bed, usually based on depleted uranium, are commonly used due to the low equilibrium pressure at room temperature and the efficient tritium release at temperatures above 400°C. However, the use of uranium requires a dedicated licencing and additional safety measures due to the pyrophoric nature of the storage material. Therefore, research efforts into alternative materials like ZrCo based alloys are required. At the Tritium Laboratory Karlsruhe (TLK), a new dedicated setup is currently being commissioned to assess the storage properties with high accuracy and using an inventory of up to 3 grams of tritium. This setup will be able to perform thermodynamic and kinetic measurements as well as investigations of disproportionation and regeneration behaviour for different getter bed materials

This contribution gives an overview of the working principles and status of the experiment and the considerations for the use with tritium.

FUS-ThP-3 Development of a Method for Hydrogen Species Analysis in Fusion Breeder Materials Using ICP-MS, ***Clemence Mont***, UKAEA, UK

The UK Atomic Energy Authority is investigating breeder material technologies through the LIBRTI (Lithium Breeding Tritium Innovation) programme to support tritium production for Fusion Energy. Tritium is a scarce resource around the world and one of the key fuels for Fusion with deuterium. The Fusion sector must develop breeding technologies to transform lithium into tritium using the neutrons generated during the fusion of deuterium and tritium. This will create a tritium fuel cycle where tritium is created as it is used for the fusion reaction.

The LIBRTI programme is investigating different breeder materials such as FLiBe, LiPb and liquid lithium among others. A facility will be built in the coming years on the Culham Campus in Oxfordshire, UK, to test the materials in a large-scale mock-up experiment. Within the LIBRTI programme, a project called CLIO is looking at developing an analytical method to determine the concentration of tritium in the breeder materials using ICP-MS (Inductively Coupled Plasma – Mass Spectrometry). Developing analytical techniques for tritium accountancy is a priority to ensure process control, safety, environmental protection and security around a fusion power plant.

The CLIO project is split into 4 phases. The first 1 started in June 2026, and its aim was to develop a method for hydrogen and deuterium analysis as surrogate to tritium. Hydrogen is famously difficult to analyse with an ICP due to its high ionisation energy, the development of a novel method would allow the instrument to be used in the Fusion sector. Phase 2, started in October 2026, introduces breeder materials as a sample. The detection of hydrogen might suffer from matrix effect coming from the different type of materials, assessing each of them is important to ensure accuracy of the results. Phase 3 starting in January 2027 will look at simplifying the sampling technique by adding the Laser Ablation – LIBS (Laser Induced Breakdown Spectrometry) system to the ICP-MS. While using the ICP-MS on its own necessitates the dissolution of the sample, the LA-LIBS add-on will allow surface analysis. The LA-LIBS-ICP-MS will be able to do bulk and surface analysis. The final phase planned later in 2027 will introduce tritium to the system. This step will ensure that the system can analyse all hydrogen isotopes and that it can be used in the LIBRTI programme as a tritium detection system.

Results from the method development carried out in phase 1 as well as preliminary data from phase 2 are presented in the poster.

FUS-ThP-4 the Actively Pumped Open-Surface Lithium LOop (APOLLO) – a Liquid Lithium Plasma Facing Component Technology Testbed, ***Brady Moore***, University of Illinois Urbana-Champaign*; Daniel O'Dea,* University of Illinois at Urbana Champaign*; Zachary Nordan, David Ruzic,* University of Illinois at Urbana-Champaign

Liquid lithium is being explored as a plasma-facing component (PFC) for fusion devices, particularly in the divertor region. Compared with traditional solid materials like tungsten, a flowing liquid surface can better recover from extreme heat fluxes during transient events, continually renew itself, and is impervious to neutron damage. Lithium also has a low atomic number leading to a higher tolerable concentration in the plasma core. Additionally, lithium readily reacts with hydrogen isotopes leading to a low-recycling boundary that can improve plasma performance and flatten plasma temperature profiles. However, this same property creates a key challenge: lithium can retain radioactive tritium which has strictly monitored inventories. Future fusion reactors will aim to minimize total tritium inventory and therefore effective tritium separation from liquid lithium is critical.

