Activation Energy Extraction of Electrodeposit Growth in Nanoionic Materials and Devices

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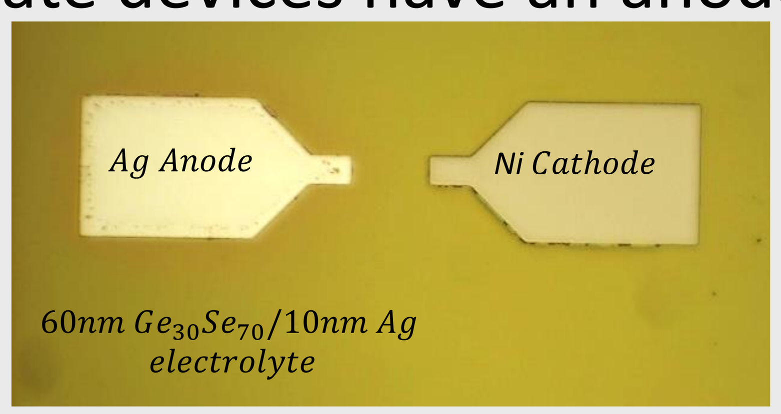
ABSTRACT

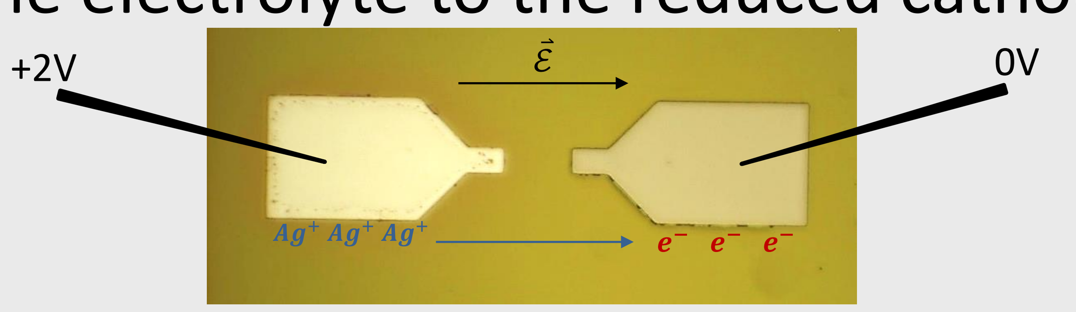
This research focuses on chalcogenide-based electrolytes that support the growth of metallic dendrites. The **activation energy** of the electrodeposit growth rate can be extracted. The purpose of this project is to investigate how the activation energy is affected by changing the **electrolytic layer**, the **device shape**, and the **amount of silver**.

BACKGROUND

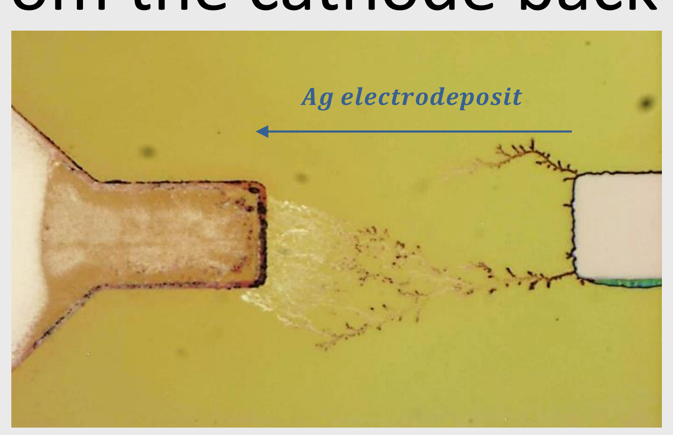
Ion transport requires a reduction-oxidation reaction. These solid-state devices have an anode, cathode, and electrolyte:



When a bias is applied between the electrodes, positively charged ions flow from the oxidized anode through the electrolyte to the reduced cathode [1]:



The ions grow from the cathode back to the anode:



