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Research Article

A Novel Neural-Based Design of Graphene and Molybdenum Disulfide Magnetic Tunnel Junction

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ABSTRACT

Magnetic tunneling junction (MTJ) research is currently growing dramatically due to the progress of spintronic devices. Due to the varying electrode and tunneling behaviors, it is critical to conduct a more accurate analysis of MTJ behavior also MTJ has limited behavior analysis research. To accurately analyze the behavior of MTJ a novel design of Graphene and Molybdenum Disulfide Magnetic Tunnel Junction is proposed. Initially, Graphene–MoS2–Graphene MTJ is designed, in this, graphene acts as the electrode and MoS_2 acts as the tunneling junction, which gains a better efficiency score, high TMR ratio, and current transmission range. Furthermore, to predict the magnetic and electrical properties of the designed MTJ, the intelligent behavior analysis strategy known as the radial basis magnetic behavior framework (RBMBF) is implemented, which makes the computations faster and provides better characterization. To analyze the implemented MTJ, it is developed in the MATLAB environment and trained on the RBMBF. Finally, the calculated metrics are compared to those of standard MTJs, and improvement scores are recorded. The intended model has a better transmission coefficient of 1.7 and a TMR ratio of 586% than the previous models.

Keywords: magnetic tunneling junction, tunneling magnetoresistance, tunnel barrier, spintronics, ferromagnetic and electrode, graphene, MoS2.

1. Introduction:

Tunneling Magnetoresistance (TMR) is a big step forward in the science of spintronics, a pioneering discipline that combines electron intrinsic spin and magnetic moments with standard electronic charge [1]. Spintronics, as opposed to traditional electronics, uses electron spin to store and manipulate data. Magnetic Tunnel Junctions (MTJs) are nano-structured devices that are critical for regulating spin-based electron currents in this domain [2]. Because of huge rotating polarizations inside the magnetic phases [3, 4], these MTJs exhibit considerable resistance fluctuations when the magnetic phase moments switch from parallel to anti-parallel configurations [5]. MTJs contain ferromagnetic (FM) phases paired with an insulator phase, which contributes to their essential role in spin electronics [6]. Notably, MTJs are widely used because of their excellent scalability, low energy consumption, and high durability [7]. These applications include a wide range of industries that require data processing and memory operations [8]. MTJs play a vital role in optimizing spectrum applications in the radio frequency domain, notably in compressive sensing, which attempts to minimize space and energy consumption [9]. As a result of its adaptability, MTJs may be incorporated into a variety of signal applications, including analog-to-digital conversions, increasing their value in the area of integrated circuitry [10]. As a result, MTJs' potential uses go beyond traditional electronics, promising breakthroughs in data processing, memory technology, and signal processing, opening the way for more efficient and high-performance electronic devices and systems [11].

Magnetic Tunnel Junctions (MTJs) offer the substantial benefit of being entirely powered off when not in use, assuring data preservation while consuming no energy [12]. This characteristic is very appealing to diverse industries looking for power-efficient solutions, making MTJs a tempting choice for a wide variety of applications. MTJs are electronic spin tools that enable specialized data recall while consuming minimum energy, making them appropriate for low-power applications such as those found in the Internet of Things [13, 14]. MTJs are also used in sensor linkages that operate under extreme circumstances, as well as devices that facilitate the electronic transmission of the current status by using spin-orbit torque (SOT) for efficient data processing. However, building spin electronic-dependent MTJ devices is difficult [15, 16]. Despite their capacity to store long-term data, MTJs' quality and efficacy are always being improved [17]. Researchers are continually working to improve MTJ design in order to boost data storage capacity and overall device efficiency [18]. To solve the restrictions associated with MTJ applications, certain novel techniques, such as the development of double-barrier MTJs and voltage-gated SOTs, have been proposed [19]. These developments seek to improve performance, alleviate disadvantages, and open the way for the widespread use of MTJs in a variety of practical applications, therefore contributing to the creation of efficient and sustainable electronic devices for the future [20].

Because of the rapid expansion of MTJs, the TMR value of MTJs has increased rapidly in recent years, approaching the theoretical value. Nonetheless, despite significant study and advancement, there are various difficulties and hurdles that must be identified and addressed in order to improve the efficiency, performance, and stability of MTJs [21]. Tunneling between top and bottom electrodes has been significantly reliant on the choice and fabrication of the barrier in MTJ. With the emergence of 2D materials, opportunities for MTJs based on 2D materials, which have many appealing properties and benefits, emerge. Transition metal dichalcogenides (TMDs) are two-dimensional materials with the potential to enable the creation of spintronic devices.

