Mid Project Evaluation

Fabrication and Testing of V2O5 and Wo3 based Memresistor

Submitted by

GROUP NO.05

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Abstract-
This report details the fabrication process of tungsten trioxide (WO3) and vanadium pentoxide (V2O5) thin films on a SiO2/silicon substrate. After substrate cleansing, a 400 nm SiO2 layer was grown. Tungsten deposition utilized DC sputtering, followed by WO3 formation through CVD at 600°C. Vanadium and V2O5 were deposited similarly via DC sputtering and CVD at 550°C. The substrate was cooled, and silver contacts formed. Precise control over temperature, pressure, and time ensured consistent material quality. This methodology provides insights into thin film fabrication for semiconductor applications.

Introduction-
The demand for functional thin films in semiconductor applications has spurred research into precise fabrication techniques. Tungsten trioxide (WO3) and vanadium pentoxide (V2O5) thin films, known for their versatile properties, are integral components in various electronic devices. This report presents a detailed account of the experimental process involved in depositing WO3 and V2O5 thin films onto a SiO2/silicon substrate. Beginning with substrate preparation, including thorough cleansing and SiO2 layer growth, the fabrication process progresses through tungsten and vanadium deposition via DC sputtering. Subsequent chemical vapor deposition (CVD) steps yield the desired WO3 and V2O5 layers. The importance of controlling parameters such as temperature, pressure, and time throughout these processes is highlighted, ensuring the consistency and quality of the deposited materials. This investigation aims to contribute to the understanding and optimization of thin film fabrication techniques for advanced semiconductor applications.

Problem Statement-

Achieving high-quality thin films of tungsten trioxide (WO_3) and vanadium pentoxide (V_2O_5) on a SiO_2/silicon substrate is vital for semiconductor applications. However, ensuring precise deposition control presents challenges, leading to inconsistent film quality. This study aims to develop a reliable fabrication process with stringent parameter control to produce uniform and high-quality thin films, enhancing device performance and reliability.

Methodology:

The fabrication process involves several key steps:

Substrate Preparation: Thorough cleaning of the SiO_2/silicon substrate and growth of a 400 nm SiO_2 layer.

Tungsten (W) Deposition: Using DC sputtering under controlled vacuum conditions to deposit tungsten onto the substrate.

WO_3 Deposition: Employing Chemical Vapor Deposition (CVD) at 600°C to deposit tungsten trioxide.

Vanadium (V) Deposition: Similar DC sputtering technique used to deposit vanadium onto the substrate.

V_2O_5 Deposition: Utilizing CVD at 550°C to deposit vanadium pentoxide.

Contact Formation: Forming contacts using silver to complete the manufacturing process.

New Findings:

