STRUCTURAL, MORPHOLOGIAL & ANTI MICROBIAL PERFORMANCE OF NiO THINFILMS SYNTHESIZED BY SILAR METHOD

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ABSTRACT:

Nickel oxide (NiO) thin films have garnered significant attention in recent years due to their potential application in recent years due to their potential applications in energy storage and biomedical devices. In this study, we report the advanced synthesis and characterization of NiO thin film via facile and cost-effective method. The structural, morphological and optical properties of the NiO were systematically investigated using X-ray diffraction, Scanning electron microscopy and UV-Vis spectroscopy. The super capacitor efficiency of the NiO thin film was evaluated using cyclic voltametry, demonstrating a high specific capacitance and excellent cycling stability. Furthermore, the antimicrobial performance of the NiO assessed against Gram-positive and Gram-negative bacteria, exhibiting significant antimicrobial activity. The results of this study demonstrate the potential of NiO thin films for applications in energy storage and biomedical devices, and provide a foundation for further research and development in these areas.

Keywords: Nickel Oxide (NiO), Super capacitor, Antimicrobial Performance, energy storage, Cyclic voltametry.

INTRODUCTION

Nickel oxide (NiO) thin films have generated significant attention in recent years due to their exceptional electrochemical and anti microbial properties, making them for various applications. In the realm of energy storage, NiO thin films have shown great promise as electrode for super capacitor, offering high specific capacitance, excellent cycling stability and rapid charge-discharge rates. Additionally, NiO's anti microbial activity against a broad spectrum of microorganisms has been extensively studied, revealing its potential as a coating material for biomedical devices and surfaces.

MATERIALS AND METHOD

As a synthesis of NiO thin film, we want to use SILAR method. It is the best method for preparing thin films at room temperature.

PREPARATION OF SUBSTRATE:

Before deposition, the glass substrate is cleaned by acetone, ethanol and demonized water for removing any contamination in the glass substrate.

PREPARATION OF NiO THIN FILMS:

To synthesise the NiO thin films, aqueous nickel- ammonia complex ions ($[Ni(NH_3)_4]^{2+}$) were chosen for the cation precursor, using reagents of $Nicl_2$(99%) and concentrated ammonia(25-28%) were used. The concentration values defined for Ni solution was 0.1M and the molar ratio Ni:NH_3 is 1:10.

For synthesis of the NiO thin films, one SILAR growth cycle included the following four steps:

- Immersing the substrate in the complex $[Ni(NH_3)_4]^{2+}$ on the substrate for 30seconds to create a liquid film.
- Immersing the withdrawn substrate immediately in hot water (90℃) for 7 seconds to form NiO layer.
- Drying the substrate in the air for 60 seconds.
- Rinsing the substrate in a separate beaker for 30 seconds to remove large and loosely bound NiO particles.

Thus one SILAR cycle of NiO deposition is completed. By repeating deposition cycles we obtain the NiO thin films.

