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LBL-3977 Summary
c.1

HYDROGEN ATTACK OF FUSION REACTOR FIRST WALLS MADE OF GRAPHITE

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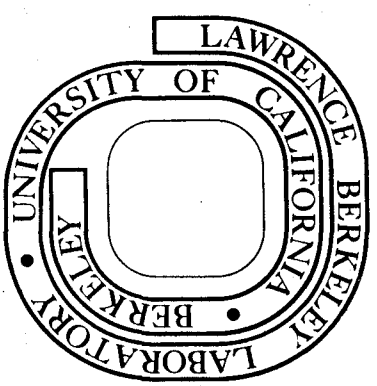

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DISCLAIMER

HYDROGEN ATTACK OF FUSION REACTOR FIRST WALLS MADE OF GRAPHITE*

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Recently, considerable attention has been devoted towards exploiting the desirable features of graphite either as a first wall material[1] or as a shield for a conventional metallic first wall[2-4]. One aspect of the suitability of graphite for this purpose is its reactivity with plasma hydrogen. Although graphite, at temperatures below 2000°C, is relatively resistant to attack by the molecular form of hydrogen, significant fluxes of atomic hydrogen impinge upon graphite structures in a CTR. We have examined the reaction of H atoms with pyrolytic graphite using the apparatus shown in Fig. 1. A beam of mixed H and H_2 is produced by thermal dissection and effusion from an oven containing a few torr of hydrogen gas at ∿2500°K. The beam travels through the vacuum to the target which is either the prism or basal plane orientation of high-temperature annealed pyrolytic graphite. The flux of thermal H atoms on the target is $\sim 10^{17}$ atoms/cm^2-sec. Reaction products emitted from the surface are detected by a mass spectrometer which is in line-of-sight of the target. The system contains a beam chopper and employs phase-sensitive detection in order to improve the signal-to-noise ratio and to provide information on the residence time of the product species on the surface.

Figure 2 shows the temperature dependence of the reaction probability, which is the ratio of the flux of reaction product to the flux of impinging H atoms. At low temperatures, methane is the sole reaction product. Between 800 and 1000°K, little graphite gasification occurs because the surface acts simply to recombine

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H atoms to form H_2. At high temperatures, acetylene is the principal product. The rates shown in Fig. 2 are quite large; at 2500 °K, about one out of 200 hydrogen atoms impinging on the prism plane react to form C_2H_2. In thermal beam experiments, reaction is limited by the fraction of the impinging H atoms which stick (i.e., do not reflect) to the surface. In a plasma, however, energetic H ions or neutrals will be trapped beneath the surface with a trapping probability on the order of 0.1. H atoms stopped in the bulk can readily diffuse to the surface where thermal reaction to produce hydrocarbons proceeds in the same manner as if the atoms were directly deposited there from a thermal beam. Thus, a typical energetic hydrogen flux of 10^{16} particles/cm^2-sec on the first wall of a CTR is equivalent to a thermal H atom flux of 10^{17} atoms/cm^2-sec insofar as assessing carbon gasification is concerned. Using the data obtained in the present study, the graphite corrosion velocity is found to be $\sim$3 mm/yr. It does not appear to be realistic to regard a graphite first wall shield as chemically inert to the plasma.

References:

1. G. Hopkins, D. Kearney, and L. Rovner, Trans. Amer. Nucl. Soc. 21, 54 (1975)
2. R. W. Conn and G. L. Kulcinski, ibid.,p 49
3. J. Patten and T. Coultas, ibid., p 53
4. G. A. Carlson, ibid., p 20

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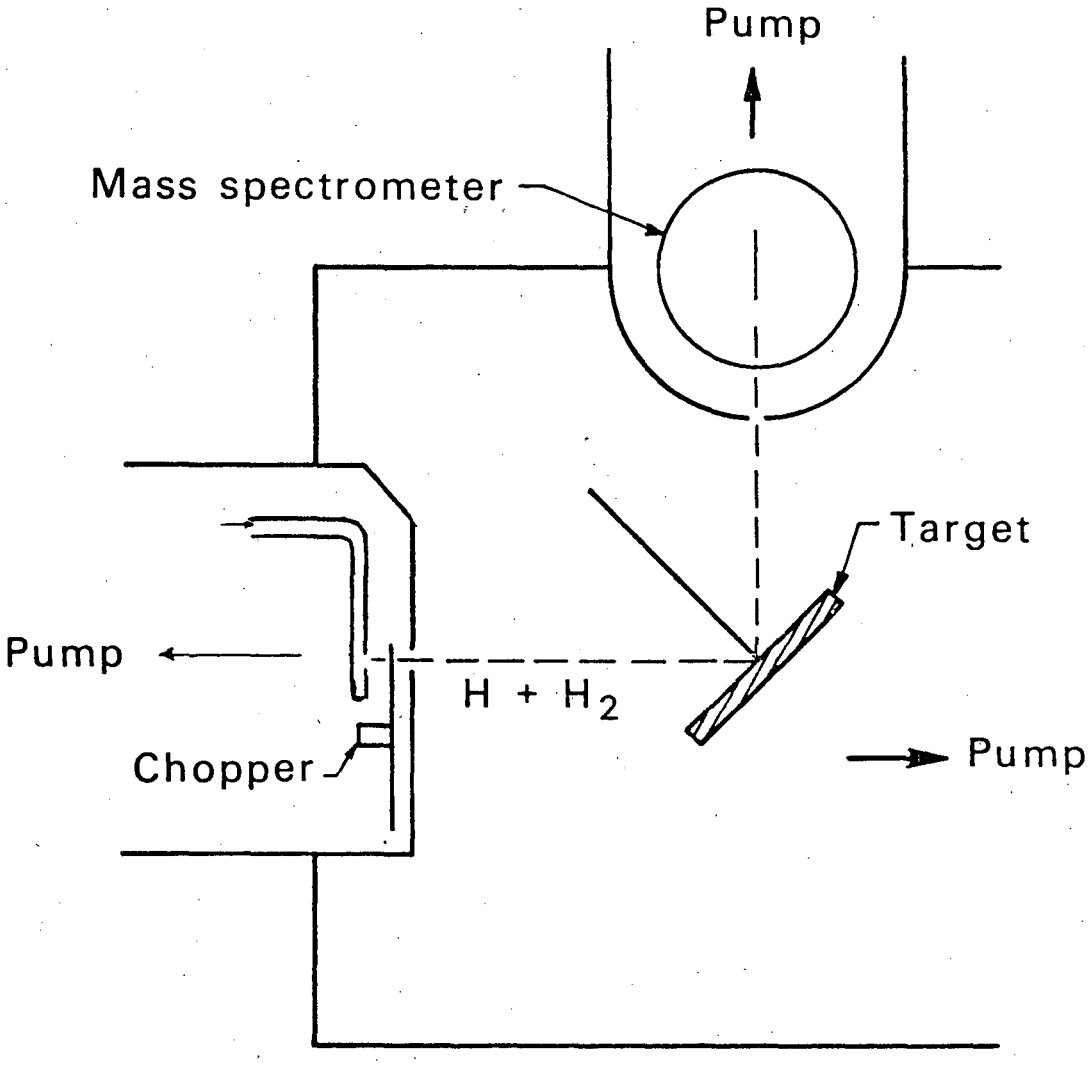

