A Hybrid Capacitor with 300V Cell Voltage

Jong-Huy Kim, Yong-Sung Lee, Chang-Soo Jin

Energy Conversion and Storage Research Center,
Korea Institute of Energy Research
71-2 Jang-dong Yousung-gu, Daeduck Science Town,
Taejeon, 305-343, KOREA
e-mail: kjhy@kier.re.kr

Comparing with conventional electrolytic capacitors, secondary batteries and electrochemical supercapacitors have limited cell voltages under few Volts no matter how much the capacitances are. Hence, these two types of electrochemical energy storage devices still have technical hurdles of cell voltage balance and ESR increment problems in operating with series wired circuit of cells especially for hundreds Volts of high voltage system such as HEV, FCEV, and UPS systems. Also, the conventional electrolytic capacitor has a serious problem of enhancing its specific energy density in order to expand application areas to such systems as a high power energy storage device.

In this study, to assess a technical possibility for increasing the energy density of electrolytic capacitors with a higher cell voltage up to 300 Volts, a hybrid type of capacitor which has porous aluminum powder based anode and activated carbon based cathode was studied. Aluminum powders of 40 ㎛ mean particle size were mixed with NaCl powders as template materials at 4:1 of weight ratio. The mixed powders were pressed as a disk shape of 25mm diameter and about 1.2mm thickness. Each pressed Al disk was annealed at different temperatures. After dissolving the NaCls of Al disk in 50 ℃ distilled water, heat treatment, electropolishing, and chemical treatment were conducted. Then, two times of etching processes for each Al disk were performed. In every process, capacitances and resistances of the Al disk was measured by ac-impedance analyzer. Based on the measured capacitances and resistances, an optimal treatment condition was selected. Also, the surface morphology of treated disks was observed by means of SEM photographs. After etchings, the Al disk was anodized at 365V so as to operate the hybrid capacitor up to 300V safely.

Capacitance and resistance for the Al disk anode was compared with those of anodized Al foil as used as an anode material in commercialized conventional electrolytic capacitors. As shown in Fig. 1, while the conventional Al foil anode showed not so much variations of the specific capacitance per projected electrode area in the wide band of charge-discharge frequency from 0.01 to 100 kHz, the prepared Al disk anode showed about two order of magnitude variations of the capacitance. At lower frequency of 0.01 Hz, the specific capacitance of Al disk anode showed about 30 times higher capacitance than that of the Al foil anode. But, at higher frequency of 100 kHz, the capacitance of the Al disk anode was about 30 - 40% of the Al foil anode.

For the assembled hybrid capacitor with Al disk anode and EDLC's activated carbon based cathode, and for the commercialized conventional electrolytic capacitor with Al foil anode and etched Al foil cathode, variations of the capacitance ratio with respect to usually defined capacitance at 120 Hz were compared as in Fig. 2. Also, as shown in Fig. 3, variations of the ESR ratio with respect to 1 kHz ESR were compared. The conventional electrolytic capacitor had a limited maximum operating frequency below few tens kHz because of self-resonance frequency. However, for the hybrid capacitor, the ESR decrement continued linearly up to 100 kHz. Therefore, it was able to note that the hybrid capacitor had more widened operational frequency up to 100 kHz.

Acknowledgement : This study was financially supported by Korean Ministry of Science and Technology(MOST) based on the National Lab Research(NRL) program and Korean Institute of Energy Research(KIER).

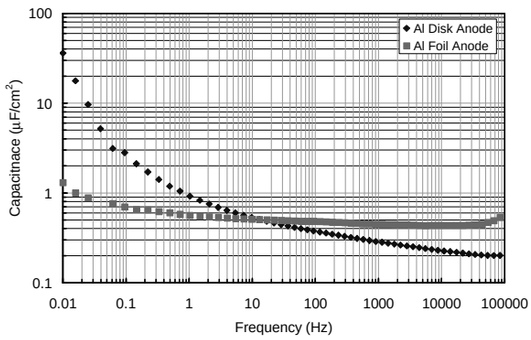

Fig. 1. Specific capacitances of anodized Al disk anode and conventional Al foil anode for 300V cell voltage capacitor.

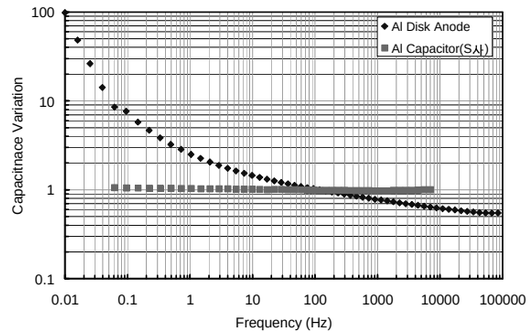

Fig. 2. Capacitance variations of hybrid capacitor and commercialized electrolytic capacitor.

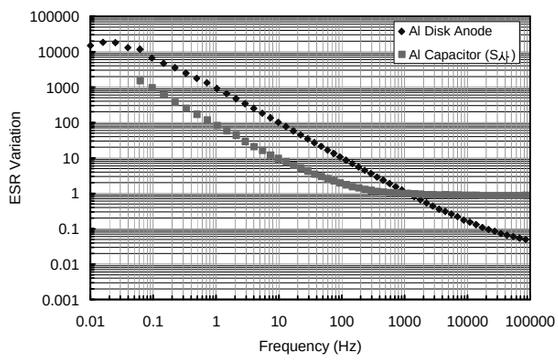

Fig. 3. ESR variations of hybrid capacitor and

commercialized electrolytic capacitor.