Tervakoski film

Performance comparison of ECU capacitor film vs. state-of-the-art BOPP capacitor film ECT

MAPPING THE POTENTIAL PERFORMANCE AREA OF TERVAKOSKI FILM ECU

1.1. INTRO

The application areas of DC capacitors have their own very specific requirements regarding capacitor performance levels and capacitor film properties. As E-mobility applications are specific, typically with very high ambient temperatures, the dominant stress factor is high voltage in power capacitors used in renewable energy generation systems. High-performance capacitor solutions are expected to have high safety features and lifetime requirements which can exceed 30 years. This is all achieved by sophisticated capacitor designs with highly engineered materials, which are resistant to degradation under the stress factor of high temperature, high voltage or both. In addition, the entire supply chain from polymer design, film converting, to final capacitor manufacturing must be equally competent.

The evolution in power semiconductor technology brings to the forefront the units equipped with wide band-gap power semiconductors - the technology applicable in the whole power range from the gigawatts down to the e-mobility systems. Such solutions bring a positive influence to energy efficiency vs. standard silicon-based semiconductors. However, the solutions also bring new challenges to used components, such as higher operating temperatures, for example, whereby the performance capabilities of state-of-the-art BOPP dielectric film start to be insufficient.

The new Tervakoski film ECU is a bi-oriented capacitor film made from the Stelora™ advanced polymer brand manufactured by Borealis. This particular ECU capacitor film was developed to overcome the performance limitations of existing BOPP solutions at ultra-high temperatures as well as maintain all its positive features, such as DC performance with the presence of AC harmonics, self-healing behaviour and not least, good windability and full compatibility with existing conversion lines.

This report provides a summary of the results from authentic testing performed by Tervakoski Films Group (TFG) using 6µm thickness film. An additional series of tests was also performed using 4 µm thickness film (not included in this report) which confirms the results obtained with 6 µm film. All the endurance/ageing tests were performed using real capacitor elements wound in TFG from the metallized capacitor film ECU and reference film ECT.

Films used in the tests:

- Tervakoski film ECU 6µm
- Tervakoski film ECT 6µm

1.2. TEST SETUP

The report contains the comparisons from testing the DC breakdown strength of the films, the DC endurance tests as well as an AC ageing test, all with a minimal time duration of 1,000 hours, with various combinations of stress factors -temperature, voltages.

The results are structured in 3 groups:

- DC breakdown strength
- Long-term DC endurance tests (min. 1,000 hrs.)
- Long-term AC ageing test (min. 1,000 hrs.)

1.2.1. DC BREAKDOWN STRENGTH COMPARISON

The basic indicator of film performance is the DC breakdown strength comparison. Tests are performed with a large electrode area (typical 2.5m^2) – every measured point represents the weakest point in each. The results show the equal performance of ECU film in comparison to state-of-the-art BOPP capacitor film ECT. We also include the breakdown strength of an earlier version of "ECU" film (evo), which indicates the development path of ECU film. (The data for the ECT film are taken from commercial film manufacturing statistics).

