“Breathing” of secondary battery at cycling. Non-destructive ultrasonic control method.

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The paper is devoted to the development and investigation of the non-destructive control methods of lithium power sources. At the same time the prospect to use the non-destructive control methods for the investigation of electrode structure during cycling of secondary lithium batteries has been shown.

High level of reliability and serviceability is of particular concern at using lithium secondary batteries. Application of non-destructive control methods enable 100% control of the batteries during their manufacture and before handing over to a customer.

In actual prototypes of power sources availability of the irregularity of their structure, non-uniform and incomplete impregnation with electrolyte, contact discontinuity between the elements (current lead-anode-electrolyte-cathode-current lead) and others are possible. All these defects influence significantly on the discharge capacity of chemical power sources.

During the discharge process of power source the redistribution of volumes between the components of electrode structure occurs. Cathode volume increases, volume of lithium anode decreases. At cycling electrode structure “breathes” – cyclic changes of electrode volumes take place. In the case of disbalanced element such side undesirable effects as loss of contact between structure components or, quite the reverse, break of separator and short circuits are possible.

Pulse shadow ultrasonic control method is promising, reliable and informative both for battery control and their investigation in cycling process. In the case of mechanical and, therefore, acoustic contact unavailability between the components of electrode structure, the pulse of mechanical ultrasonic oscillations falling on the interface will be completely reflected from a clearance and will not penetrate through chemical power source on a receiving converter.

In the work the mathematical description of the propagation of elastic ultrasonic oscillations in multi-layer system is presented. It has been shown that in the case when elastic wave falls on the interface dividing two media with the different acoustic impedances, at the calculation of reflection and wave passing two boundary conditions should be taken into consideration:

- condition of the particle rate continuity V at the interface,
- condition of the continuity of acoustic overpressure P at the interface.

The investigation results of lithium secondary power sources with liquid, polymer and solid inorganic electrolyte at the different stages of cycling using the developed pulse shadow ultrasonic method and specially developed primary ultrasonic converters providing a dry contact [2,3] through the elastic protector (e.g. polyurethane), or by non-contact excitation and the method of acoustic oscillations with the help of magneto-acoustic method [4] are presented.

These control methods are especially actual when independent power sources are used under extreme conditions (the cosmos, aviation, desert, under water).

The prospects for automatic control by ultrasonic method are presented.

References.

1. Non Destructive Testing Handbook. Ed. R. McMaster, N.Y., 1959.
2. Control method of the value of acoustic contact area. Redko V.I. Inventor’s certificate of the USSR, No. 375543, March 08, 1973.
3. Material for the manufacture of ultrasonic sensors protector. Redko V.I., Cherny Z.D., Mikhaylenko E.V. Inventor’s certificate of the USSR, No. 672560. March 15, 1979.
4. Electromagnetic converter. Budenkov G.A., Redko V.I. Inventor’s certificate of the USSR, No. 429561. May 25, 1974.
5. Ultrasonic pulse flow detector. – Gershberg M.V., Redko V.I., Sirota D.N. Inventor’s certificate of the USSR, No. 1594414. May 22, 1990.
6. The Foundations of Acoustics. Basic mathematics and basic acoustics. E. Skudrzyk, N.Y., 1971, 426 pages.