Molybdenum disulfide (MoS2) is one of the most well-studied TMDs. MoS2 has received a lot of interest because of its unusual electrical and optical features, such as electrostatic coupling [22], great carrier mobility [23], high current carrying capacity [24], and excellent thermal stability [25]. It has a variable bandgap that varies from an indirect 1.2 eV [26] in bulk to a direct 1.8 eV [27, 28] in monolayers, displaying typical semiconducting properties. Prediction systems are being upgraded with various elements that incorporate neuronal behaviors. As a result, neuron-based prediction or data analysis behavior is revealed in two ways: machine learning and deep networking, often known as deep learning. In terms of machine learning, deep learning has provided the most accurate forecasting results due to hyperparameters. These advancements motivated the current spintronics endeavor, which aimed to use the neural system as a behavior analysis model. Finally, the validation performance measurements have shown that an intelligent model is required in these spintronics applications.

The following are the primary contributions of this current study:

1) To achieve a high TMR ratio and the current transmission range, a novel graphene MoS_2-based MTJ is designed.
2) To conduct a more accurate analysis of MTJ behavior an RBMBF is introduced, which provides a faster computation and better generalization.

The content of the paper is as follows: Section 2 outlines the literature survey, the design of the system, and the proposed algorithm for MJT is described in Section 3 and Section 4 provides the testing outcome and performance for the novel solution. Finally, section 5 brings the paper to a conclusion.

2. Neural-Based Design of Graphene and Molybdenum Disulfide Magnetic Tunnel Junction:

MTJs are a potential spin electronics device. Because of their performance in commercial products, they are used in a variety of industries. As a result, effective high-spin current transmission with appropriate TMR in the MTJ is required for future applications. Many investigations have found that graphite-coated materials have the highest efficiency ratings for recording a high TMR ratio and current transmission range. Thus, graphene is used as an electrode in this proposed research. In addition, when a deep network is used, it is required to analyze TMJ behavior for tunneling devices. To estimate MTJ qualities, several mathematical models have been established in the past for MTJ applications. However, in order to build a mathematical model for electronic applications, such models require more functionalities and manipulation.

The proposed model designed an MTJ based on graphene and MoS_2. Here, the graphene acts as the electrode, and MoS_2 acts as the tunneling junction. Hereafter, the spin properties of the designed MTJ are defined. Then, a novel RBMBF is proposed to analyze the electrical and magnetic properties of the designed MTJ. The major advantages of the radial basis function are its straightforward design, faster computational process, and better generalization.

Finally, a comparative analysis is performed along with an analysis of the estimated magnetic and electrical properties of the designed graphene–MoS_2 MTJ.