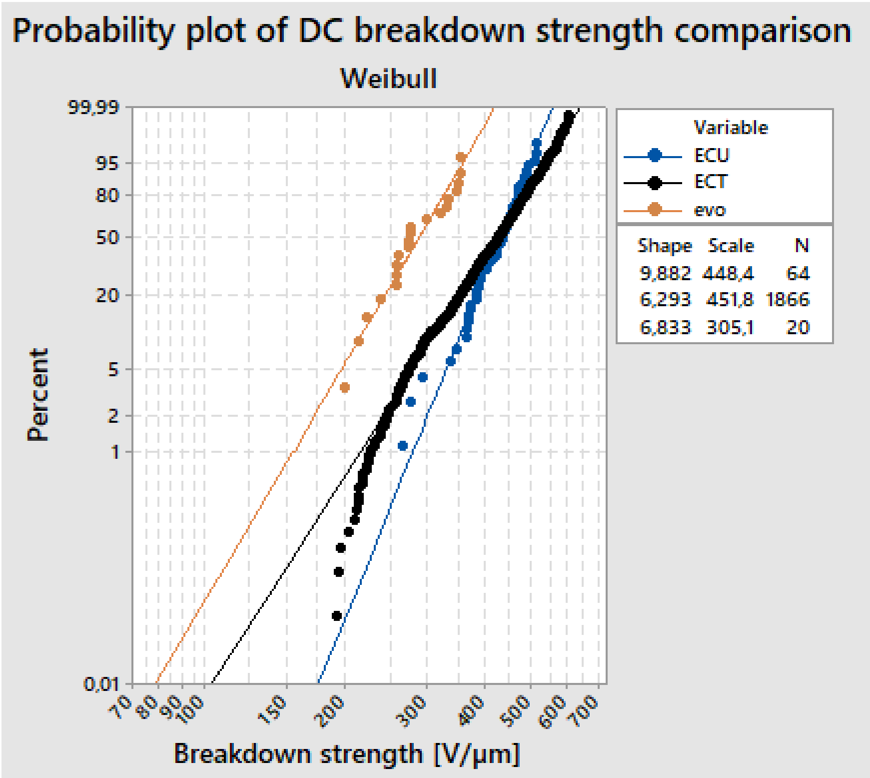


Fig.1-DC breakdown strength, large electrode, 6 µm film

1.2.2. LONG-TERM DC ENDURANCE TESTS

In the long-term DC endurance tests, we focused on the key combinations of stress factors – an ambient temperature starting at 75°C to simulate typical HVDC application conditions, continuing up to 105-135°C, and the DC test voltage from 150 up to 400V/µm. Tests were run either as a constant combination of ambient temperature and voltage, or as a step increase. The evolution of the element capacitance value and the evolution of the dissipation factor (tanD) were followed during the test.

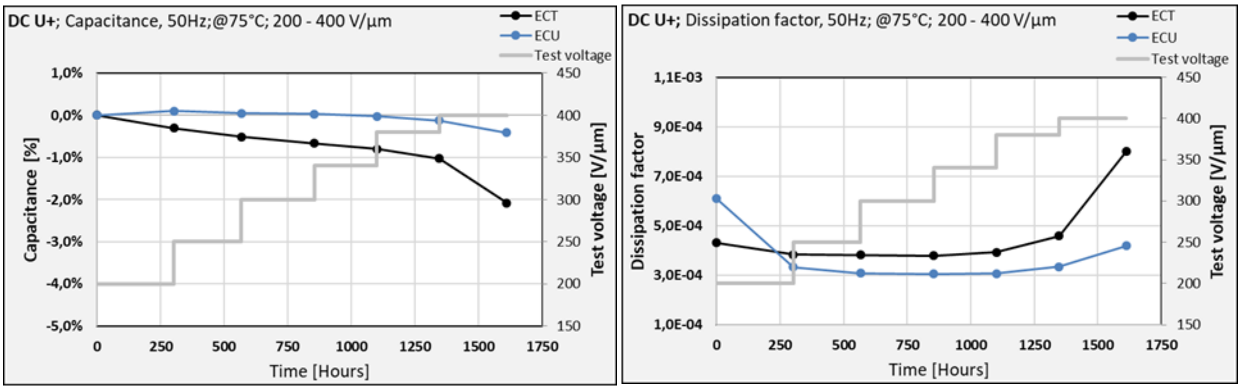


Fig.2-DC endurance test at constant 75°C, testing voltage 200-400V/µm

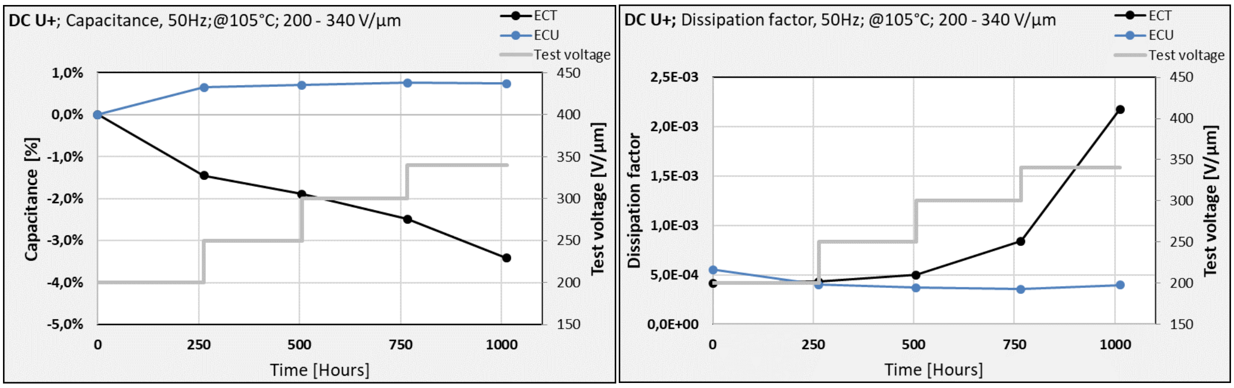


Fig.3-DC endurance test at constant 105°C, testing voltage 200-340V/µm

In these tests, the test elements made of ECU and ECT film were always present in equal numbers to allow a very effective performance comparison between both film types. The comparison shows that the performance properties of ECU film do not degrade even when extreme voltage stress is present; additionally the ECU is clearly superior in elevated temperatures.

