sensitivity, real-time deposition monitor was needed to continue Pd film deposition development.

The new deposition monitor utilizes a surface acoustic wave (SAW) device in a differential delay-line configuration to produce both a reference response and a response for the portion of the device on which the film is being deposited. Both responses are monitored simultaneously during deposition. The reference response remains unchanged, while the attenuation of the sensing path (where the film is being deposited) varies as the film thickness increases.

This device utilizes the fact that on high-coupling piezoelectric substrates, the attenuation of an SAW undergoes a transition from low to very high, and back to low as the conductivity of a film on the device surface goes from nonconductive to highly conductive. Thus, the sensing path response starts with a low insertion loss, and as a conductive film is deposited, the film conductivity increases, causing the device insertion loss to increase dramatically (by up to 80 dB or more), and then with continued film thickness increases (and the corresponding conductivity increases), the device insertion loss goes back down to the low level at which it started. This provides a continuous, real-time monitoring of film deposition. For use with different films, the device would need to be calibrated to provide an understanding of how film thickness is related to film conductivity, as the device is responding primarily to conductivity effects (and not to mass loading effects) in this ultrathin film regime.

This work was done by Jacqueline Hines of Applied Sensor Research & Development Corp. for Glenn Research Center. Further information is contained in a TSP (see page 1).

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Innovative Partnerships Office, Attn: Steven Fedor, Mail Stop 4–8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-18651-1.

Optimized Li-Ion Electrolytes Containing Triphenyl Phosphate as a Flame-Retardant Additive

This technology is applicable to portable electronics, electric vehicles, and other applications requiring safety and performance over a wide temperature range.

NASA's Jet Propulsion Laboratory, Pasadena, California

A number of future NASA missions involving the exploration of the Moon and Mars will be "human-rated" and thus require high-specific-energy rechargeable batteries that possess enhanced safety characteristics. Given that Li-ion technology is the most viable rechargeable energy storage device for near-term applications, effort has been devoted to improving the safety characteristics of this system. There is also a strong desire to develop Li-ion batteries with improved safety characteristics for terrestrial applications, most notably for hybrid electric vehicle (HEV) and plug-in hybrid electric vehicle (PHEV) automotive applications. Therefore, extensive effort has been devoted recently to developing non-flammable electrolytes to reduce the flammability of the cells/battery.

A number of electrolyte formulations have been developed, including systems that (1) incorporate greater concentrations of the flame-retardant additive (FRA); (2) use di-2,2,2-trifluoroethyl carbonate (DTFEC) as a co-solvent; (3) use 2,2,2-trifluoroethyl methyl carbonate (TFEMC); (4) use mono-fluoroethylene carbonate (FEC) as a co-solvent and/or a replacement for ethylene carbonate in the electrolyte mixture; and (5) utilize vinylene carbonate as a "SEI promoting" electrolyte additive, to build on the favorable results previously obtained.

To extend the family of electrolytes developed under previous work, a number of additional electrolyte formulations containing FRAs, most notably triphenyl phosphate (TPP), were investigated and demonstrated in experimental MCMB (mesocarbon microbeads) carbon-$LiNi_{0.8}Co_{0.2}O_2$ cells. The use of higher concentrations of the FRA is known to reduce the flammability of the electrolyte solution, thus, a concentration range was investigated (i.e., 5 to 20 percent by volume). The desired concentration of the FRA is the highest amount tolerable without adversely affecting the performance in terms of reversibility, ability to operate over a wide temperature range, and the discharge rate capability.

The use of fluorinated carbonates, much in the same manner as the incorporation of fluorinated ester-based solvents, was employed to reduce the inherent flammability of mixtures. Thus, electrolyte formulations that embody both approaches are anticipated to have much lower flammability, resulting in enhanced safety.

This work was done by Marshall C. Smart and Ratnakumar V. Bugga of Caltech and G. K. Surya Prakash and Frederick C. Krause of the University of Southern California for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1).

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to:

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