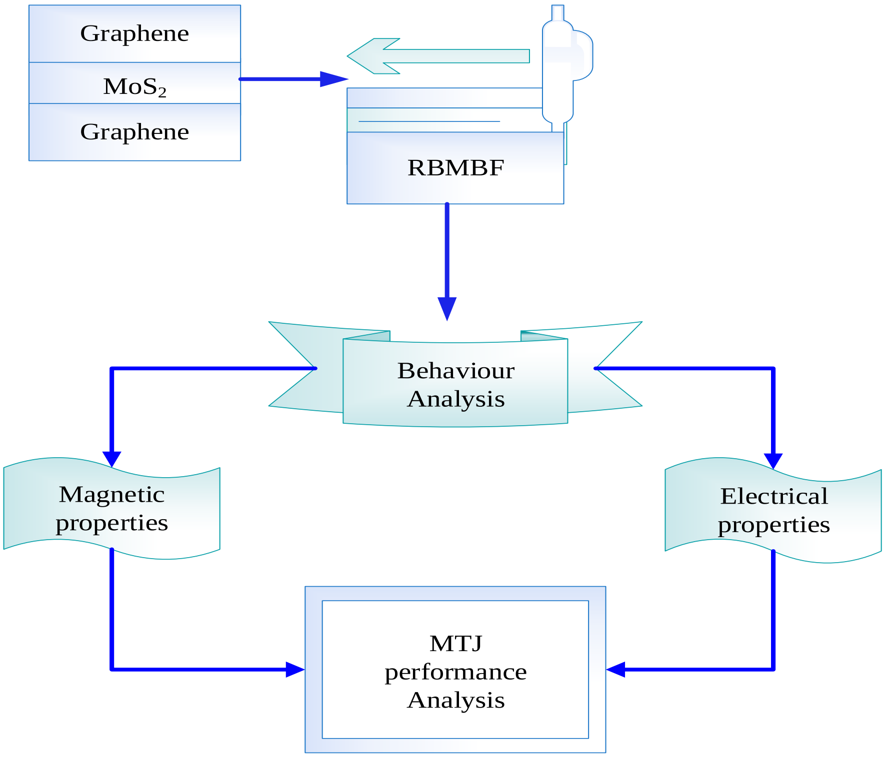

Figure 1: Architecture of the proposed model

The above figure 1 shows the architecture of the proposed model. Initially, the proposed MTJ-based Graphene–MoS_2–Graphene is designed, in which graphene acts as an electrode and MoS_2 acts as a tunneling junction. A deep network RBMBF is chosen as the behavior analysis model for the MTJ domain. Moreover, it provides a better-tuned behavior analysis outcome than conventional MTJs. The two behavior analyses, one is electrical and the other one is the magnetic characteristics of the constructed MTJ are analyzed. The radial basis model, which features a tuning layer that tunes MTJ behavior, is the focus of the deep network-based behavior analysis approach.

2.1. Design of Graphene–MoS_2–Graphene MTJ:

The proposed MTJ-based Graphene–MoS_2–Graphene design is implemented by integrating the different features of graphene and MoS_2 to produce certain electrical and magnetic functions. The first step is to conceptualize the arrangement of the MTJ layers, with the goal of utilizing the qualities of each material in a complimentary manner. The proposed Graphene–MoS_2–Graphene MTJ is made up of three major components: two layers of graphene that serve as ferromagnetic elements and a central layer of MoS_2 that serves as the tunneling junction. Graphene, a single layer of carbon atoms packed densely in a two-dimensional honeycomb lattice, is selected for its remarkable qualities, including excellent electrical and thermal conductivity, exceptional mechanical strength, significant flexibility, and higher accuracy. These characteristics are due to graphene's unique structure and make it a great choice for the proposed design. Furthermore, graphene's high mobility indicates that its electrons are capable of moving freely, allowing for efficient charge carrier transfer throughout the material. MoS_2, a semiconductor material composed of molybdenum (Mo) and sulfide (S), has unique electrical and optical characteristics. MoS_2 is a layered structure composed of layers of molybdenum atoms sandwiched between layers of sulfur atoms. The combination of these materials in the proposed MTJ offers the advantages of enhanced conductivity, improved tunneling efficiency, and potentially better control over the spin properties of the MTJ.

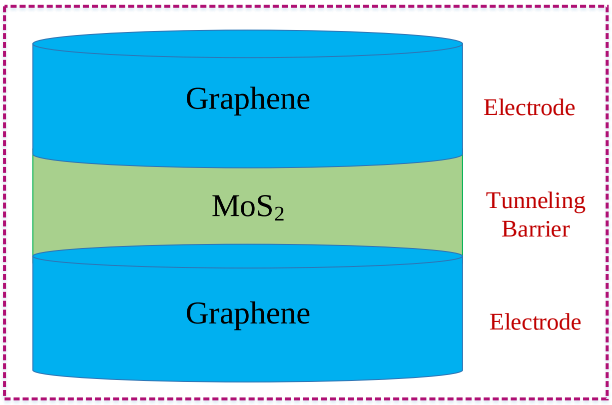

Figure 2: Design of Graphene–MoS_2–Graphene MTJ

The above figure 2 illustrates the design of the proposed graphene-MoS_2-graphene MTJ. The MTJ has a basic structure made up of two layers of graphene that act as electrodes, allowing charge and spin currents to flow. The essential component of the MTJ is the MoS_2 layer, which serves as the tunneling junction and is located between the graphene layers. The MoS_2 layer permits electron movement via quantum mechanical tunneling, which is critical in regulating current flow in the MTJ.

