Chapter 1
Resistance of Cell in Fractal Growth in Electrodeposition

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ABSTRACT
This paper presents the study of dynamic electrical resistance of the electrodeposition cell during the growth metallic dendrites showing fractal character. The electric resistance of the circular electrodeposition cell is measured in real time using a computer based data acquisition system. The data acquisition system constructed is capable of measuring the cell voltage and the current through the cell under program control at pre-decided intervals. This allows for the measurement of the dynamic electrical resistance of the electrodeposition cell. The system is based on standard analogue to digital controller ADC interfaced to the computer through the printer port.

1.1 INTRODUCTION
Fractal pattern formation (Yaroslavsky, 2007) is one of the important phenomena in nature. One of the commonly used techniques for the growth of metallic dendritic patterns showing fractal character is electrodeposition (Atchison, Burford, & Hibbert, 1994). Patterns developed as a result of Diffusion Limited Aggregation (DLA) (Cronemberger & Sampaio, 2006; Chakrabarty et al., 2009; Hibbert, 1991) are often found in various processes in physical sciences, chemical sciences, and engineering.

The electro-depositions obtained in circular cell (Vicsek, 1992; Costa, Sagues, & Vilarrasa, 1991) geometry under constant cell operating voltage conditions indicate that the growth at the outer part of the depositions is relatively denser.
(Shaikh, Khan, Pathan, Patil, & Behere, 2009). The increased branching at the later stage of development of the growth was attributed to the increased electric field (Argoul, Huth, Merzeau, Arnrodo, & Swinney, 1993; Fleury, Chazalviel, Rosso, & Sapoval, 1990) due to the reduction in gap between cathode and anode. This change is gradual and continues with the growth and with the evolution of the growth the electrical properties of the cell undergo changes. This motivated us to measure the dynamic electrical resistance of the electrodeposition cell as this will help better understanding of the mechanism.

1.2 Design and Construction of Computer Controlled Data Acquisition System Using ADC 0809 and Printer Port Interface

The data acquisition system was based on an 8 bit, 8 input ADC 0809 (Tocci & Widmer, 1998; Ram, 1991; Anderson, 1996) interfaced to the computer through the printer port (Anderson, 1996; Peacock, 1994) with the eight analogue inputs independently selectable through the address lines on the ADC through the software is as shown in experimental set up in Figure 1. The ADC used has an 8-bit resolution, which was found to be sufficient for the present work. The ADC was operated at full voltage range of 0 – 5 V dc, this resulted the accuracy in measurement of 1 part in 256 over the full range of operation. This corresponds to a resolution of 0.02 volts and was sufficient for the present application. The voltage measurement employed a potential divider to cover the desired range of voltage.

Calibration of the divider was checked and adjusted before use. The cell voltage was measured using a standard digital voltmeter and the values were compared with the data read in the computer and its equivalent cell voltage. Table 1 gives a typical set of readings, the column labeled actual cell voltage is the voltage measured across the cell using a digital voltmeter.

The two columns under ADC measurements gave the corresponding values of digital values read by the program and then converted to value of analogue voltage across the cell. For comparison, the measured voltage across the cell is plotted against actual cell voltage in Figure 2. The resulting plot is a reasonably linear, the straight line joining the points is the least square fit applied to the data points. The least square fit line fairly fits the data as is seen from the value of \( r^2 = 0.9993 \). The slope of the line is 1.0017 indicating a linear relationship and the measured values are in agreement with the true values of the cell voltages.

For the measurement of current, a resistance was included in series with the electrodeposition cell and the voltage developed across the resistance was measured. The actual current was obtained in controlling programme using the ratio of potential difference to the resistance \( I = \frac{V}{R} \), \( V \) is the voltage measured across the series resistance \( R \). Ideally a low series resistance is desirable so that the potential drop across the sensing resistor is small enough and can be neglected. A low series resistance develops low voltage across it for the present working conditions thus the potential developed is to be amplified for recording. Typically a current of 0.5A through a series resistance of 0.2 ohm will develop a potential dif-

Figure 1. Experimental set up for resistance of cell in electrodeposition
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