Electrical Properties of Aluminum Electrolytic Capacitors with Conducting Polymers

Steffen Buhrkal-Donau, PhD Student
Center for Industrial Electronics, CIE
University of Southern Denmark, SDU

Thomas Ebel
CIE, SDU (Principal Supervisor)

Wulf-Toke Franke
CIE, SDU (Co-supervisor)

Introduction

As seen in Fig. 1 and 2, aluminum electrolytic capacitors consist of a highly porous aluminum anode foil. A thin dielectric film of aluminum oxide is formed on the aluminum foil by anodization. Traditionally, the contact between the cathode foil and the anode foil is formed by a liquid electrolyte. These electrolytes have the advantage of filling out the porous structure of the anode very well, without reacting with the aluminum oxide leading to a good capacitance value and a high breakdown voltage. However, the conductivity of these electrolyte materials is low (< 1 S/cm). This significantly increases the equivalent series resistance (ESR) of the device. A possible alternative to traditional electrolyte is the use of a conducting polymers such as PEDOT (Fig. 3). This has a conductivity hundreds to thousands times higher than that of traditional electrolyte materials, resulting in a significantly lower ESR.[1]

Problems with lower breakdown voltage and high leakage current in conducting polymer capacitors have been seen, and still today commercially available conducting polymer capacitors have a significantly lower voltage rating compared to traditional electrolyte capacitors, despite a strong market request for low ESR, high voltage capacitors.

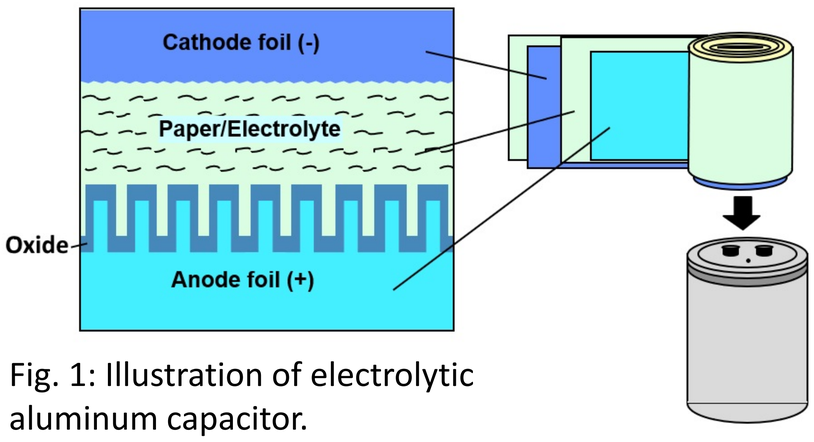

Fig. 1: Illustration of electrolytic aluminum capacitor.

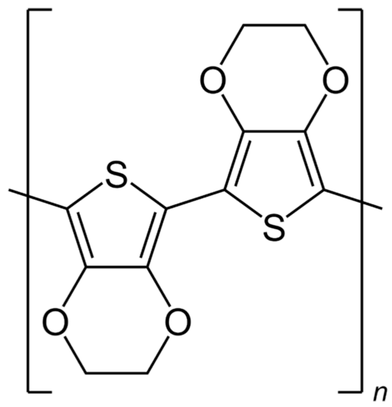

Fig. 3: PEDOT

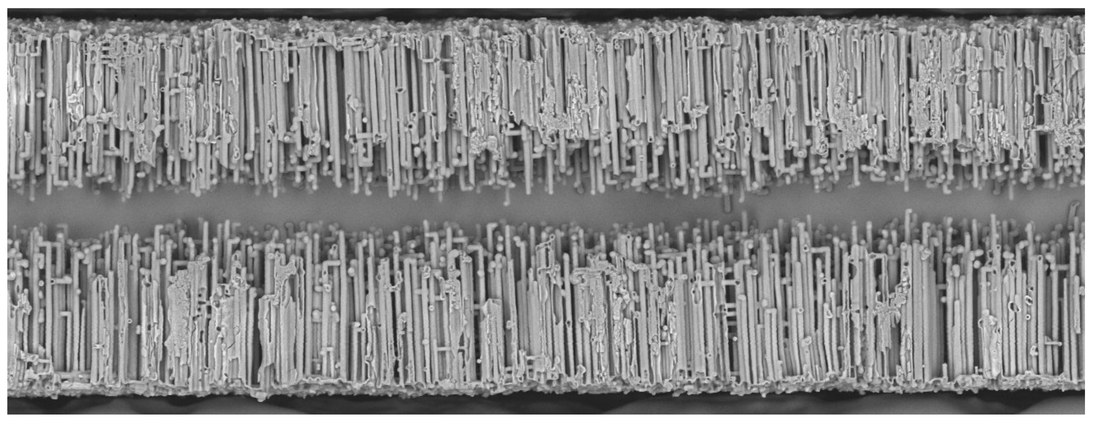

Fig. 2: SEM image of porous aluminum anode foil

Objectives

The objectives of this project are to analyze the interactions between the conducting polymer PEDOT and the aluminum oxide in aluminum electrolytic capacitors with conducting polymer. A thorough examination of these interactions' effect on the breakdown voltage of the capacitor will be performed and this will allow for modifications to be made in order to increase the breakdown voltage, thereby allowing for the production of capacitors with conducting polymers with a higher operative voltage.

Methodology

As this is a newly started field of study for the department, the first goal is to replicate results seen from state-of-the-art technologies through model capacitor stacks. Procedures and equipment for anodizing of aluminum anode foils will be developed, along with procedures for making the cathode contact from conducting polymer (PEDOT).

Measuring equipment for electrical properties of the model capacitor stacks will be acquired. Parameters measured will include breakdown voltage, capacitance, leakage current and ESR. Furthermore different microscopy methods and other surface measurements will be used to examine the anode foil and the quality of the oxide.

When state-of-the-art is replicated modifications will be made to the model capacitors. The effect of different additives to the polymer will be examined, along with modifications of the oxide surface.

[1] Elschner, A. (2011). PEDOT. Boca Raton, FL: CRC Press.