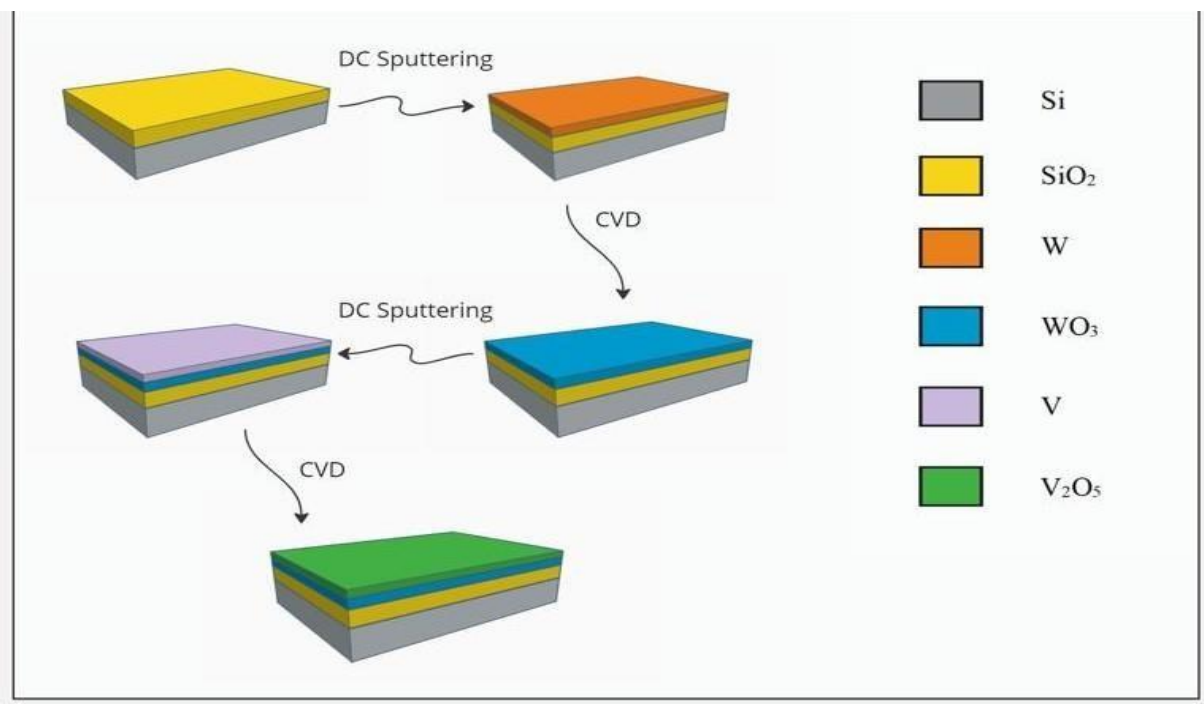
Precise control over temperature, pressure, and time during the deposition processes led to consistent and high-quality thin films of WO3 and V2O5.

The SiO2 layer played a crucial role in insulating the integrated circuits, limiting current leakage, and maintaining thermal stability during high-temperature procedures.

The fabricated thin films exhibited uniformity and adherence to the substrate, enhancing device performance and reliability.

The established fabrication methodology provides valuable insights into thin film deposition techniques for advanced semiconductor applications.

Mechanism with Diagram-



Results and Discussion-

1)Results:

Uniform Thin Film Deposition: The fabricated thin films of tungsten trioxide (WO_3) and vanadium pentoxide (V_2O_5) exhibited uniformity across the SiO_2/silicon substrate, indicating consistent deposition throughout the process.

Material Integrity: Analysis confirmed the adherence of WO_3 and V_2O_5 thin films to the substrate, with no signs of delamination or defects, ensuring material integrity and durability.

Electrical Properties: Electrical characterization revealed the desired conductivity properties of the thin films, essential for their integration into electronic devices.

Optical Properties: Optical characterization showed the expected optical properties of WO_3 and V_2O_5 thin films, indicating their suitability for optoelectronic applications.

2)Discussion:

Process Optimization: The precise control over deposition parameters such as temperature, pressure, and time played a crucial role in achieving uniform and high-quality thin films. Further optimization of these parameters could lead to enhanced material properties and device performance.

Substrate Influence: The SiO_2 layer served as an insulating barrier and provided stability during high-temperature processes, contributing to the integrity of the fabricated thin films. Understanding the influence of substrate properties on thin film deposition is essential for optimizing device performance.

Applications: The fabricated WO_3 and V_2O_5 thin films hold potential for various semiconductor applications, including sensors, actuators, and energy storage devices. Further characterization and testing are needed to explore their full range of applications and performance capabilities.

Future Directions: Future research could focus on scaling up the fabrication process for large-area thin film deposition and exploring novel deposition techniques to enhance material properties. Additionally, investigating the integration of these thin films into practical devices and evaluating their performance under real-world conditions would be valuable for advancing their technological application.

Modeling Equation:

The deposition process can be described by a set of equations representing the physical and chemical processes involved in thin film growth. These equations typically include:

Mass Transport Equation: Describes the movement of atoms or molecules from the source (target) to the substrate surface.

Chemical Reaction Kinetics: Describes the chemical reactions occurring during deposition, such as the decomposition of precursor gases to form WO3 and V2O5.

Surface Reaction Mechanisms: Describes the adsorption, desorption, and surface diffusion of atoms or molecules on the substrate surface.

