STATUS REPORT

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Solid electrolytes or superionic conductors embrace a rapidly changing field. Some 15 years ago three major changes nearly coincided concerning oxygen, sodium and silver conductors, respectively. Thus, around 1970 there was a drastic cut in the support for work on high-temperature fuel cells working with electrolytes such as calcia-doped zirconia. Obviously, both research-supporting agencies and industry had been too optimistic around 1960. The backlash was so strong that for several years it seemed to be very improper even to mention solid electrolyte fuel cells as a possible field of research. Work has recommenced, however, in recent years, and considerable progress has been reported. The sodium–sulphur battery with the solid electrolyte β-alumina was proposed in 1967. It has been considered of great interest for large scale use in traction or load levelling for several years, but there appears to be a great deal of doubt at present whether these projects can be realized, and the number of applied projects has recently been reduced. At the same time, fascinating discoveries have been made concerning various types of β-alumina, which is no longer considered as a sodium conductor alone.

The applications considered so far concern units in the kW range or greater. In such cases, not only the energy and power density but also capital costs are of major importance. The latter severely limits the choice of possible materials compared with applications where the power demand is modest. It is in this latter field that great expectations arose from reports in 1966 of solid electrolytes with conductivities at ambient temperature comparable with, or even exceeding, those of aqueous solutions. The search for new solid electrolytes became very popular, and it has been very successful indeed over the last 15 years. Today, the list of silver ion conductors is very large, and many examples are known of sodium, copper, fluoride, oxygen, and hydrogen ion conductors. Several other mono- and divalent ions are also known to be mobile in certain materials. There are many examples also of solid, mixed conductors, *i.e.*, materials with both electronic and ionic conductivity. These latter are of interest as electrodes in various power sources. The number of patents involving batteries with solid electrolytes or mixed conductors is very large, but the only commercial breakthrough so far seems to be that of lithium batteries for pace makers. A non-power-source application is as sensors to determine the oxygen content of high temperature melts in the metallurgical industry.

What will the situation be in the next ten years or so? It is very difficult to make predictions in a field where two types of activity are proceeding in

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parallel. One concerns the development of existing concepts into power sources that can compete in the market. The other includes the search for new solid electrolytes as well as a study of the fundamental properties of a large number of materials. There is also a communication problem, since the varieties of solid electrolytes are already so great that important information can easily be overlooked by people working on applications in various fields. Over 300 papers were submitted to the Conference on Solid State Ionics at Grenoble in July, 1983. They were classified into 17 different groups, and some of these had subgroups. These figures are presented to give an indication of how large and diversified the activities are at present. Thus, the following paragraphs can only be considered as being my personal judgement of what we can expect the situation to be in the middle of the nineties.

We can expect a growing interest in solid oxide, high-temperature fuel cells, and the chances are good that their usefulness for large scale energy conversion will be firmly established in about 10 years time, but it will probably be at least 10 more years before such fuel cells will actually take over a considerable fraction of the conversion of chemical to electrical energy. The situation is complicated by the fact that it also depends on how the fuel market develops. The other expected high power application of solid electrolytes is in the use of the sodium–sulphur battery for load levelling and for electrical vehicles. Activity during the next few years will be decisive in determining whether these projects must be abandoned. If they are continued, which seems rather uncertain, we should have sufficient experience with engineering prototypes in ten years time to start with full scale units for load levelling.

In respect of low power devices, the chances are good that miniature power sources for electronic units will be available before 1990 with Li^+ ion conductors for primary batteries and Ag^+ or Cu^+ conductors for secondary batteries and double layer capacitors. In a few years' time we will know much more about the possibilities of using solid electrolytes in photochemical (photogalvanic) cells to transform solar energy into electricity or hydrogen. There is, however, also, competition with concepts using aqueous electrolytes, and it is much too early to say which of the alternatives will be chosen for applications concerning solar energy. Finally, I am convinced that there will be much more use in the near future of solid electrolytes for various analytical applications in the laboratory as well as in industry.