The University of Illinois Urbana–Champaign (UIUC), in partnership with Tokamak Energy Ltd., has developed the Actively Pumped Open-Surface Lithium Loop (APOLLO) to develop technologies required for implementing liquid lithium PFCs. APOLLO features a circulating liquid lithium loop, a free-surface lithium plasma-facing component operating under a magnetic field, a hydrogen/deuterium plasma source or electron beam heating system, and an in-line distillation column for the removal of hydrogenic species. The PFC employs a computationally optimized distributor that ensures uniform delivery of lithium from an inlet pipe across a 7.5 cm-wide, additively manufactured refractory metal mesh within an open-surface flow channel. Lithium traverses the mesh at average surface velocities up to 10 cm/s, with mass flow rates reaching 12 g/s, while simultaneously interacting with an electron cyclotron resonance (ECR) hydrogen/deuterium plasma. Plasma properties have been characterized in-situ using an array of 16 Langmuir probes, a retarding field energy analyzer (RFEA), and actinometric spectroscopy. After plasma exposure, the lithium is directed to the inductively heated Hydrogen Distillation Experiment (HyDE), where it is thermally processed at temperatures up to 700 °C to remove hydrogenic species and other impurities before being recirculated through the loop.

In this work, hydrogen uptake in flowing liquid lithium exposed to an ECR plasma, as measured by a novel resistive impurity probe, is investigated as a function of lithium flow rate and plasma operating conditions. The efficiency of hydrogen thermal extraction is also quantified using a resistive impurity probe and thermal desorption analysis.

FUS-ThP-7 An Analysis of Radiation Tolerance of Parylene Coatings for Nuclear Energy Applications, ***Steven Larson***, *Alex Mings, Joshua Young, Ronald Goeke,* Sandia National Laboratories

Steven R Larson, Alex Mings, Josh Young, Ron GoekeSandia National Laboratories

Parylene is a chemical vapor deposited (CVD) polymer coating widely used in the electronics industry due to its excellent chemical resistance and dielectric properties. Recently, Parylene has also attracted interest as a protective coating for components in nuclear reactor systems, where materials are often exposed to highly corrosive environments, elevated temperatures, and high radiation. Despite this interest, relatively little is known about how the different Parylene polymers response to ionizing radiation. Additionally, the extent to which radiation tolerance varies among the different types of parylene remains largely unexplored. While some data exists for parylene C, D, and N very little data has been published on the different parylene F polymers (VT-4 and AF-4) due to their difficulty in precursor fabrication. This talk will present efforts to determine the physical, chemical, optical, and electronic changes that occur in Parylene C, D, N, VT-4, and AF-4 following exposure to lifetime-relevant gamma and neutron irradiation. We will discuss the differences between the various parylene polymers and how to cost optimize for extremely expensive precursors. Sandia National Laboratories is managed and operated by NTESS under DOE NNSA contract DE-NA0003525 SAND2026-21514A

FUS-ThP-9 Investigating Gaseous Impurity Production in a Baked UHV System, ***Gabriel Wilber***, Tritium Solutions, Inc.*; E. Koukina, K. McCormack, A. Knaian,* Acceleron Fusion*; W.T. Shmayda,* Tritium Solutions, Inc.

Muon-catalyzed fusion offers a unique alternative energy source. In this approach muons are injected into a high-pressure gas target containing a deuterium-tritium mixture. When a muon attaches itselves to a DT molecule, the probability for the DT molecule to fuse increases significantly.

This event generates energy, creates a 4He atom, and releases the muon to attach itself to another DT molecule over its 2.2 μs mean lifetime. However, if the muon interacts with a gaseous impurity, it can no longer participate in catalyzing fusion reactions. This paper investigates on the type and quantity of impurities produced when D2 is injected into a heated 316-stainless steel ultrahigh vacuum system.

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