3 - 5 An Experiment Setup for Synergetic Effect of Irradiation and LBE in IMP

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Due to its unique properties, such as favorable neutronic characteristic, low melting point(∼125 °C) and high boiling point (> 1 600 °C), good natural circulation and chemical inertness with water and air (unlike sodium), *etc*, lead bismuth eutectic (LBE) has been considered as perspective coolant and spallation target for accelerator driven systems (ADS)[1,2]. The spallation structural materials of ADS will be long-term irradiated with fast neutrons while simultaneous being contact with LBE coolant. In the past few decades, irradiation or LBE corrosion behaviors in various of materials have been massively investigated for the purpose of developing ADS. However, there are only a few experiment data on the combined effect of irradiation and LBE corrosion on structural materials due to lack of related experimental setups[3,4]. Such tests are not only essential for ensuring the safety and reliability of ADS, but also necessary for building a database for licensing any materials for use in LBE cooled nuclear systems.

To comprehensive investigate the effect that neutron irradiation induced damage has on the corrosion behavior of materials exposed to LBE, a synergetic effect of irradiation and corrosion experimental installation (SEICE, shown as in Fig. 1) which utilize heavy ion beam as irradiation source has been completed. It consists of three components: the vacuum system for ion beam transferring, LBE corrosion loop and sample chamber. An oxygen control system will be integrated into the installation in 2015.

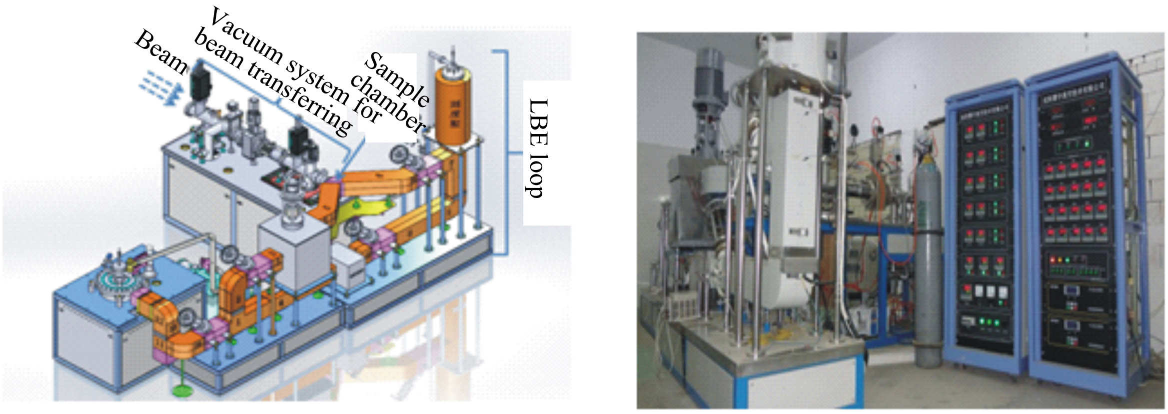

Fig. 1 (color online) Conceptual view (left) and side view (right) of SEICE setup.

The vacuum system for beam transferring is characteristic of metal pipe and a series of diagnosis devices (such as Faraday cup, beam profile measurement system) that detect the position, size and current of beam. In the front of vacuum system, an electromagnetic equipment with X and Y directions that ensures evenly irradiation was installed. In the experiment, vacuum degree of 1×10^{-5} Pa will be obtained by a set of mechanical pump and vacuum gauge.

The LBE loop was made of metal pipe, valve, electromagnetic flow meter, liquid metal pump, heater systems and thermocouples. The loop's temperature ranges from 200 to 600 °C, and the maximum velocity of LBE can reach up to 2 m/s.

The sample chamber in which the sample with the thickness of 25 μm is carefully fixed bridges the vacuum system and LBE loop. One side of the sample is subjected to high vacuum and is vertically irradiated by ions, while the other side of it is in contact with high temperature LBE. In the irradiation experiment, the ion beam with energy of 7 MeV/u will be provided by HIRFL. For example, if we choice Fe with the energy of 400 MeV ion in experiment, the maximum penetration depth by SRIM code is about 30 μm in typical F/M steel, therefore the Fe ions can pass through the sample completely. We also utilize the RELAP5 code to evaluate the velocity and pressure distribution of LBE with averaged initial velocity of 1 m/s on the surface of sample. The calculation results in Fig. 2 show that LBE exhibits well-distributed flow field on the sample's surface and the sample's surface pressure caused by fluids is less than 1atm.

