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Several years ago, Jennings and Linnett[1,2] reported difficulties in obtaining stable microwave discharges in hydrogen at pressures below 120 mtorr with powers as high as 250 W. Although Fehsenfeld, Evenson, and Broida recently provided a solution to these difficulties—improved microwave cavities operating at as low as 1 mtorr with 100 W of input power[3]—there is an alternative technique (which is not widely appreciated) to improve the performance of less efficient microwave cavities: the cyclotron-resonant microwave discharge.

First thoroughly described by Buchsbaum, Gordon, and Brown, the technique simply requires the excitation of a microwave discharge in the presence of a magnetic field whose intensity is given by the formula for the electron cyclotron frequency, $B = m\omega/e$, where ω is the microwave radian frequency and e/m is the charge-to-mass ratio for the electron (B is 880 G at 2.45 GHz).[4] The action of the magnetic field decreases the rate of loss of electrons to the discharge-tube walls by forcing them to orbit the field axis rather than travel in straight paths. The result is a lower breakdown potential and a reduction in the power levels required to sustain the dicharge.

Since frequency is an unimportant parameter in the production of atoms from a low-pressure discharge, the apparatus of Buchsbaum et al. can be simplified. A large magnetron magnet (9-cm pole gap, 40-cm^2

pole-face area, and 1400-G maximum field strength) was employed instead of the electromagnet to minimize the complexity and power requirements of the equipment. The field inhomogeneity of the permanent magnet was actually an asset, since it reduced the sensitivity of the discharge to perturbations in frequency, and in principle permitted the use of a broad-band microwave source.

The advantage of this type of discharge over others used was that it could be sustained with as little as 250 mW absorbed power in hydrogen at 75 mtorr. Power levels above 2.5 W did not substantially increase the yield of hydrogen atoms. Water was shown to have no effect, but oxygen increased the atom yield by at least 2 atoms per molecule of oxygen added (as measured by a Wrede-Harteck gauge).[5]

With improvements in microwave power transistors, it should soon be possible to construct an inexpensive and compact microwave power-supply—magnet—cavity assembly for use with ESR spectrometers and room-temperature discharges, and perhaps to increase the power efficiency of some gaseous lasers.

FOOTNOTES AND REFERENCES

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