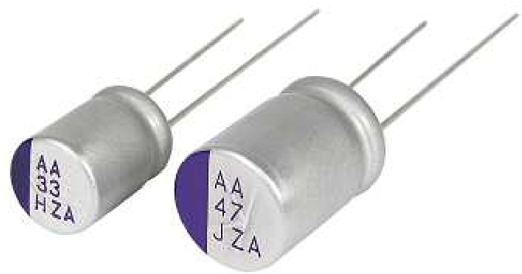
IMPROVEMENT IN WITHSTAND VOLTAGE OF
WOUND-TYPE CONDUCTIVE POLYMER ALUMINUM SOLID ELECTROLYTIC CAPACITOR

Introduction

Under the concern on depletion of global resources due to global warming, radical growth of developing countries and population increase in cities and developing countries, effective utilization of energy is becoming to the common subject, for which many countries have started projects for smart grid, smart city and smart community.
In electric and electronic field, development of products contributing to global warming and reduction of CO_2 emission is now popular. In such circumstances, the market is demanding downsizing and higher performance of electronic devices including aluminum electrolytic capacitor, which is the main product of Rubycon.
Conductive polymer aluminum solid electrolytic capacitor ("Solid Electrolytic Capacitor") has the advantages such as wide operation temperature range, compact, low ESR and high resistance against ripple current, but the only disadvantage is low working voltage under 35V. Then the applications of the capacitor have been restricted as a component of 25V or lower.
Rubycon has brought PZA Series (Photo 1) to the market realizing high withstand voltage with the original technologies, while many capacitor manufacturers have been developing Solid Electrolytic Capacitor at high operation voltage. PZA Series is described in this paper.



（Photo-1）Winding type Conductive Polymer Aluminum Solid Electrolytic Capacitors "PZA Series"

Specifications

Rated Voltage	25～63V.DC
Capacitance	10～150μF
Temperature	-55～ ＋105℃
Size(mm)	φ6.3X8L～φ10X13L
Load Life	105℃　3000hrs

- Standard Size

WV (V.DC)	Cap (μF)	Size	Ripple	ESR
25	100	8X10	2000	29
	120	8X12.5	2400	27
	180	10X10	2400	27
	220	10X13	2800	26
35	22	6.3X8	900	64
	33	8X8	1200	55
	56	8X10	1900	29
	82	8X12.5	2300	27
	100	10X10	2400	27
	150	10X13	2700	26

WV (V.DC)	Cap (μF)	Size	Ripple	ESR
50	12	6.3X8	800	81
	18	8X8	1100	63
	33	8X10	1900	32
	39	8X12.5	2200	29
	47	10X10	2300	29
	68	10X13	2600	28
63	10	8X8	1000	75
	22	8X10	1800	35
	27	8X12.5	2100	33
	33	10X10	2200	31
	47	10X13	2600	29

Size :　φD×L (㎜)
Ripple :　mA r.m.s./105℃,100kHz
ESR :　mΩ,Max/20℃,100kHz

Need of High Working Voltage for Solid Electrolytic Capacitor

Conventional aluminum non-solid electrolytic capacitor ("Al Electrolytic Capacitor") uses liquid electrolyte to work through ion conduction as transfer of electric charges. On the other hand, Solid Electrolytic Capacitor uses electron conduction for such transfer, so that conductivity is 4 or 5 digits higher than that for Al Electrolytic Capacitor, which means superior ESR. It is the reason why Solid Electrolytic Capacitor is good for electronic equipment requiring quick response or high resistance to ripple current.

However conventional Solid Electrolytic Capacitor had poor working voltage not higher than 25V because of less anodic oxide restoration ability of conductive polymer than liquid electrolyte, so that applicable circuits were restricted. Then expectation of high working voltage in Solid Electrolytic Capacitor has been increasing for down sizing and realization of higher performance in electronic equipment.

Features of PZA Series

PZA Series is the product covering from 25 to 63V, which has realized high working voltage beyond the conventional limit voltage of 25V through Rubycon's original polymer technology. The capacitors of the series have the values of impedance and ESR at high frequency range much lower than those for Al Electrolytic Capacitors, so that the capacitors are applicable to high ripple current applications. The capacitors also have smaller characteristic changes where ambient temperature varies widely, as well as long life at actual operating temperature.