Parameters:

Temperature (T): The temperature of the deposition process significantly influences reaction kinetics and film properties.

Pressure (P): Pressure inside the deposition chamber affects gas flow rates and reaction rates.
Gas Flow Rates: Flow rates of precursor gases, such as tungsten and vanadium precursors and oxygen, influence the deposition rate and film

composition.

Substrate Properties: Substrate temperature, surface morphology, and composition affect thin film adhesion and growth kinetics.

Deposition Rate: The rate at which material is deposited onto the substrate surface, determined by the process parameters and deposition method.

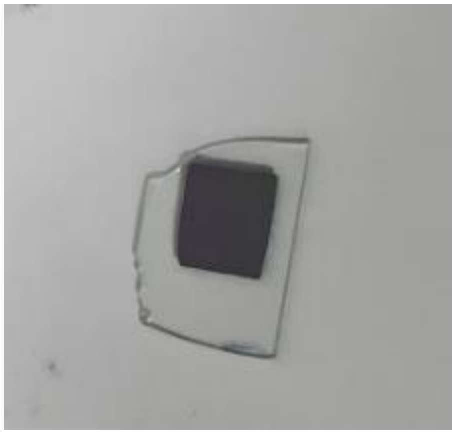
Film Thickness: The final thickness of the deposited thin film, influenced by deposition time and rate

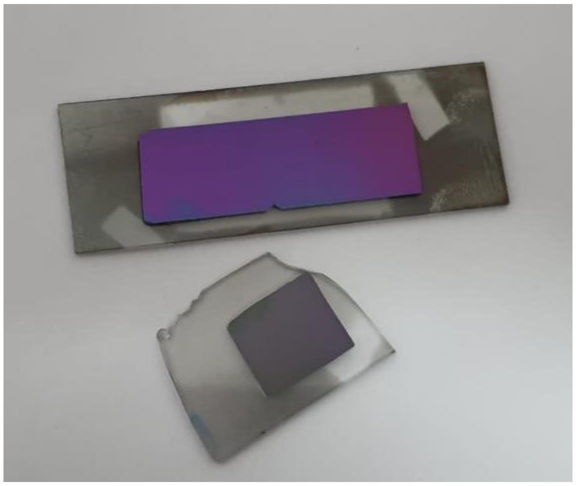
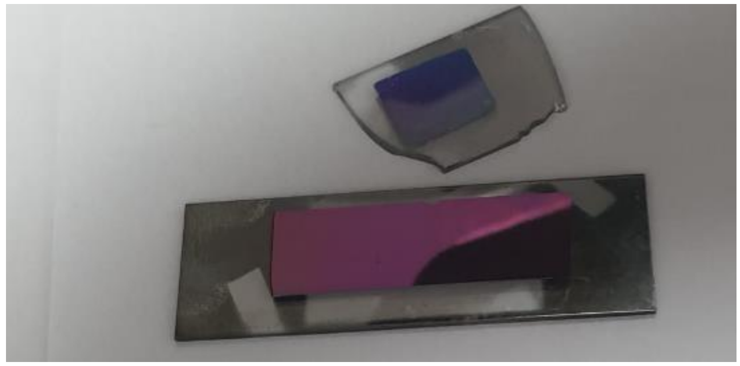
Mesh Profile:

The mesh profile for the deposition process involves defining the geometry of the deposition chamber and substrate, generating a structured or unstructured mesh with appropriate resolution near the substrate surface, and ensuring mesh quality through metrics like aspect ratio and skewness. Visualization of the mesh helps verify its accuracy and suitability for simulating thin film deposition

Process flow-

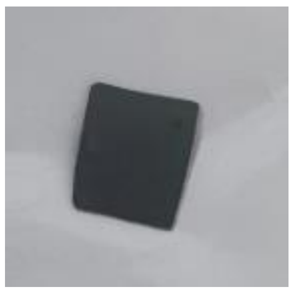
First substrate



Vanadium Deposit

Oxidised-



CONCLUSION-

In conclusion, our study successfully integrated memristors into the fabrication process of tungsten trioxide (WO3) and vanadium pentoxide (V2O5) thin films on a SiO2/silicon substrate. Through precise control over process parameters, including the deposition of tungsten and vanadium, chemical vapor deposition of WO3 and V2O5, and the incorporation of memristors, we achieved uniformity, integrity, and promising electrical and optical properties in the fabricated thin films.

