

§18. Steady State Hydrogen Plasma Interactions with Solid and Liquid Lithium in Vehicle-1

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To resolve technical issues associated with plasma-surface interactions in steady state magnetic fusion devices, over the past decade a number of innovative plasma-facing component (PFC) concepts have been proposed [1,2,3]. These technical issues include: (1) fuel and impurity particles control; (2) erosion and redeposition; (3) tritium build-up and removal; and (4) high-heat flux removal.

Generally, these innovative PFC concepts are composed of two groups: one using solids [1,2] and the other using liquid [3] as the plasma-facing material, but both are moving so that the edge-plasma will always see "refreshed" surfaces, perhaps after out-of-pile regeneration processes.

Using a titanium or lithium gettered rotating drum, Hirooka et al. demonstrated reduced hydrogen recycling even at steady state [4], a success of proof-of-principle experiments on the moving-surface plasma-facing component (MS-PFC) concept.

Extending this success to the use of liquid surfaces as the plasma-facing material, a new versatile facility was proposed previously [5] and has actually been constructed. This facility is referred to as "Vehicle-1" for the vertical and horizontal configurations interchangeable test stand for components and liquids for fusion experiments). Schematic drawings of Vehicle-1 are shown in Fig. 1[6].

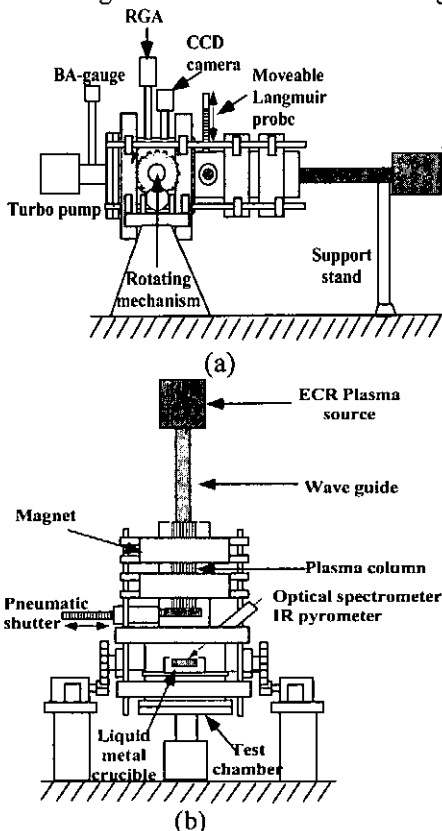


Fig. 1 Schematic drawings of Vehicle-1 [5].

Vehicle-1 employs a 1 kW ECR plasma source that can produce steady state hydrogen, nitrogen, helium, argon, and oxygen plasmas. Typically, the plasma densities are of the order of 10^{10} 1/cc and the electron temperatures are around 3 eV. Also installed for plasma-surface interactions diagnosis are: linearly moveable Langmuir probe, CCD digital camera, total & partial pressure gauges, IR pyrometer and two thermocouples; one dipped into the liquid and the other attached on the crucible. Using these diagnostics, Vehicle-1 plasma characterization has done and the selected data are shown in Fig. 2.

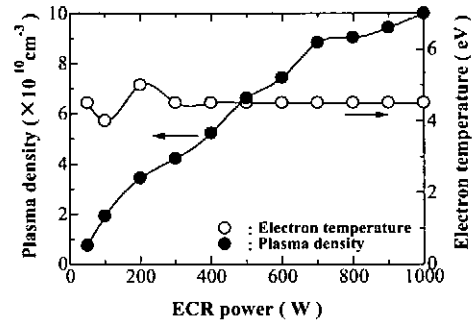


Fig. 2 Vehicle-1 plasma characteristics [5].

Using the H-alpha intensity as the measure of hydrogen recycling, hydrogen recycling kinetics has been analyzed to obtain the recycling time constants. Because reciprocal time constants are considered to be equivalent to rate constants, these are plotted in the Arrhenius manner. Notice that there is a break at temperatures around 300°C, indicative of a change of the rate-limiting step. The activation energies below and above the break are 0.095 eV and 0.17 eV, respectively. Currently, it is conjectured that surface sticking is the rate limiting at low temperatures whereas recombinative desorption is the one at high temperatures. More detailed analysis is under way.

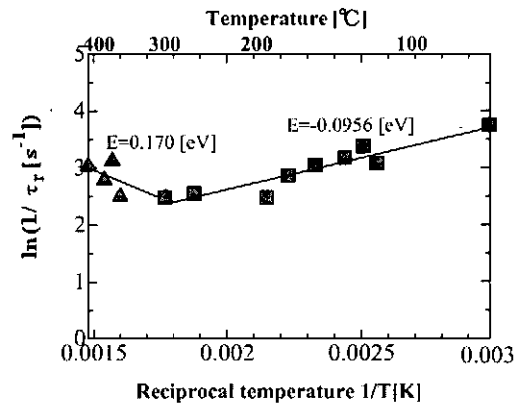


Fig. 3 Reciprocal recycling time constants [5].

References

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