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Improving qubit coherence time through detailed materials analysis

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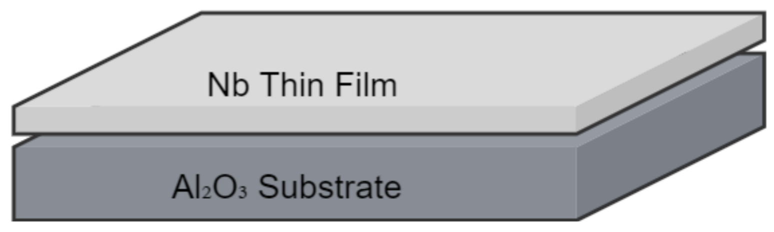
INTRODUCTION

In the technological landscape of today, quantum computing represents a frontier comparable to the space race of our generation. Central to the development of quantum computers are superconducting materials, which exhibit almost zero electrical resistance at low temperatures. These materials hold immense promise for qubits due to their potential to improve coherence times, which refers to the duration over which quantum information remains accurately preserved in a quantum state.

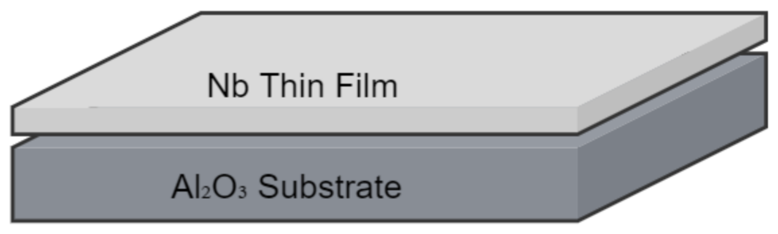
This project aims to investigate defects, imperfections, and variations in deposited thin films of Nb. To achieve this, characterization techniques such as Scanning Electron Microscopy (SEM), Energy Dispersive Spectroscopy (EDS), and X-Ray Photoelectron Spectroscopy (XPS) are used to meticulously analyze the homogeneity of Nb thin films. This research contributes to the development of more reliable and efficient quantum computing technologies, addressing fundamental challenges and paving the way for future advancements in this rapidly evolving field.

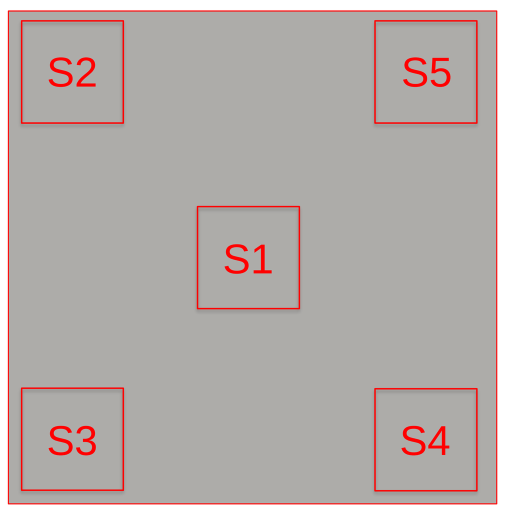
METHODS

W114 (DC Magnetron Sputtering)



W118 (Electron Cyclotron Resonance)