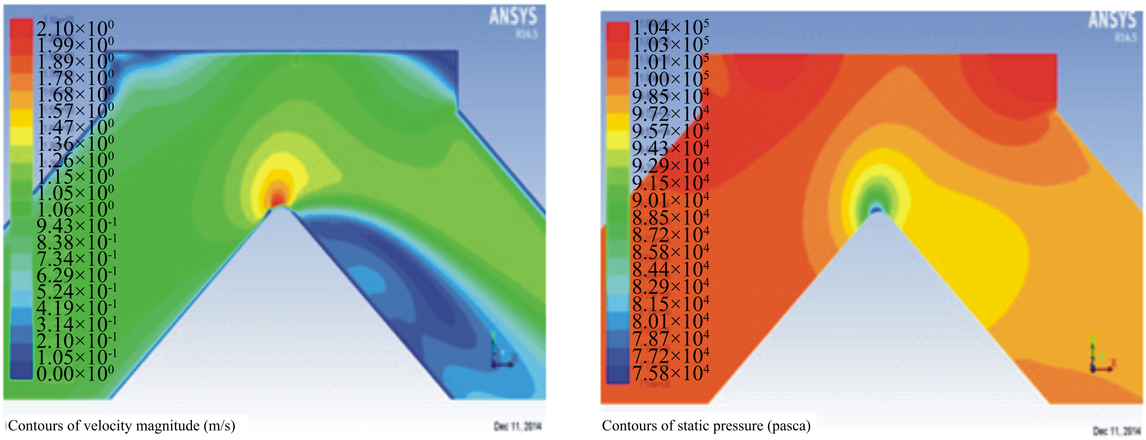

Fig. 2 (color online) Velocity (left) and pressure (right) distribution on the surface of sample calculated with RELAP5 code.

Now, the first corrosion test without irradiation was successfully conducted for 1 000 h without any failure. A study for synergetic effect of irradiation and LBE on the materials of interest for ADS will be carried out next.

References

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3 - 6 Molecular Dynamic Simulation of Point Defects under Strain Field in W

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Tungsten is one of the promising candidates for the divertor plate in International Thermonuclear Experimental Reactor (ITER) because of its high melting temperature, high thermal conductivity and low sputtering erosion. During the operation of ITER, it will be exposed to high energy particles: hydrogen, helium and neutron, producing high density of interstitials and vacancies which will change the structure and properties of materials. The formation of defects changes the local stress/strain field, and the external stress/strain field will also affect the properties of defects. In this work, we use the Large-scale Atomic/Molecular Massively Parallel Simulator LAMMPS[1] to study the formation of defects under strain field in tungsten.

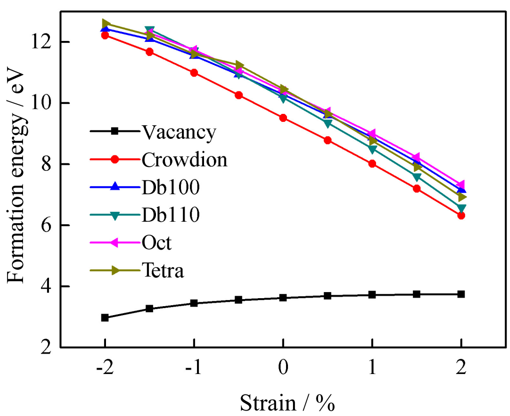

Fig. 1 (color online) Formation energy of vacancy and single self-interstitials with different strains in bcc W.

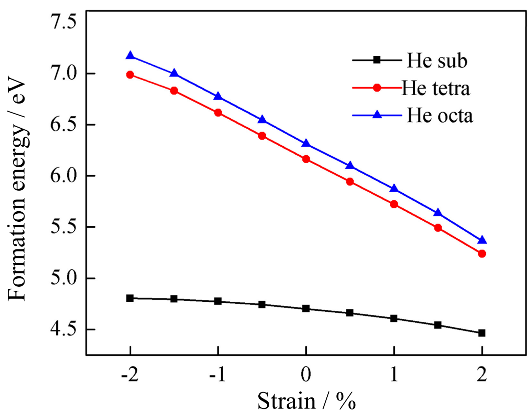

Fig. 2 (color online) Formation energy of different He interstitials with strain in bcc W.

A bcc lattice with 16 000 W atoms (20 × 20 × 20) was constructed as the simulation box. The potentials used for W-W and W-He both were developed by Juslin and Wirth[2]. The vacancy and interstitials were produced by