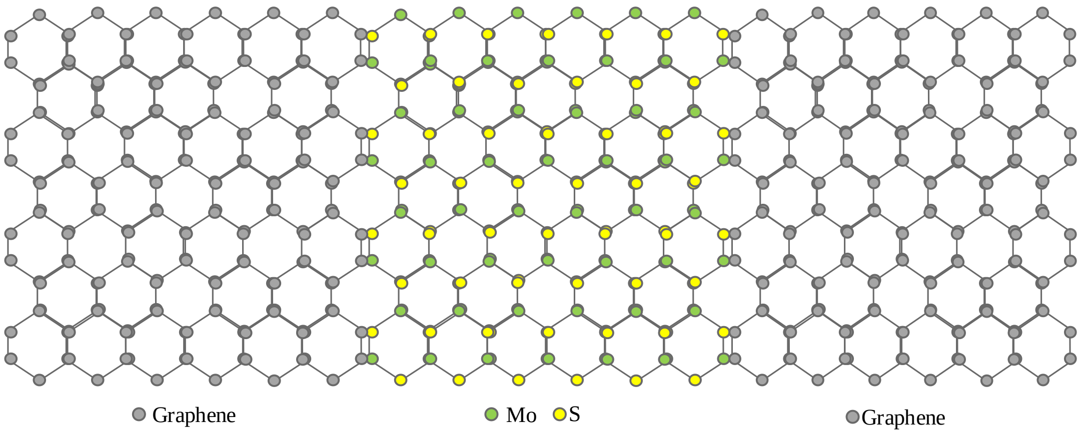

Figure 3: Crystal structure of graphene–MoS_2–graphene MTJ

The above figure 3 shows the crystal structure of the proposed graphene-MoS_2-graphene MTJ. The utilization of dual sulfide, as illustrated by the yellow dots in the crystal structure, results in the creation of MoS_2, which is required for the MTJ. The arrangement of molybdenum (Mo) atoms is shown as green dots and sulfur (S) atoms are represented as yellow dots within the MoS_2 layer following the typical crystalline structure of MoS2.

The crystal structure of the proposed graphene–MoS_2–graphene MTJ is illustrated in figure 3. The correct atomic arrangement inside the MoS_2 layer determines the MTJ's tunneling behavior and spin characteristics, which are critical for obtaining desirable magnetic and electrical functions.

The semiconductor material utilized in this proposed design is MoS_2, which has a modeled energy level of 1.7 eV. Graphene is employed as the Fermi stage on both sides, which aids in the investigation of the quantum behavior of spintronics devices. MoS_2 is a monolayer, and the spin channel is graphene, which is introduced into electron spin devices. The quantum behavior of the spintronics devices is measured using two electrodes. To construct the magnetic composite of the proposed MTJ model, which is a critical component of magnetic spintronics devices. The MTJs aid in the manipulation of electron spin and hence play an important part in the operation of spintronics devices. As a result, understanding the magnetic characteristics of the material utilized in the MTJ model is essential to constructing efficient spintronics devices. The design properties of the MTJ are expressed in the following equation (1)

$$H(E) = \frac{\alpha/2\pi}{(\omega^2)+(\frac{\alpha}{2})^2} \quad (1)$$

Where, the density state represents molecular strength is defined as ω, while represents tunneling barrier elevation α. These characteristics are important in influencing the MTJ's behavior. $H(E)$ is the MTJ's design characteristics, including the effect of molecular strength and tunneling barrier elevation on total MTJ performance. The coupling strength between the MTJ and spintronic devices is calculated using the following equation (2).

$$\alpha = I_0 \exp(-\eta \times t) \tag{2}$$

During the transmission's spin current, the thickness of the barrier (t) of the proposed MTJ is adjusted from 2.2mm to 1.2mm. The magnetic atoms' coupling energy is expressed as I_0, and the exp signifies the exponential also the efficiency of the injected spin is expressed as η. The spin current (I^σ) is expressed in the following equation (3)

$$I^\sigma = \frac{e}{\hbar}\int_{-\infty}^{+\infty} T(E)[f_L(E, \mu_L) - f_R(E, \mu_R)]dE \tag{3}$$

The integration is done within the bias window under bias voltage V_b. Where the charge of an electron is represented as $e = 1.6 \times 10^{-19}C$ and $\hbar = 6.626 \times 10^{-32} m^2kg/s$ is the plank constant and f_L and f_R are the Fermi-Dirac distributions for the left and right electrodes with chemical potential μ_L and μ_R respectively. The fermi-Dirac distribution function is expressed in the following equation (4)

$$f_{L/R}(E) = \frac{1}{\exp\left(\frac{E-\mu_{L/R}}{k_B T}\right)+1} \tag{4}$$

Where the Boltzmann constant is $k_B = 1.38 \times 10^{-23} JK^{-1}$. The Wentzel-Kramers-Brillouin (WKB) approximation, which is often employed for thin barriers, is often used to characterize the electron tunneling probability across a barrier. The tunneling probability P is determined using the WKB approximation as follows in equation (5)