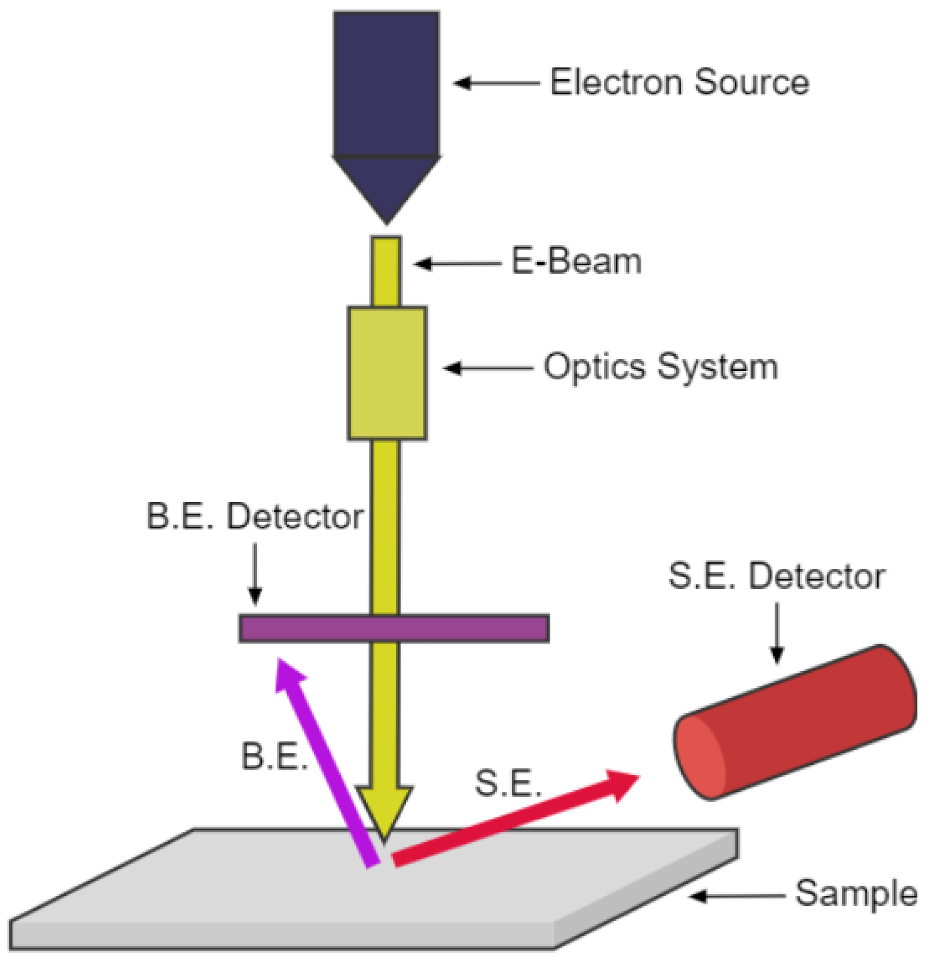


Figure 1: Diagram of SEM and EDS.

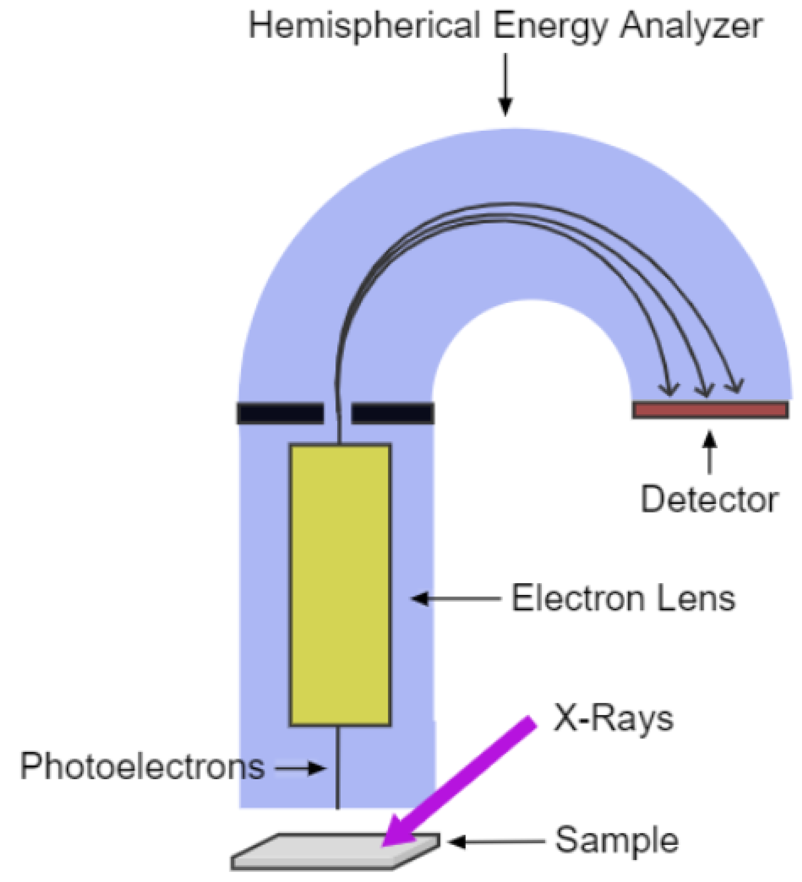


Figure 2: Diagram of XPS.