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Fig. 1

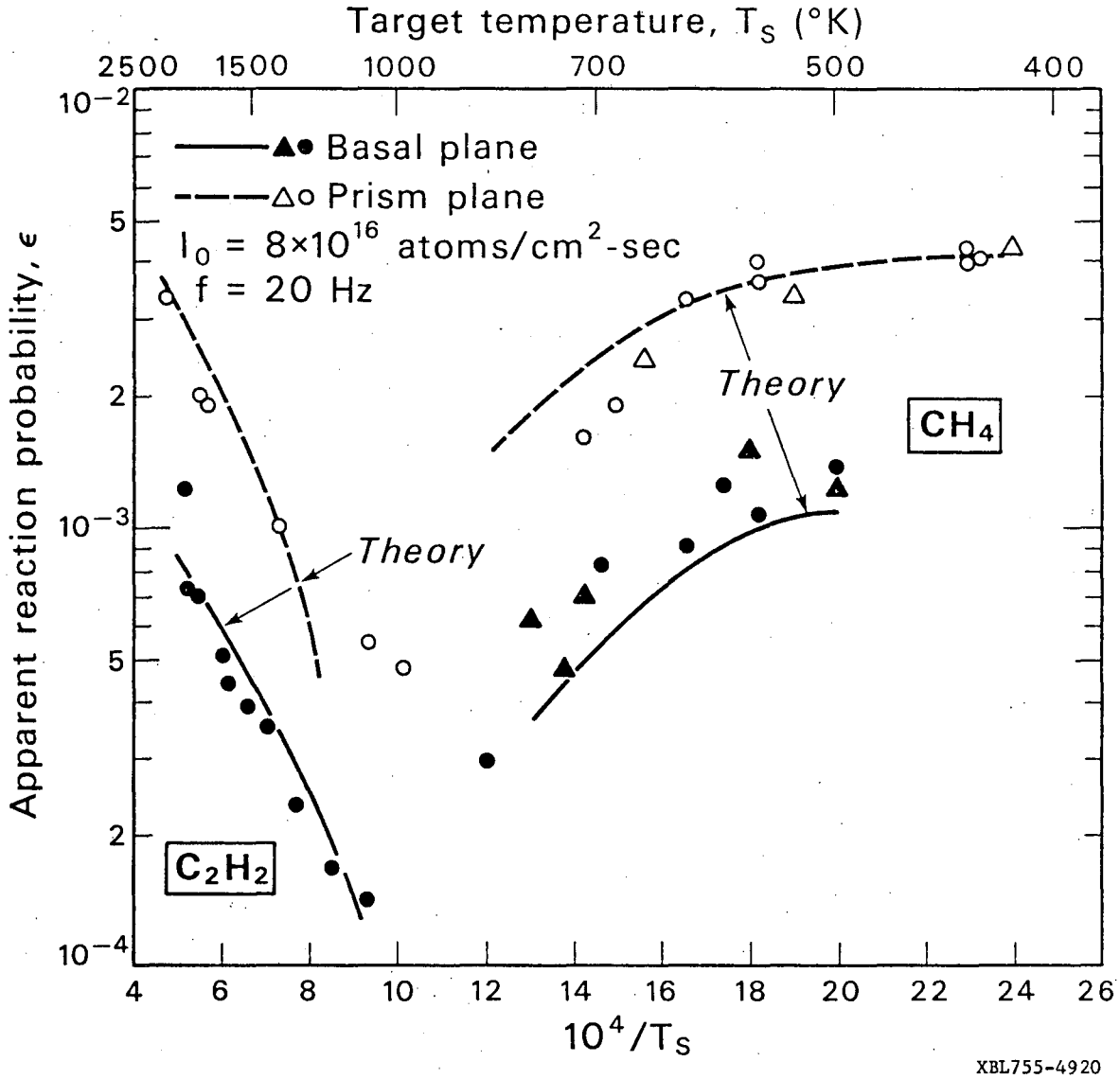

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Fig. 2

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