$$P \propto e^{-2\mathcal{K}d} \tag{5}$$

Where $\mathcal{K}$ is the decay constant and d is the barrier width. The decay constant is related to the barrier height U and the electron energy E, which is expressed in the following equation (6)

$$\mathcal{K} = \sqrt{\frac{2m}{\hbar^2}(U - E)} \tag{6}$$

Where m denotes electron mass. If represent the tunnel barrier's height as U_0, state that the tunneling probability is inversely proportional to the height, implying that in equation (7)

$$P \propto e^{-2\mathcal{K}d} \propto e^{-4\frac{\sqrt{2m(U-E)}}{\hbar}d} \tag{7}$$

An MTJ often shows a spin-dependent conductance that is connected with the parallel (P) and antiparallel (AP) alignments of the magnetic moments in the layers. The MTJ appears inefficient in delivering a suitable spin transport function in spin-down states. This is due to a variety of variables, including material qualities, junction design, or the existence of defects that impact spin-dependent transport behavior. The terms SaP and SP conductance are used to describe the flow of spin-polarized electrons in an element. The Landauer formula is used to compute conductance, which is given in equation (8)

$$G = \frac{2e^2}{\hbar}T(E_F) \tag{8}$$

Where $T(E_F)$ is the transmission probability of the fermi energy. The spin-parallel (SP) and spin-anti-parallel (SaP) conductance of the proposed model is characterized using the following equations (9) and (10)

$$G_{SaP} = \frac{2e^2}{\hbar}T_{SaP} \tag{9}$$

$$G_{SP} = \frac{2e^2}{\hbar}T_{SP} \tag{10}$$

The transmission coefficient for the anti-parallel arrangement is T_{SaP}, whereas the transmission coefficient for the parallel configuration is T_{SP}. The parallel configuration has a larger conductance than the antiparallel configuration, which is consistent with the increased probability of electron tunneling for parallel alignments due to the lower effective barrier.

As a result, the molecular strength and tunneling barrier elevation described in the MTJ model are critical in enhancing magnetic characteristics, which improve device performance by increasing the efficiency of spin transport and electron tunneling. The variable coupling strength enables fine control of the MTJ-spintronic device connection. This allows for efficient control of spin current transmission, which increases the efficiency of injected spin. Moreover, the behavior analysis is performed using RBMBF, which is explained in the next section.

2.2. RBMBF Behavior Analysis

To predict the magnetic and electrical performance of the MTJ, a unique RBMBF is developed. The radial basis function has a simple design that provides a quicker computing process, reliable predicting results and improves generalization.

At first, the process of initializing the design variables involves the utilization of a proposed radial basis model. This model type has been extensively used in various prediction scenarios, owing to its ability to effectively capture complex, non-linear relationships within the data. The initialization process is decisive, because of its potential to generate very accurate predicting outcomes.