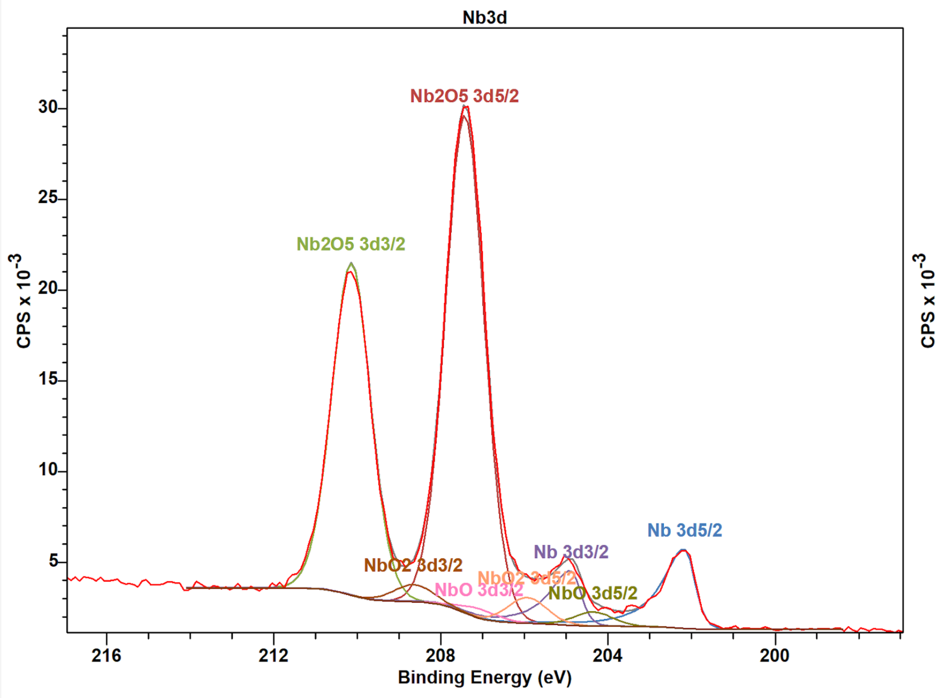
Parameters	SEM	EDS	XPS
Instrument Model	Thermofisher Helios 5 CX	Thermofisher Helios 5 CX	SPECS Custom System
Accelerating Voltage	5.00 kV	10.00 kV	Al Kα (1486.6 eV)
Current	1.4 nA	1.4 nA	5.00 μA (Flood Gun)

