regard to their operation in a PEMFC environment. Siemans reported a performance of 400 mA/cm^2 and LANL quoted 300 mA/cm^2, both at 0.5 V, with Nafion 117 electrolyte and platinum/ruthenium anode catalysts. While these performances are considerably higher than those achieved in the past using systems based on a liquid sulphuric acid electrolyte, there is still a need for major catalyst development to reduce the anode overpotential and increase the current density. A further significant problem in this system is methanol permeation through the polymer electrolyte membrane to the cathode.

Other Applications

Fuel cells continue to be developed for numerous military related applications. Analytic Power Corporation reported on portable hydrogen-fuelled PEMFC units, rated from 50 to 500 W, for applications such as powering backpack microclimate cooling systems. Studies show that the units can effectively replace batteries on performance and cost, in situations involving long mission times. Direct methanol fuel cells are also being developed for these applications under U.S. Government Advanced Research Projects Agency contracts.

Ballard PEMFC systems are being developed as power sources for submarines. A one-tenth scale 40 kW technology demonstrator, fuelled on reformed methanol with liquid oxygen as the oxidant, is due to be developed by 1996. Design studies on an 850 kW PEMFC for application as the service generators of ships are also being undertaken. A particularly challenging target in this programme is to develop a multi-fuel reformer, which can operate on logistic fuels. IFC have also demonstrated a high power-density 10 kW prototype of a 20 kW PEMFC system, designed to be installed in a 44-inch unmanned undersea vehicle, as a higher energy-density replacement for the currently used silver-zinc batteries. IFC believe that this power plant will have high reliability, durability and mission duration. This is due to design features in which the hydrogen side of the power plant is dead-ended, and on the cathode side a passive water removal system is used, thereby avoiding the circulation of gaseous reactants.

Conclusions

The 1990s will be the most significant period in the long development of fuel-cell power generation systems. The first PAFC co-generation plants are proving to be highly efficient and reliable generators, but further developments of the fuel cell, or the emergence of PEMFC stationary plants, are required before a fully commercial, cost effective product is available, near the end of the decade. Opportunities for using fuel cells in transportation have been provided by the impending legislation in the U.S.A. and the U.S. Government programme to improve vehicle fuel economy. Rapid progress is being made in overcoming technical and economic hurdles in the development of PEMFC based systems, and the late 1990s should see the start of a large scale use of this clean, efficient technology for powering vehicles – with the first markets likely to be heavy-duty transit buses. G.A.H., T.R.R.

Nanocatalysis Uses Platinum-Rhodium Tip

Studying the atomic structures involved in catalysis under catalytic conditions is possible using the recently developed scanning tunnelling microscope (STM) that operates inside a reactor cell. This equipment has enabled the STM tip to pattern a surface and manipulate atoms. Researchers at the University of California, Berkeley, have suggested that the tip can be made to act catalytically to produce investigable surface reactions (B. J. McIntyre, M. Salmeron and G. A. Somorjai, *Science*, 1994, **265**, (5177), 1415–1418).

With a platinum-rhodium STM tip in a reactor cell and a propylene atmosphere ordered propylidyne structures were formed on the platinum surface. Carbon monoxide and propylene-hydrogen mixtures were introduced into the cell to observe the reaction, and characteristic clusters were seen after activation of the tip by short electric pulses. The catalytic action caused by the tip may be atomisation of hydrogen from the gas phase and hydrogenation of the carbon bonds of the clusters under it.

This method provides possible insights into atomic-scale structures and the kinetics of local catalytic activity, which presently is only studied in an average way by more conventional tools.