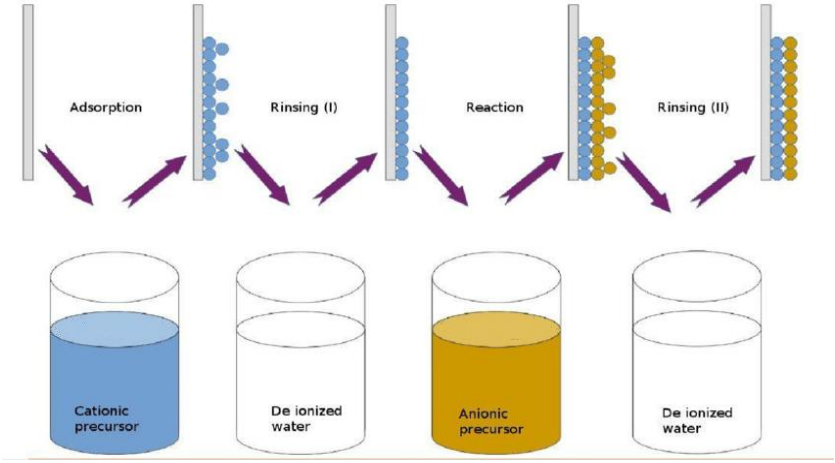

Fig 1. SILAR method

Here we choose $Nicl_2.6H_2O$ and hot distilled water as a cationic and anionic precursors. The SILAR method involves successive adsorption of ionic species onto a surface, followed by a reaction triggered by the adsorption of a different ionic species. This reaction leads to the formation of an insoluble product, which constitutes the thin-film coating.

RESULT AND DISSCUSSION

XRD PATTERN FOR NiO THIN FLM BY SILAR METHOD

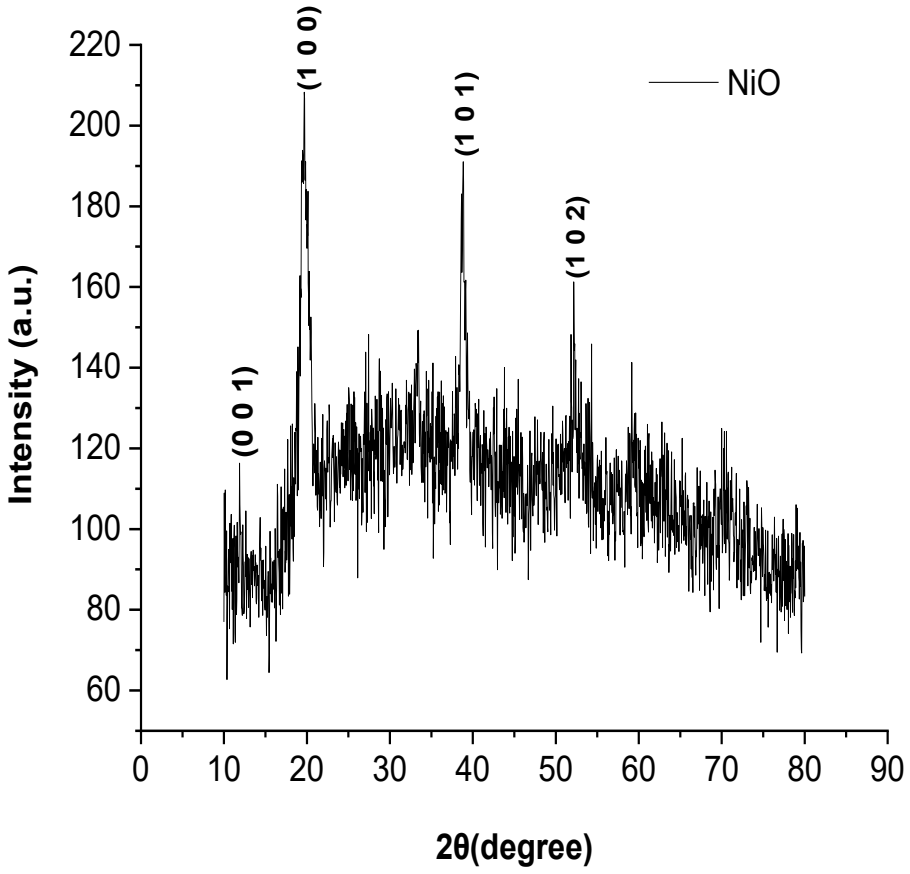

Fig 2. XRD pattern for NiO thin film deposited by Silar method

To study the structural properties of the deposited NiO thin films X-ray diffraction (XRD) study was carried out. Fig 1 show that XRD pattern of NiO deposited by SILAR Method for different deposition cycles of 80 respectively. The observed XRD pattern show the prominent peaks (001), (100), (101), (102) plane orientation for all the films prepared by different deposition cycles. However film deposited with 80 cycles show well defined peak with high intensitcompared to films prepared at 40 and 60 deposition cycles. All diffraction Peaks of the NiO thin film correspond to the characteristic cubic structure of NiO thin films. The observed 'd' values were compared with standard 'd' values using joint Committee on Powder Diffraction Standards (JCPDS card no 47-1049).