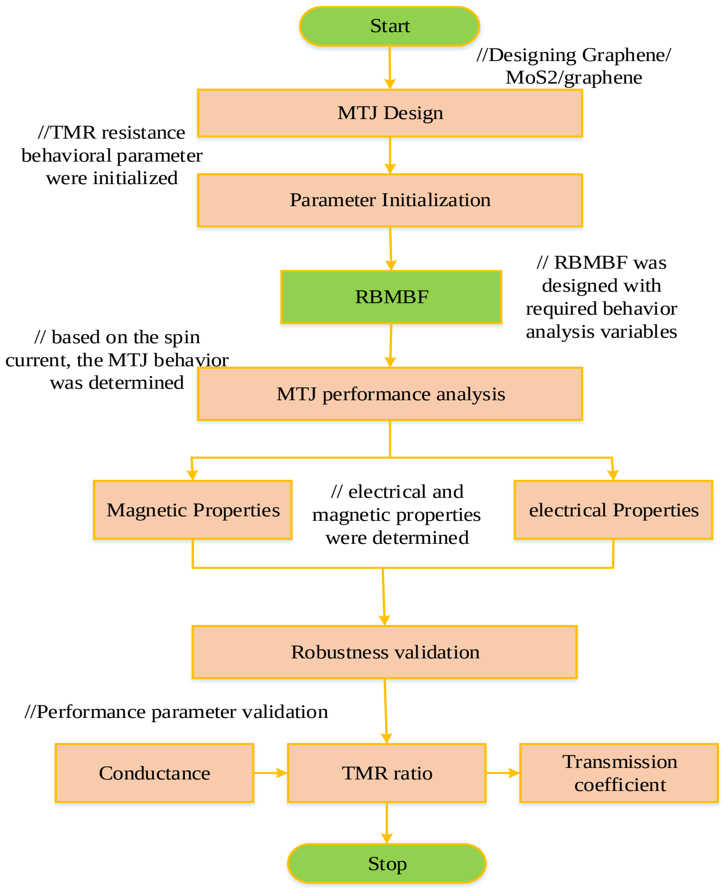

Figure 4: Flow of RBMBF

The MTJ property analysis flows are described in Figure 4. In first the MTJ of graphene-MoS_2-graphene is designed. Then the TMR resistance behavioral parameters are initialized. After parameter initialization RBMBF model is designed with the required behavioral analysis variable, and based on the spin current the MTJ behavior is determined. The function appears to entail a prediction process, with the goal of estimating the system's behavior based on the input variables and previously initialized parameters. Following the forecast, the program estimates the system's electrical and magnetic characteristics.

The MTJ design parameters get activated in the neural system during the initial phase. This is most likely the procedure of configuring the MTJ parameters within the RBMBF model. The initiation process in the neural network is indicated by N_a, which symbolizes the activation process. The MTJ parameter initialization inside the proposed prediction framework is expressed as follows in Equation (11).

$$N_a = \left(exp.u - \frac{H(E)+I_0-\eta}{t}\right) \quad (11)$$

When the MTJ is coupled to the spintronic devices, its conductance is measured. This measurement is essential for evaluating the proposed MTJ's electrical characteristics in the spintronic devices. The MTJ conductance has the potential to be calculated as follows in equation (12).

$$\frac{1}{S_d} u(t_{MoS_2}) = C\left(1 - b_x(t_{MoS_2})\right) \cdot \exp\left(-2J_0(t_{MoS_2} - I_0)\right) + \frac{w(t_{MoS_2}) \cdot I_0}{S_{di} \cdot tMoS_2} \quad (12)$$

Where the hyperparameter variable is utilized to fine-tune the performance of the MTJ is u. This equation includes the effect of the 'hyperparameter variable,' which is used to fine-tune the MTJ's performance. The tunnel barrier is exposed as J_0 and the calculated spin device's S_d conductance parameter is specified as C. Furthermore, the bridge parameter between MTJ and the spin device is determined as b_x, and the spin current transmission initiation is described as S_{di}. The variable for performance tweaking hyperparameters is denoted as w; which indicates the relative contribution of the nanobridge.

The 'optimal MTJ performance score' acts as a reference point for this tuning procedure. The neural network training process is repeated until the MTJ performance is at the appropriate level of quality.

The behavior analysis step process is defined in Algorithm 1

```
Algorithm 1. RBMBF
Input: ω, α, S_d, N_a, and u
Output: Estimation of electrical and magnetic properties
Start ()
{
    int ω, α;
    //initializing  the  molecular and the tunneling barrier variable
    Coupling strength = spin efficiency ×  atom_diode
    Behavior analysis ()
    {
        int S_d, N_a, u;
        // initializing the training and the prediction variables
        u(conductance) = transmission range  +  TMR
        // fixing the finest transmission range in the tuning layer of RBMBF
        prediction → S_d(behavior)
    }
Estimation of electrical and magnetic properties
}
Stop()
```

As a result, the MTJ's behavior is optimized by fine-tuning its parameters within a neural system. The goal is to maximize MTJ performance, namely producing a wide range of spin current transmission and high TMR ratio values. This strategy seeks to improve the MTJ's overall efficiency and effectiveness of the spintronic device. The next section is the result and discussion.

3. Result and discussion:

The MATLAB platform was used to construct the anticipated MTJ design and the behavior analysis model, and the performance score was calculated using electrical and mechanical attributes. The spin current transit was measured using the conductance and resistance characteristics. Table 1 lists the design parameters as well as the tool description.

Table 1: Parameter specification

Parameter Description	
Device	MTJ
Electrode	Graphene
Tunneling behavior	MoS_2
Designing platform	MATLAB
Version	R2021a
Operating system	Windows 10

Table 1 shows the parameter specification of the proposed model. To assess the design, certain essential parameters were evaluated and validated with other associated models based on spin injection and the TMR score.