Expectations of PZA Series are as follows:

(1) Smaller size and lower ESR than Al Electrolytic Capacitor realize downsizing of electronic equipment.
(2) Large capacitance relieves electronic equipment from use of multiple Al Electrolytic Capacitors, so as to cut costs.
(3) Less characteristic change allows use of small Solid Electrolytic Capacitor instead of much larger Al Electrolytic Capacitor, so as to contribute to downsizing of electronic equipment.
(4) Stable operation in low and ultra low temperature ranges allows removal of extra circuits required for Al Electrolytic Capacitor.
(5) Long life at room temperature reduces maintenance costs of electronic equipment used in remote locations or at height.
(6) Solid Electrolytic Capacitor is applicable to potting and use of desiccant, both of which have been restricted for Al Electrolytic Capacitor that uses liquid electrolyte.

Technical Elements in High-voltage PZA Series

It is necessary to describe why withstand voltage of conventional Solid Electrolytic Capacitor has been low, in order to explain Rubycon's original technology for improvement in the withstand voltage.

Many polymers have been examined for Solid Electrolytic Capacitor, since Dr. Shirakawa who won the Nobel Prize has discovered conductive polymer. One of such conductive polymers is poly-3,4-dioxithiophene (PEDOT).

In the conventional Solid Electrolytic Capacitor, conductive polymer was synthesized in the capacitor element. The polymerization reaction of conductive polymer is shown in Fig. 1. Monomer ethylene dioxithiophene (EDOT) is synthesized into polymer (PEDOT) through oxidation polymerization. A highly acidic iron compound is used as an oxidant for the polymerization.

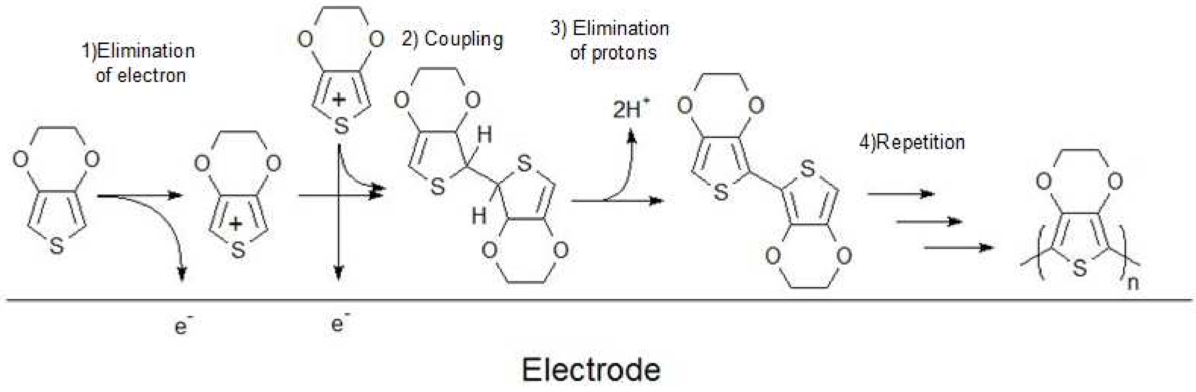


Fig-1 PEDOT Polymerization process

The polymerization affects capacitor's characteristics, reducing withstand voltage and life.

The cause of reduction in capacitor's withstand voltage is considered to be hydrogen ion produced in the polymerization, which attacks oxide film on the surface of anode foil.

The iron compound and the strong acid remain in the capacitor element even after the polymerization, which could cause increase of leakage current or short circuit in hot life test or humid life test. Then methods to remove such risks have been examined.

The key point in production of such capacitor is polymerization of highly conductive PEDOT and filling the polymer over the element. Stabilizing agents and reaction control agents are inevitable to obtain stable capacitor performance. But it is unable to use stabilizing agents and reaction inhibitors hindering such polymerization. Another problem is that addition of stabilizing agents is difficult after polymerization since element is fully covered with polymer.

