Li/CF_x Cells Optimized for Low-Temperature Operation

Several prior developments are combined.

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Some developments reported in prior *NASA Tech Briefs* articles on primary electrochemical power cells containing lithium anodes and fluorinated carbonaceous (CF_x) cathodes have been combined to yield a product line of cells optimized for relatively-high-current operation at low temperatures at which commercial lithium-based cells become useless. These developments have involved modifications of the chemistry of commercial Li/CF_x cells and batteries, which are not suitable for high-current and low-temperature applications because they are current-limited and their maximum discharge rates decrease with decreasing temperature.

One of two developments that constitute the present combination is, itself, a combination of developments: (1) the use of sub-fluorinated carbonaceous (CF_x wherein x<1) cathode material, (2) making the cathodes thinner than in most commercial units, and (3) using non-aqueous electrolytes formulated especially to enhance low-temperature performance. This combination of developments was described in more detail in "High-Energy-Density, Low-Temperature Li/CF_x Primary Cells" (NPO-43219), *NASA Tech Briefs*, Vol. 31, No. 7 (July 2007), page 43. The other development included in the present combination is the use of an anion receptor as an electrolyte additive, as described in the immediately preceding article, "Additive for Low-Temperature Operation of $Li\text{-}(CF)_n$ Cells" (NPO-43579).

A typical cell according to the present combination of developments contains an anion-receptor additive solvated in an electrolyte that comprises $LiBF_4$ dissolved at a concentration of 0.5 M in a mixture of four volume parts of 1,2 dimethoxyethane with one volume part of propylene carbonate. The proportion, x, of fluorine in the cathode in such a cell lies between 0.5 and 0.9. The best of such cells fabricated to date have exhibited discharge capacities as large as 0.6 A·h per gram at a temperature of –50 °C when discharged at a rate of $C/5$ (where C is the magnitude of the current, integrated for one hour, that would amount to the nominal charge capacity of a cell).

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Number Codes Readable by Magnetic-Field-Response Recorders

Where useable, these codes offer advantages over conventional optical bar codes.

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A method of encoding and reading numbers incorporates some of the features of conventional optical bar coding and radio-frequency identification (RFID) tagging, but overcomes some of the disadvantages of both: (1) Unlike in conventional optical bar coding, numbers can be read without having a line of sight to a tag; and (2) the tag circuitry is simpler than the circuitry used in conventional RFID.

The method is based largely on the principles described in "Magnetic-Field-Response Measurement-Acquisition System" (LAR-16908), *NASA Tech Briefs*, Vol. 30, No. 6 (June 2006) page 28. To recapitulate: A noncontact system includes a monitoring unit that acquires measurements from sensors at distances of the order of several meters. Each sensor is a passive radio-frequency (RF) resonant circuit in the form of one or more inductor(s) and capacitor(s). The monitoring unit — a handheld unit denoted a magnetic field response recorder (MFRR) — generates an RF magnetic field that excites oscillations in the resonant circuits resulting in the sensors responding with their own radiated magnetic field. The resonance frequency of each sensor is made to differ significantly from that of the other sensors to facilitate distinction among the responses of different sensors. The MFRR measures selected aspects of the sensor responses: in a typical application, the sensors are designed so that their resonance frequencies vary somewhat with the sensed physical quantities and, accordingly, the MFRR measures the resonance frequencies and variations thereof as indications of those quantities.

In the present method, the resonance circuits are not used as sensors. Instead, the circuits are made to resonate at fixed frequencies that correspond to digits to be encoded. The number-encoding scheme is best explained by means of examples in which each resonant circuit consists of a spiral trace inductor electrically connected to a set of parallel-connected capacitors in the form of interdigitated electrode pairs (see figure). The inductor and capacitor(s) in each resonant circuit can be fabricated as a patterned thin metal film by means of established metal-deposition and -patterning techniques. The capacitance and, hence, the resonance frequency, depends on the number of interdigitated electrodes connected to the inductor. In a similar manner, sets of electrodes could be used.

Initially, in each resonant circuit as fabricated, the number (N) of interdigitated electrode pairs equals the base (e.g., 10) of the number system of the