RESULTS

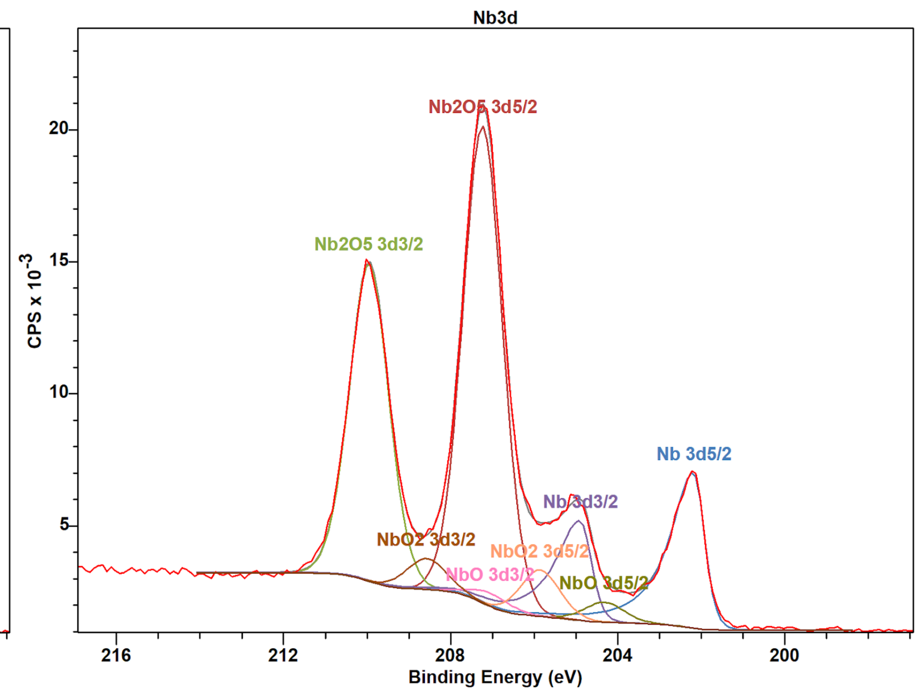
SPOT 1	W114		W118	
Name	Position (eV)	%At Conc	Position (eV)	%At Conc
C 1s	284.9	16.5	285.3	17.0
O 1s	530.6	20.3	530.7	21.9
F 1s	688.5	0.5	690.0	1.1
Nb 3d	207.1	12.8	207.4	13.3
Si 2p	101.9	0.4	102.4	2.8

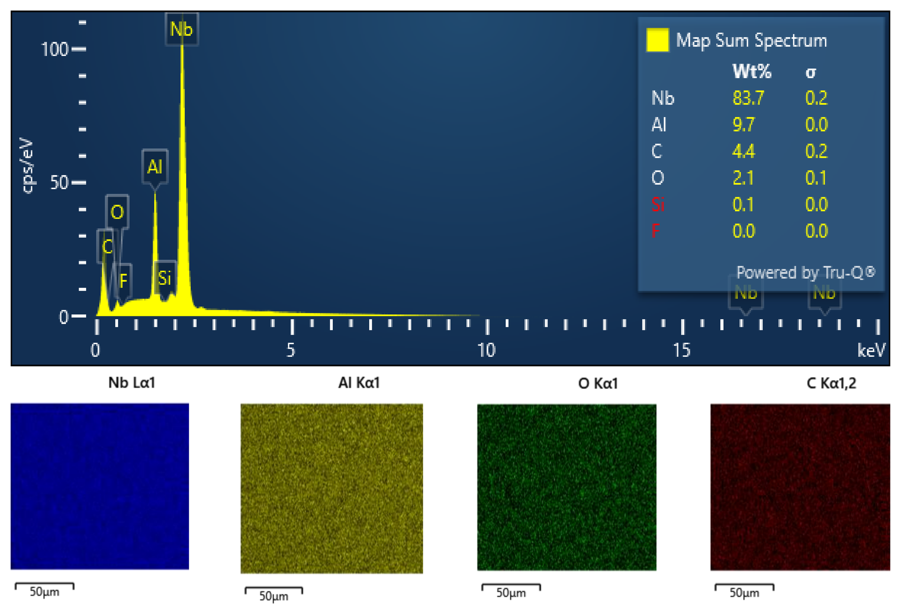
SPOT 1	W114		W118	
Name	Position (eV)	Rel %At	Position (eV)	Rel %At
Nb_2O_5 3d5/2	207.2	67.4	207.4	80.5
Nb 3d5/2	202.2	23.2	202.2	13.1
NbO 3d5/2	204.3	2.8	204.4	2.3
NbO_2 3d5/2	205.9	6.5	205.9	4.2