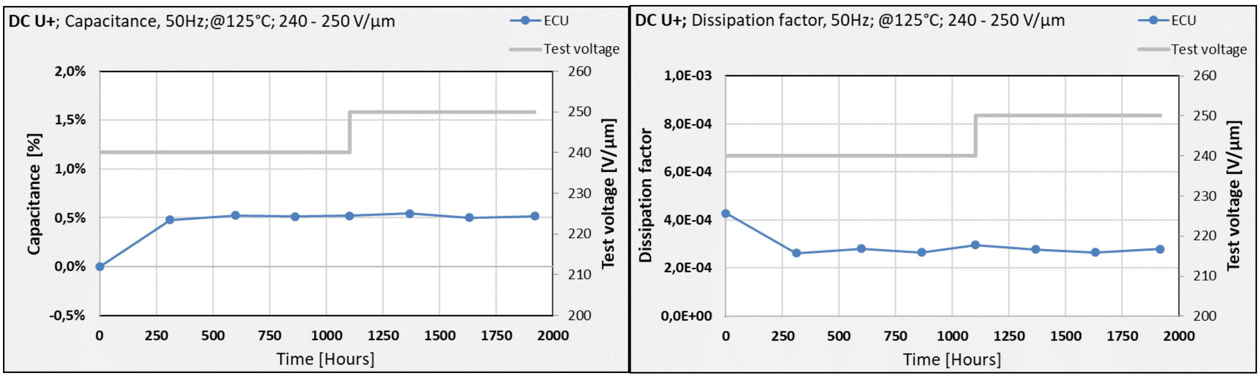


Fig.4-DC endurance test at a constant 125°C testing voltage 240-250V/µm

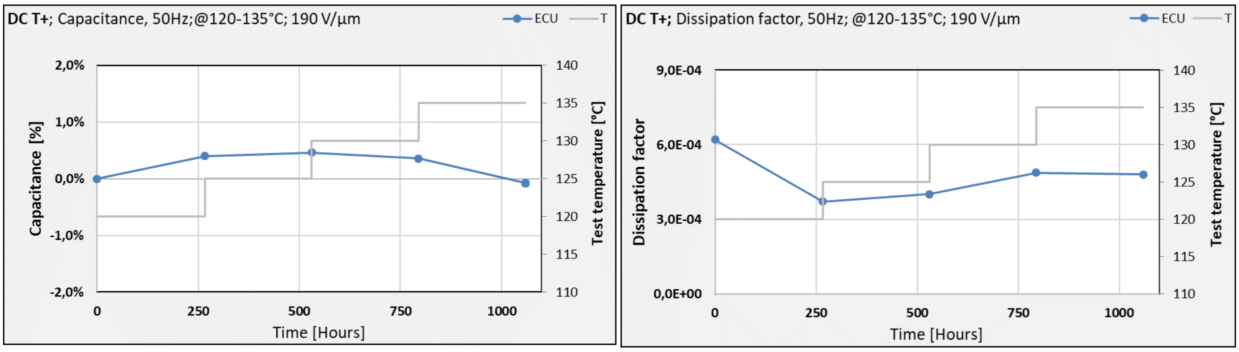


Fig.5-DC endurance test at a constant voltage 190V/µm, testing temperature 120-135°C

The tests at ultra-high temperatures were run without a reference ECT film as the tested combinations of ambient temperature and test voltage are too challenging for the BOPP capacitor film. The results confirm the excellent performance potential of ECU film at ultra-high ambient temperatures.

1.2.3. LONG-TERM AC AGEING TESTS

Due to a common presence of an AC ripple current in DC capacitor applications we ran a long-term AC ageing test on the capacitor elements under a combination of an ambient temperature up to 95°C and the AC test voltage of 93V/µm. The test duration was 2,500 hours and the result shows that ECU capacitor film is performing at least as well as state-of-the-art BOPP capacitor film ECT. It is encouraging to note that at higher ambient temperatures, the superior performance of ECU film will be shown in AC tests in a similar way as in DC tests.