METHODOLOGY

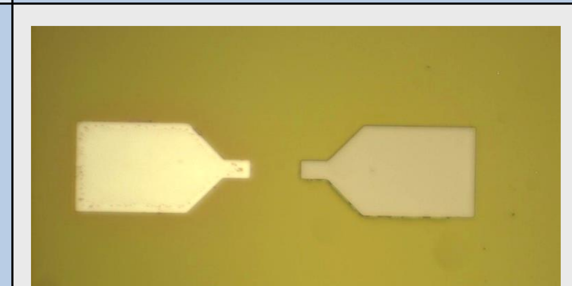
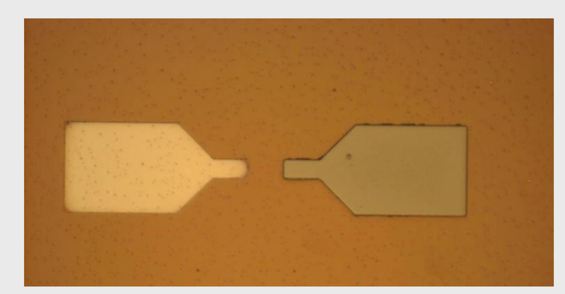
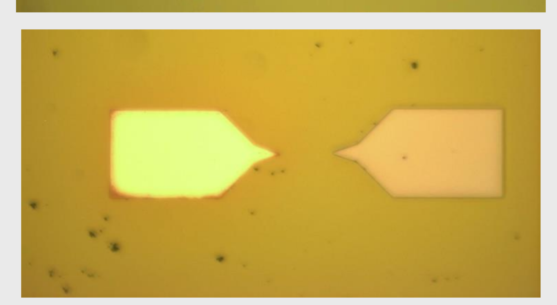
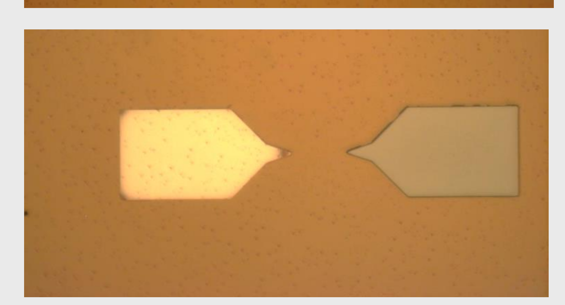
1. Apply constant bias to anode electrode.
2. Measure time for electrodeposit to create a short between electrodes.
3. Repeat for a range of temperatures.