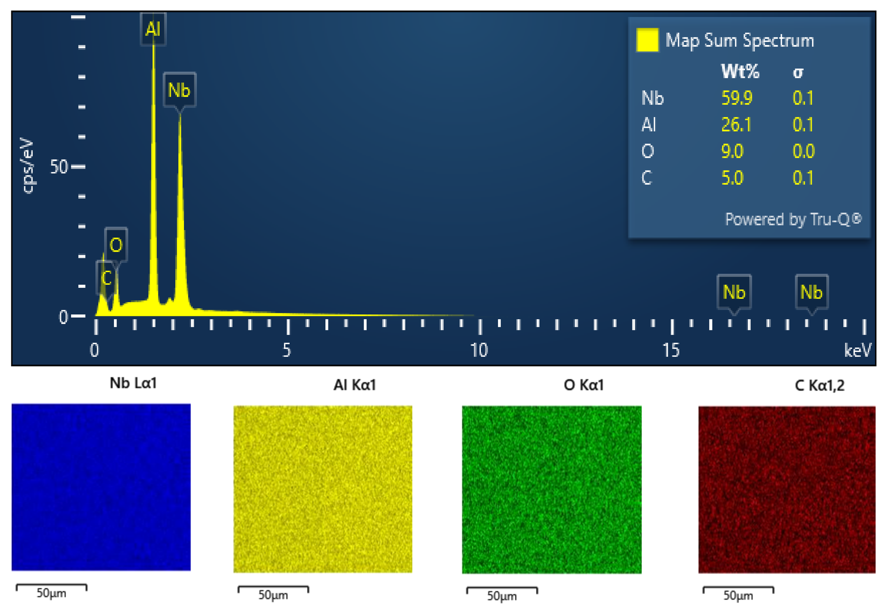
W114

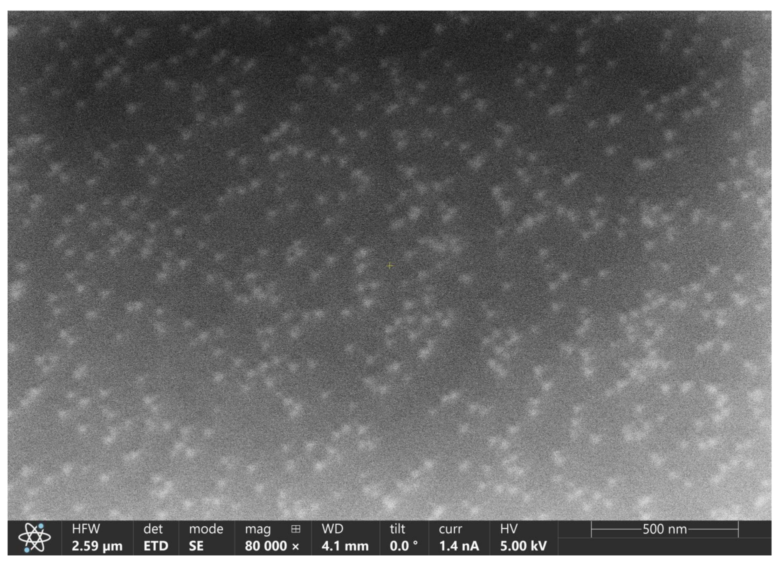


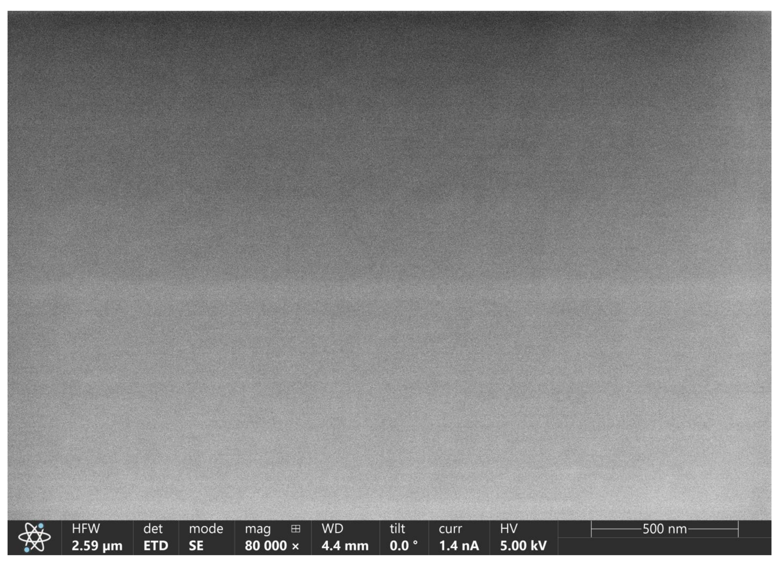
W118

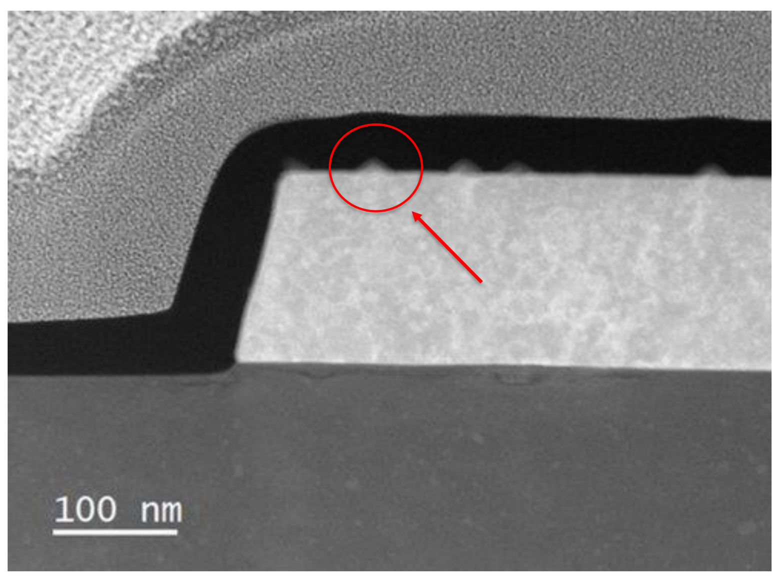


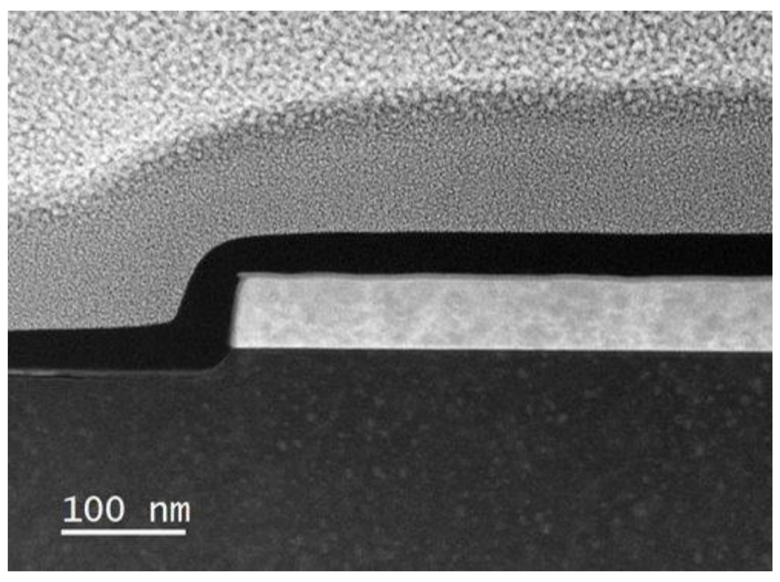












[TEM images courtesy of Jae-Yel Lee]

OBSERVATIONS AND CONCLUSIONS

- SEM: Observed presence of **small**, distinct **structures** in W114. Surface morphology is visibly uniform in W118.
- EDS: The elemental composition is uniform across the films. There is **a higher signal** for aluminum in sample W118 compared to sample W114, attributed to the **thickness difference** between the samples.
- XPS: There is a higher Nb_2O_5 signal detected in W118 compared to W114, which is due to a thicker oxygen layer in sample W118.

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