The concept of development of PZA Series is effective filling of PEDOT and retention of high performance of capacitor element together with inclusion of stabilizing agents. Production factors of PZA Series are as follows:

(a) To remove attack of hydrogen ion to anode foil in polymerization
(b) To use PEDOT not including iron compounds or strong acid as well as residue of polymerization
(c) To effective fill PEDOT over capacitor element
(d) To add stabilizing agents and reaction inhibitors to maintain reliability of capacitor in hot life and humid life tests.

PZA Series adopting high-purity PEDOT realizes high working voltage with the minimum damage to capacitor element. The new filling method brings high capacitance and low ESR.

In the new series not accompanying polymerization within capacitor element, easy addition of stabilizing agents and reaction inhibitors drastically improves reliability of the capacitor. Such stabilizing agents and reaction inhibitors restore oxide film of anode foil as well as in Al Electrolytic Capacitor, if the oxide is damaged. The image of the new stabilizing agents is shown in Fig. 2.

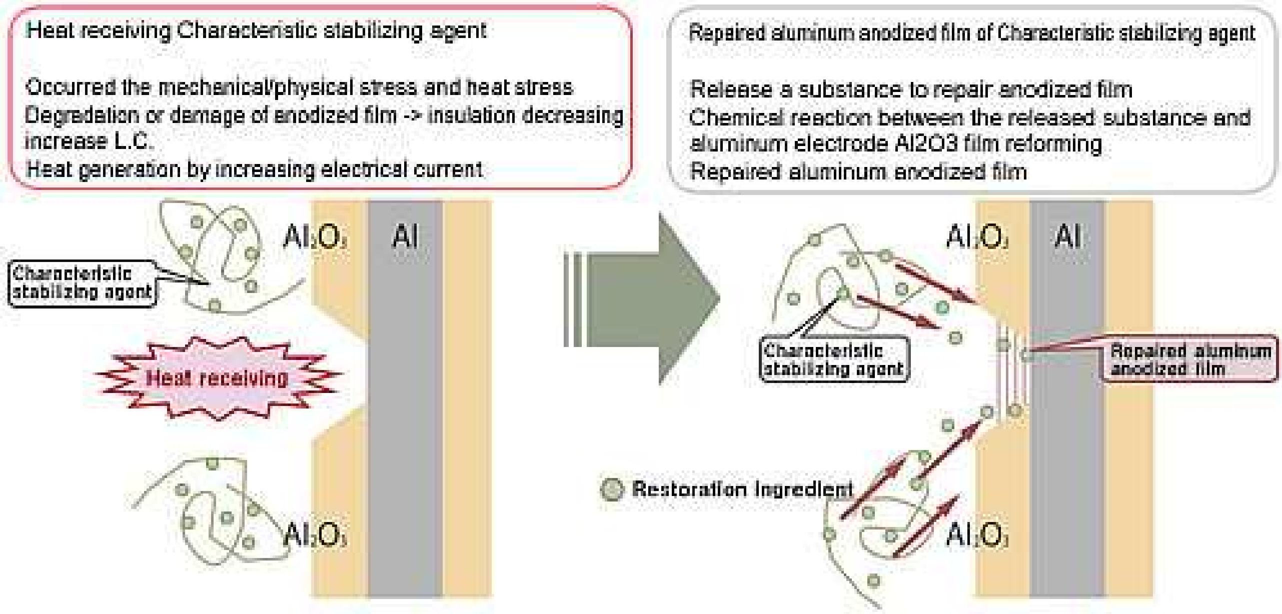
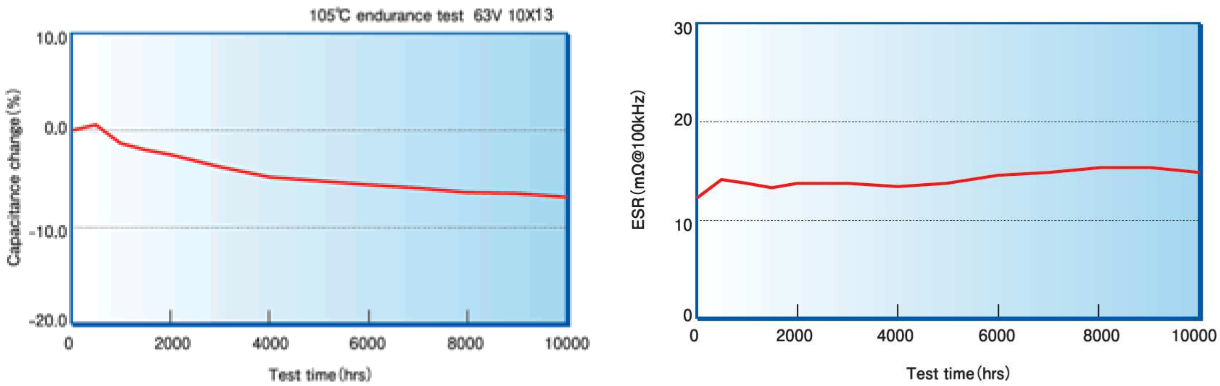