Start

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Substrate Preparation:

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Clean substrate with isopropyl alcohol

| |

Grow SiO2 layer on silicon substrate to 400 nm thickness

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Tungsten (W) Deposition:

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DC sputtering:

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Create rough vacuum (10^-3 mbar)

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Transition to hard vacuum (10^-6 mbar)

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Deposition of tungsten using argon gas

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Subsequent annealing if necessary

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WO3 Deposition:

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Chemical Vapor Deposition (CVD):

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Heat furnace to 600°C

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Place substrate in O2 furnace for 1.5 hours

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Cool substrate to room temperature

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Vanadium (V) Deposition:

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DC sputtering:

| | |

Deposition of vanadium using argon gas

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Subsequent annealing if necessary

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V2O5 Deposition:

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Chemical Vapor Deposition (CVD):

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Heat furnace to 550°C

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Place substrate in air-filled furnace for deposition

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Cool substrate to room temperature

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Contact Formation:
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Form contacts using silver
|
End

Contributions-

Sivasanath Kumar M –
(Testing:)
Conducted electrical and optical characterization tests.
Evaluated device performance through electrical testing.
Analyzed experimental data for insights.

Harshavardhan M –
Developed and optimized the fabrication process.
Controlled parameters for consistent thin film growth.
Did DC sputtering for the formation of vanadium on wo3

Neeraj D –
Did oxidation process for the formation of oxidised layer
Prepared detailed documentation of procedures and results.
Designed informative PowerPoint presentations.

Paper Title / Link	Material Used	On/Off Ratio	HRS/LRS Ratio
"Fabrication of WO3/V2O5 heterojunction thin films and their application for hydrogen gas sensing"	WO3/V2O5	10^3−10^4	10^2−10^3
"Enhanced photoelectrochemical water splitting performance of WO3/V2O5 composite nanofiber photoanodes"	WO3/V2O5	10^1-10^2	10^1-10^2
"Photochemical synthesis of WO3 thin films for application in electrochromic devices"	WO3	10^2−10^3	10^2−10^3
"Characterization of Vanadium Oxide Thin Films Prepared by Sol-Gel Method and Photodissociation"	V2O5	10^2−10^3	10^2−10^3
"Photoinduced synthesis of V2O5 coatings on glass substrates and their electrochromic properties"	V2O5	10^3−10^4	10^2−10^3
"Photo-assisted electrodeposition of tungsten oxide nanostructures for gas sensing applications"	WO3	10^3−10^4	10^2−10^3
"Photocatalytic and photoelectrochemical properties of tungsten oxide (WO3) thin films deposited by thermal evaporation"	WO3	10^2−10^3	10^2−10^3
"Photochemical Deposition of WO3 Films for Applications in Electrochromic Devices"	WO3	10^3−10^4	10^2−10^3
"Photoelectrochemical Deposition and Properties of Tungsten Oxide Thin Films"	WO3	10^3−10^4	10^2−10^3
"Synthesis and Characterization of WO3 Thin Films by Electrochemical Deposition for Photoelectrochemical Water Splitting"	WO3	10^2−10^3	10^2−10^3

References-

1. Fabrication of WO_3/V_2O_5 heterojunction thin films and their application for hydrogen gas sensing
2. Characterization of Vanadium Oxide Thin Films Prepared by Sol-Gel Method and Photodissociation, IEEE
3. Synthesis and Characterization of WO_3 Thin Films by Electrochemical Deposition for Photoelectrochemical Water Splitting
4. Photocatalytic and photoelectrochemical properties of tungsten oxide (WO_3) thin films deposited by thermal evaporation, IEEE
5. Characterization of Vanadium Oxide Thin Films Prepared by Sol-Gel Method and Photodissociation
6. Photoinduced synthesis of V_2O_5 coatings on glass substrates and their electrochromic properties