The crystallite size of thin film were calculated from XRD patterns by using Scherer's formula given below

$$D=k\lambda/ \beta \cos \theta$$

Where,

D = Crystallite size

K = Constant

β = Corrected FWHM of the most intense peak

θ = Braggs angle Using these formula grain sizes can be determined.

The dislocation density has been calculated using crystallite size, by the equation

$$\text{Dislocation} = \frac{1}{D^2}$$

The micro strain has been calculated by the given formula,

$$\text{Micro strain} = \beta \cos \theta/4$$

The lattice parameter calculated for NiO by the given formula

$$a = d_{hkl}\sqrt{h^2 + k^2 + l^2}$$

The lattice parameter has been calculated and reported. The grain size, dislocation density, micro strain and lattice spacing of NiO thin film for 80 deposition cycles have been given below.

The particle size is found to be 19.07nm.

Deposition cycle	**h k l**	**2θ (Deg)**	**Grain size (10^{-9}m)**	**Dislocation density (line/cm^2)**	**Micro strain (10^{-4})**	**Lattice constant**
80	0 0 1 1 0 0 1 0 1 1 0 2	11.5778 19.6482 38.7503 52.2802	7.3765 25.5390 31.118 12.2626	0.01837 0.001533 0.0013270 0.0003684	0.469916 0.13573 0.11388 0.28266	7.6370 4.51460 3.283 3.90959

Table 1 Structural parameters of NiO for 80 deposition Cycles

RESULT OF SEM ANALYSIS OF NiO PREPARED BY SILAR METHOD

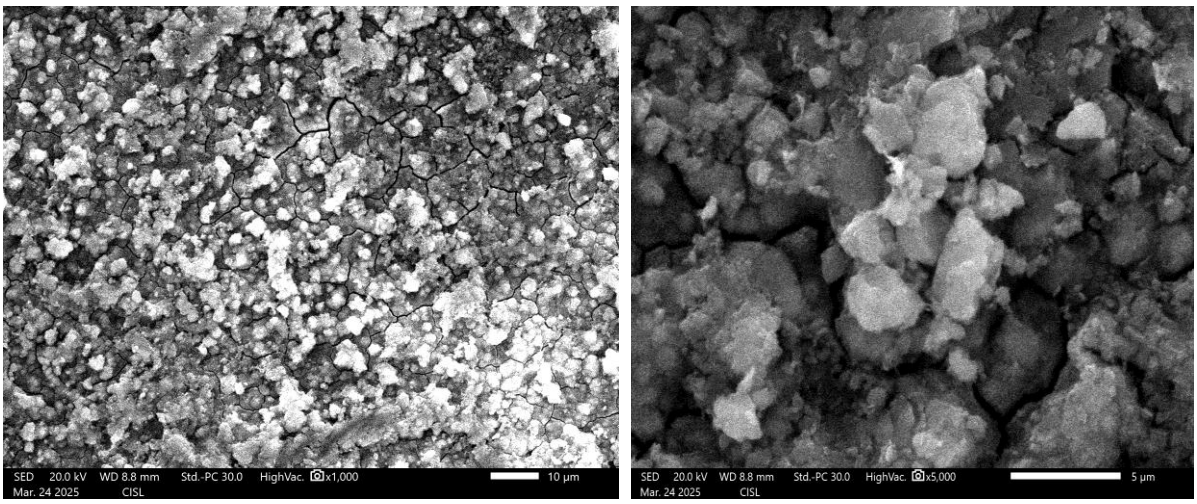

Fig 3 SEM Images of NiO

The SEM images confirms that the NiO thin film exihibits a rough, porous and polycrystaline structure with agglomeration. This morphology can influence its electrochemical, catalytic and antibacterial properties