In this case, the projected MTJ performance was justified in two phases: SaP (anti-parallel) and SP (parallel). The TMR was tested to see if the MTJ was adequate for passing the spin current to linked devices. In this test, the spinUp current was greater than the spinDown current in the dual configuration phases. In Equation (13), the TMR formulation is equated.

$$TMR = \frac{I_{SP}^{*} - I_{SaP}^{*}}{I_{SaP}^{*}} \tag{13}$$

Here, I_{SP}^{*} symbolizes the current configuration of the SP and I_{SaP}^{*} denotes the current configuration of the SaP. Equation (14) is used to calculate the injection efficiency of spin polarisation.

$$efficiency = spin \left| \frac{I^{*}Up - I^{*}Down}{I^{*}Up + I^{*}Down} \right| \tag{14}$$

3.1 Performance analysis of the proposed model:

The Performance metrics of the proposed Neural-Based Design of Graphene and Molybdenum Disulfide Magnetic Tunnel Junction and the achieved outcome were explained in detail in this section.

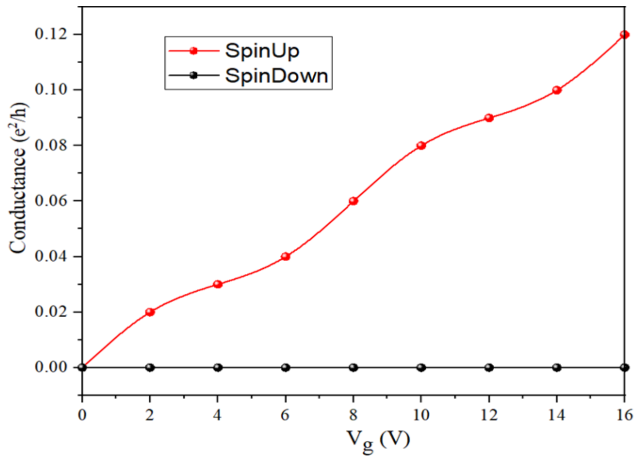

Figure 5: Conductance of SpinUp and SpinDown currents

Figure 5 depicts the conductance of SpinUp and SpinDown currents of the proposed model. The current had been altered in both designs based on varying voltage biases. The recommended voltage for calculating the TMR is 10 V. Variable conductance was measured for both SpinUp and SpinDown at voltages ranging from 0 to 16 V. When the

MTJ is not under electric load, the SpinDown current is maintained at a 0-level stability that varies with voltage. Furthermore, when the voltage range rose, the conductance of the SpinUp current increased.

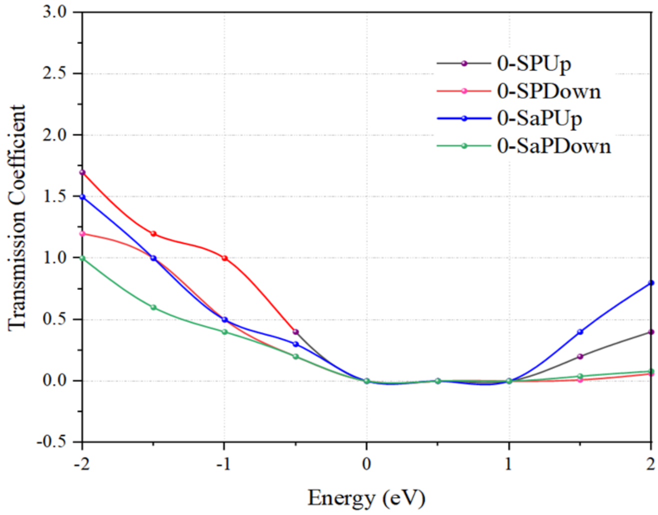

Figure 6: Transmission coefficient at 0 V

Figure 6 depicts the stated transmission coefficient for 0 V. The spin current transmission range was evaluated in dual voltage ranges of 0 V and 10 V. The spin current was measured in two methods at each voltage level: SP and SaP. The current transmission level within the MTJ was also measured in both up and down polarization. Between 0 and 1 eV, the spin current transmission reached the 0 state.

