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***Abstract*—This paper presents a custom circuit for controlling the anodization of titanium capacitors and characterizing their performance. The circuitry provides a constant current source of 0-100mA up to a compliance voltage of 30V. The system can monitor and record leakage currents down to 10 nA over periods of up to 24 hours. Typical results obtained using sputtered titanium-zirconium capacitors are presented.**

***Index Terms*—IEEEtran, journal, LaTeX, paper, template.**

I. Introduction

TITANIUM capacitors are being looked at more closely as a possible alternative to tantalum capacitors due to their lower material cost and possibly better temperature characteristics (quote Welsch, intro ARPA-E meeting). In the past, titanium capacitors have not been feasible alternatives due to their high leakage currents (quote Kis paper). In order to further research into titanium capacitors, custom anodization instrumentation has been developed to anodize and characterize prototype titanium capacitor materials. This instrumentation was necessary because conventional systems do not have the necessary dynamic range (1A-1nA measurement) or repeatability (need to get some kind of number) needed in this application.

A. Anodization Process and Requirements

Anodization is the act of growing an oxide layer on top of a metal anode. This is useful in capacitors because it allows a capacitor to store significantly more energy then it would have otherwise. The anodization process is preformed by immersing an anode and a cathode into an electrolyte solution and then hooking up either a voltage or current source across the sample. This process can be seen in fig1:

Figure 1: Anodization setup

Referring to Fig1, in the simplest case, the current transfer is an ionic transfer where the Ti anode reacts with O2 to create a TiO2 oxide layer. The reaction at the metal-oxide surface can be written as:

Ti + 02 =¿ TiO2 + 4e(equ. 1)

The titanium also reacts with the electrolyte solution to give off hydrogen:

Ti + 2H20 =¿ Ti02 + 4H+Ti02(equ 2)

This hydrogen reacts with the electrons at the cathode to create hydrogen gas and complete the ionic circuit.

4H + 4e =¿ 2H20(equ 3)

This process is very similar to anodizing aluminum. For an explanation of that process visit (—quote Case encyclopedia).

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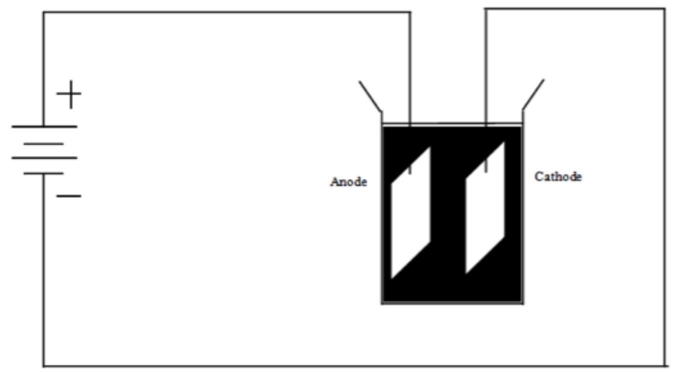

Fig. 1. Anodization Setup

Since the rate of oxide formation is dependent on the charge transport into the anode during anodization, a current source was selected. A typical anodization process with a current source will see the current and voltage progress as in Fig2

Figure 2: Anodization by a Constant Current quote micro-miniturization

If a constant current is introduced, the voltage will (ideally) rise linearly with time. This will happen until the DUT reaches the compliance voltage, at which point the current through the DUT will begin to drop off until it reaches the leakage current of the unpackaged capacitor.

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Appendix A
Proof of the First Zonklar Equation

Appendix one text goes here.

Appendix B

Appendix two text goes here.

Acknowledgment

The authors would like to thank...

References

[1] H. Kopka and P. W. Daly, *A Guide to LaTeX*, 3rd ed. Harlow, England: Addison-Wesley, 1999.

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Michael Shell Biography text here.

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