Fig-2 Aluminum anaolized film repair (Image) by characteristic stabilizing agent

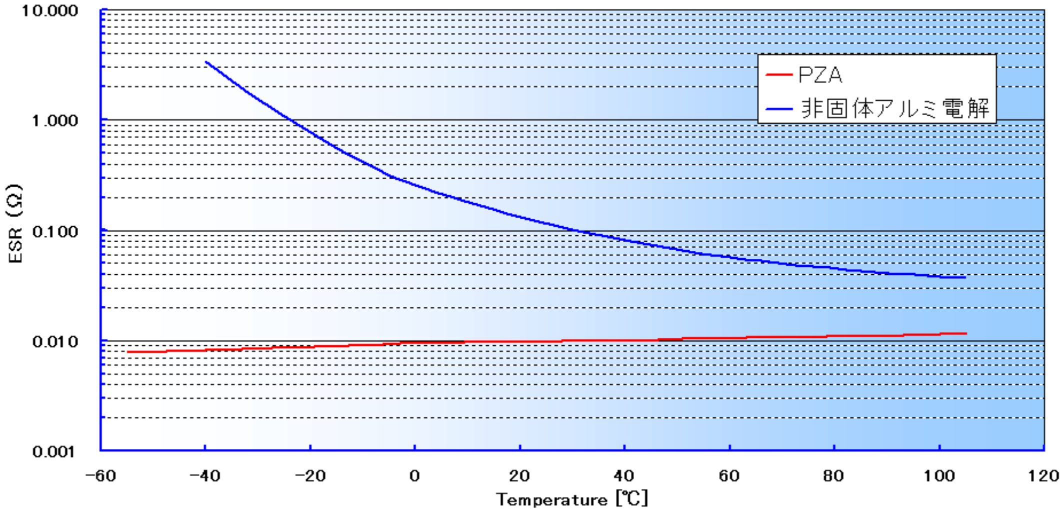
The stabilizing agents and reaction inhibitors have no adverse effect on capacitor in practical use and life tests as well as in initial characteristics, but keep capacitor in good performance. The amount of such agents has carefully been designed to be enough through the life of capacitor even with a severe environment.

Graph 1 shows the data (variation in capacitance and ESR) for 63V capacitors, which have first been realized. The graph reveals stable performance over the long period.



Graph-1 : High temperature load test result of PZA Series(Capacitance change/ESR)

Graph 2 shows temperature characteristics from -55 to +105°C. Variation of capacitance and impedance for PZA Series is quite small over the temperature range, while capacitance and impedance of Al Electrolytic Capacitor start reducing at -25°C and are very low under -40°C.



Graph 2: ESR – Temperature Characteristics

We have successfully developed high voltage Solid Electrolytic Capacitor that fully utilizes withstand voltage of capacitor element itself from production process to the end of life, through improvement in resistance to short circuit and provision of high film restoration ability.

Ending

PZA Series covers high voltage range that has never been covered by conventional Solid Electrolytic Capacitor, and is expected as a high-performance capacitor for the applications such as low EDR, high ripple current, stability in low temperature and long life.

We, at Rubycon, are expanding lineup of Solid Electrolytic Capacitor as an electronic device for wide applications.

Downsizing of electronic equipment will further advance in the views of costs, performance and environment preservation. Then we are proactively addressing to developments of non-solid capacitor, film capacitor and electric double layer capacitor, in addition to Solid Electrolytic Capacitor.

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