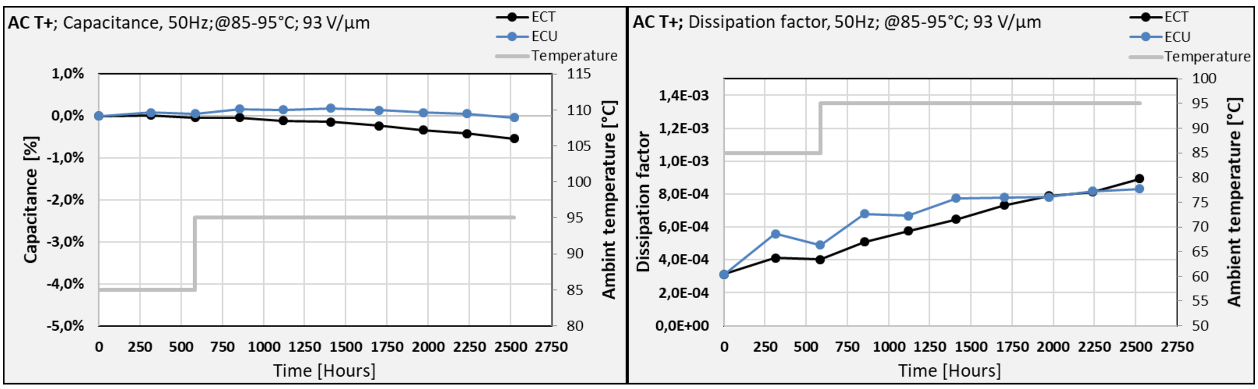
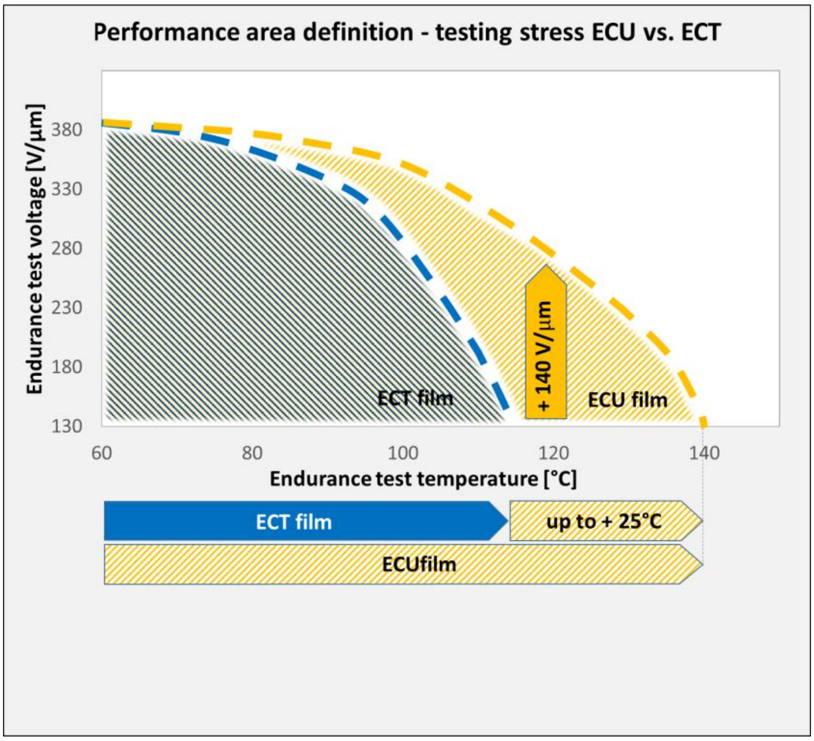


Fig.6-AC ageing test at temperature 85/95 °C, testing voltage 93V/µm

SUMMARY

The target of our development work with ECU film was to generate a capacitor film that is suitable for ultra-high temperature applications without the need of operating voltage derating as well as bring a remarkably increased safety feature to capacitors operating in much lower ambient temperatures under extreme voltage stress. The performed series of tests created the result which subsequently allowed us to map the potential performance area of the ECU film when compared with ECT capacitor film. The chart indicates the performance limit points measured in our tests, every point formed by the test with a minimum time duration of 1,000 hours.



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