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Detecting Change in Battery Condition and Preventing Damage Using Integrated Sensors

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ABSTRACT

During their operational life, rechargeable batteries in consumer electronic devices such as smartphones, tablets, wearables, laptops, etc. can experience changes that can pose a safety hazard, e.g., swelling, leakages, etc. This disclosure describes techniques that use sensors integrated within the battery to measure battery parameters such as pressure, humidity, chemical composition, temperature, number of charge-discharge cycles, etc. to detect changes in battery condition. Corrective action is taken to prevent battery damage, e.g., by limiting the maximum voltage, charging level, charging or discharging current, shutting down or disconnecting the battery, etc.

KEYWORDS

- Battery swelling
- Battery leakage
- Battery damage
- Rechargeable battery
- Integrated sensor
- Battery sensor
- Battery cycle
- Maximum voltage
- Device safety
- Charge level

BACKGROUND

During their operational life, rechargeable batteries in consumer electronic devices such as smartphones, tablets, wearables, laptops, etc. can experience changes that can pose a safety hazard, e.g., swelling, leakages, etc. A battery swell can also impact its surrounding enclosure and electronics, e.g., it can pop up or dislocate the display of the device. In some situations, battery swell below a certain threshold, e.g., 10%, can be accounted for in the battery design; however, battery swell beyond the design threshold is unacceptable. Chemicals in batteries can leak out, e.g., due to extreme temperature, accidental overcharging, abnormal discharging, failure of protection circuitry, etc. Defects in a cell can cause current to build up rapidly in turn leading to an unacceptable rise in temperature.

DESCRIPTION

This disclosure describes techniques that use sensors integrated within the battery to measure one or more battery parameters such as pressure, humidity, chemical composition, temperature, number of charge-discharge cycles, etc. to detect changes in battery condition. The sensors are integrated in a manner similar to the sensors used to monitor the fuel (energy) level of batteries. Corrective action is taken to prevent battery damage, e.g., by limiting the maximum voltage or charging level; shutting down or disconnecting the battery; activating protection circuitry to lower the charging or discharging rate of the battery; changing the usage of the battery; etc.

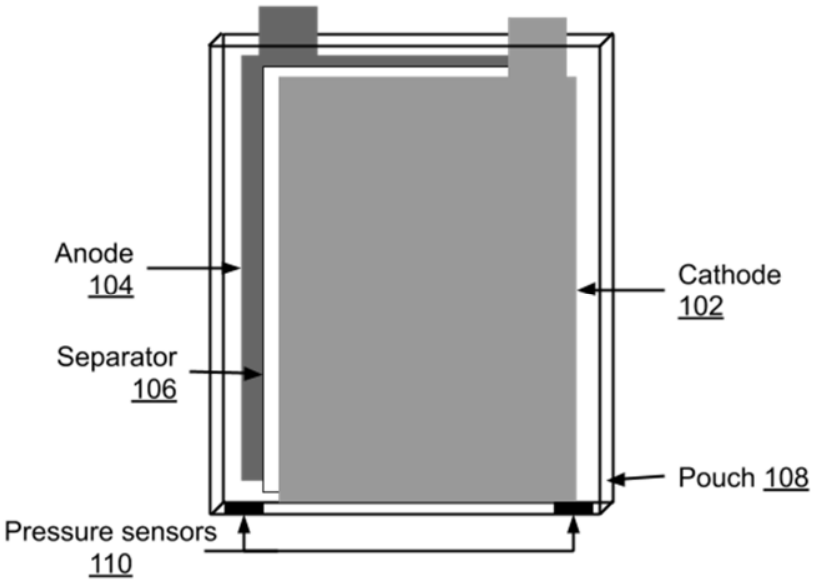

Fig. 1: Battery pack with integrated pressure sensors

Fig. 1 illustrates an example of a battery pack with integrated pressure sensors, per techniques of this disclosure. A battery pack includes one or more cells. A cell includes a cathode electrode (102), an anode electrode (104), and a separator layer (106) that separates the two electrodes. The cells are enclosed within a pouch (108).

One or more pressure sensors (110) are integrated onto the surface of the pouch at sufficient spacing from one another. The pressure sensors are configured to detect pressure within the pouch or changes thereof. The detected pressure is reported to a processor. The reported pressure is compared to a threshold pressure level, e.g., a predefined nominal pressure level at which swelling of the pouch occurs, based on battery manufacturer specification.

If the reported pressure value or the rate of change of pressure values are above nominal values given the age of the battery, corrective action is taken to prevent damage to the battery. For example, if the upper charge voltage of the battery is 5 volts, the processor can provide instructions to lower the upper charge voltage to 4.9 volts. As another example, if the number

of charge-discharge cycles and the rate of swell are both nominal, then normal battery operation is continued. If the number of cycles is within specification but the swell rate is higher than a threshold, the charge current is lowered. Protective actions can include disconnecting the battery. The age of the battery can be measured, e.g., as the number of charge-discharge cycles that the battery has experienced, as the time passed since manufacture, etc.

In a similar manner, humidity, temperature, chemical composition, or other types of sensors can be integrated into the battery pack. For example, chemical sensors can be configured and installed within the pouch to detect particular types of gas or liquid chemicals that may leak out of the cells into the pouch. The chemical sensors can detect the type of chemicals and provide this information to the processor. The sensors can be shaped and sized such that they seamlessly integrate with the pouch and the battery enclosure without changing the dimensions or shape of the pouch or enclosure.

Follow up actions can then be performed by the processor based on the type of detected chemicals. Temperature sensors can report temperature readings to the processor. If the temperature exceeds a threshold temperature, the processor can initiate action to prevent battery damage, e.g., limiting the charging current, disconnecting the battery, etc. The values from different sensors may each be subjected to different thresholds and corrective action can be performed based on a combination of the different comparisons. In this manner, the readings of sensors integrated within the battery pack can be fused (combined) to protect the battery from damage and prevent device safety-related incidents.

CONCLUSION

During their operational life, rechargeable batteries in consumer electronic devices such as smartphones, tablets, wearables, laptops, etc. can experience changes that can pose a safety

hazard, e.g., swelling, leakages, etc. This disclosure describes techniques that use sensors integrated within the battery to measure battery parameters such as pressure, humidity, chemical composition, temperature, number of charge-discharge cycles, etc. to detect changes in battery condition. Corrective action is taken to prevent battery damage, e.g., by limiting the maximum voltage, charging level, charging or discharging current, shutting down or disconnecting the battery, etc.