Temperatures

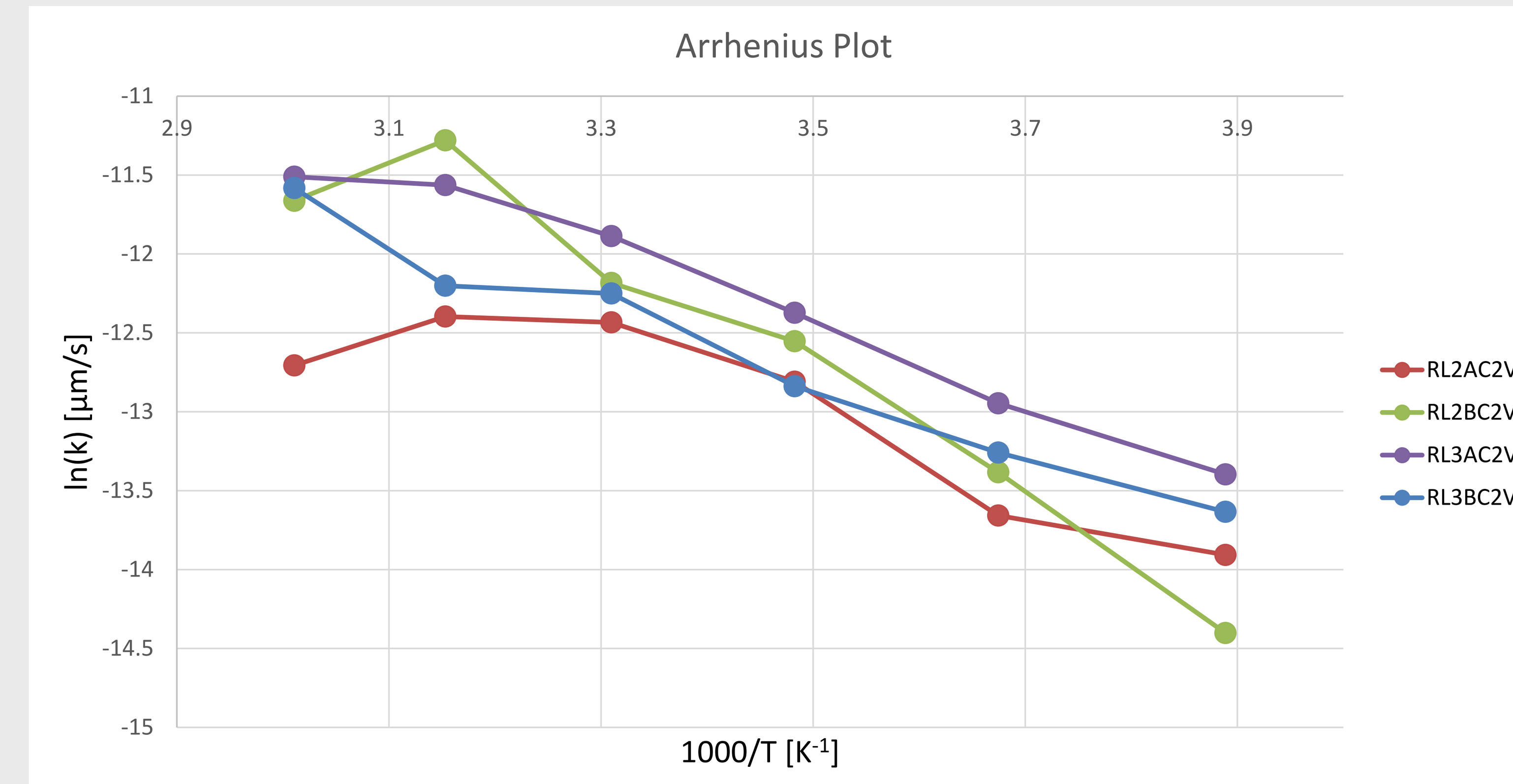
T_1	T_2	T_3	T_4	T_5	T_6
$20°C$	$35°C$	$50°C$	$65°C$	$80°C$	$95°C$

$$t = Ae^{-E_A/k_B T},$$
$$t \equiv time\ to\ short$$

$$E_A = -slope \cdot k_B$$

	$Ge_{30}Se_{70}$ + 10nm Ag	$Ge_{30}Se_{70}$ + 20nm Ag
A Electrode		
B Electrode		

RESULTS



Device	E_a (meV)
RL2AC2V	0.147583
RL2BC2V	0.2910657
RL3AC2V	0.199327
RL3BC2V	0.1962432

DISCUSSION

The activation energy is a parameter that defines how much energy is required to **completely create a short** between the two electrodes through electrodeposition. With 10nm Ag, the B electrode has a higher activation energy, so the A electrode reaches a short more quickly. With 20nm Ag, it is the opposite: the B electrode has a lower activation energy and shorts faster—however the numbers are much closer in this composition. Oxidation effects likely affect the results of the composition with 20nm Ag.

REFERENCES

[1] M. N. Kozicki, "Timing Device Using Electrodeposit Growth," US Patent 20180259911, Oct. 5, 2016.
[2] D. S. Jayakrishnan, "Electrodeposition: the versatile technique for nanomaterials," Corrosion Protection and Control Using Nanomaterials, Elsevier, 2012, pp. 86–125.
[3] P. G. Vekilov, "Nucleation," Crystal Growth & Design, vol. 10, no. 12, pp. 5007–5019, Nov. 2010.

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