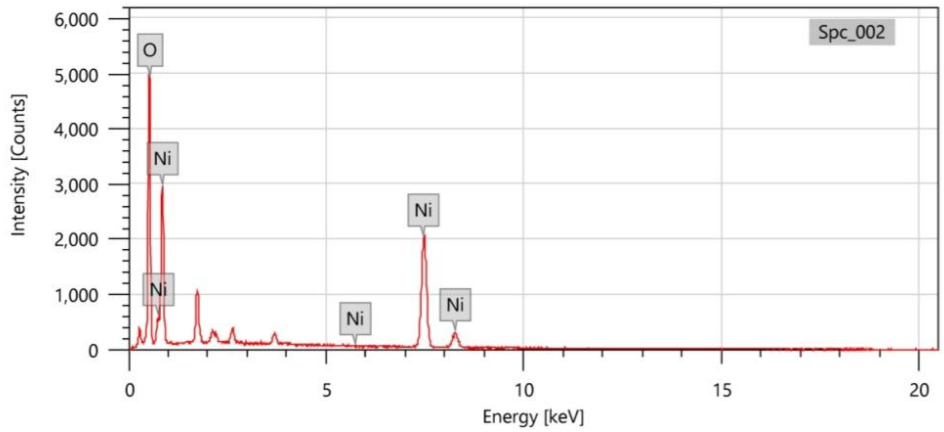

Fig 4 EDAX image of NiO

The morphological features of NiO was examined by the Scanning Electron Microscope. The SEM images exhibits inhomogeneous distribution of rock salt structure. The prepared sample was examined by EDAX analysis and expected elements of Ni and O were present in the atomic ratio 33.45% and 66.55%.

THICKNESS MEASUREMENT

In the present study thickness measurement were done by the weight gain method for different deposition cycles.

$$t = m / A\rho$$

Where,

m – Mass of difference of the substrate before and after deposition gives the mass of thin film

A – Area of the film coated

ρ – Density of film (Nickel oxide)

Thickness was calculated for the NiO thin films for 80 deposition cycle and the value was found to be 186nm.

RESULT OF ANTIMICROBIAL ACTIVITY OF NiO THINFILM PREPARED BY SILAR METHOD

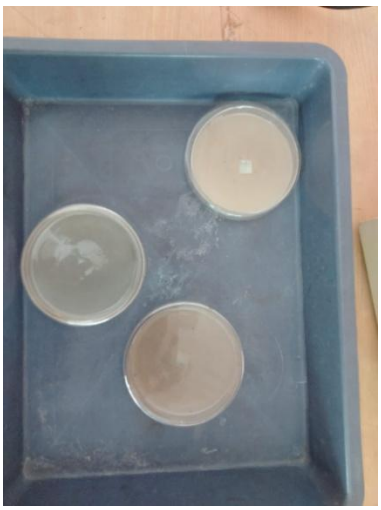

Fig 3. Antimicrobial Activity of NiO

The antimicrobial activity of the synthesized NiO thinfilms was tested using the agar well diffusion method towards two microorganisms including Escherichia coli and Enterobacter sp. The lack of absorvabal microbial inhibition suggests that NiO under the given conditions does not exihibit strong antibacterial properties against Escherichia coli and Enterobacter sp. Further investigation into film composition, surface characteristics and environmental conditions to help determine whether modification can enhance its antibacterial potential.

CONCLUSION

In summary, this study demonstrates the NiO thin film has the grain size varies from 7-31nm and it has rough, porous and polycrystaline structure with agglomeration. The antimicrobial studies suggests that NiO under the given conditions does not exihibit strong antibacterial properties. Furture studies will focus on optimizing the synthesis conditions and exploring the scability of the NiO thin films for practical applications. The findings of this study provide a foundation for the development of high-performance NiO-based supercapacitors and antimicrobialcoatings.

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