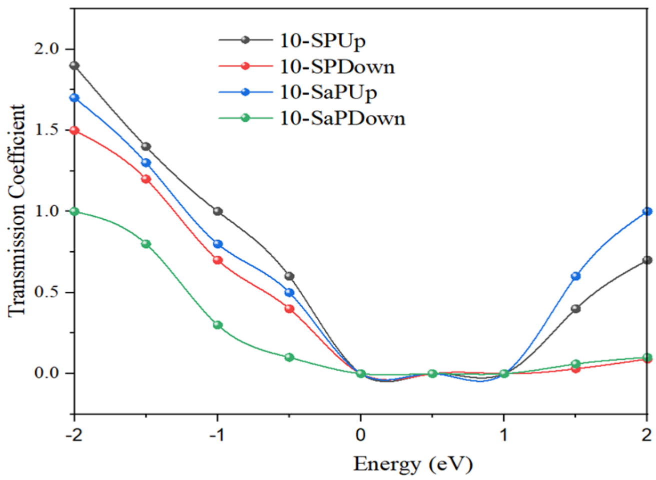

Figure 7: Transmission coefficient at 10 V

The voltage was adjusted to 10 V to test the peak level transmission coefficient of the proposed MTJ, and the transmission coefficient was measured, as shown in Figure 7. The transmission coefficient lines in this case indicate an increase rate greater than 0 eV. As a result, as the voltage level grew, the transmission coefficient range expanded. The magnetic device of the electronic application was chosen to enhance the spin current transmission method.

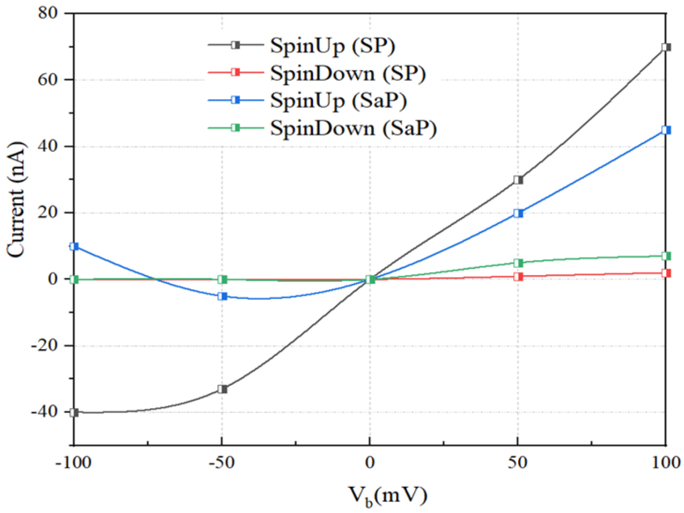

Figure 8: MTJ current variation (nA)

The above figure 8 shows the MTJ current variation of the proposed model. The electrical characteristics of the implemented MTJ were confirmed using a current value in the nA range. The graphene-MoS2 MTJ's current fluctuation range was confirmed for both negative and positive voltage bias. As a result, the voltage bias fluctuation is depicted on the x-axis. All spin-polarized currents, such as SPUp, SPDown, SaPUp, and SaPDown current transmission performance, overlapped while evaluating spin current transmission at the zeroth gate voltage. The spin-up current progressively rose to exceed the spin-down current when the bias voltage was shifted to the positive gate voltage. Furthermore, when the SaP was taken into account, the SPUp current transmission was much boosted.

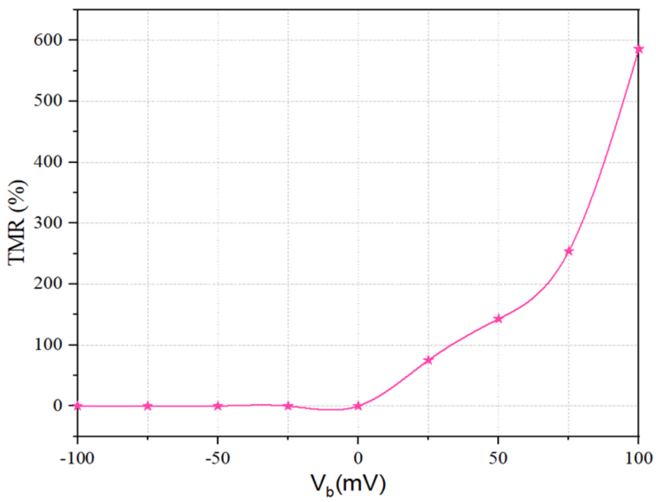

Figure 9: TMR assessment

The above figure 9 shows the TMR assessment of the proposed model. TMR's clear vision was used to analyze the MTJ's performance. As a result, the TMR is regarded as the primary measure for verifying the MTJ's transmission performance in electronic applications. A positive bias voltage was used to boost the MR ratio. The MTJ's polarization was characterized as being greater on the positive bias voltage side. Furthermore, the new technique yielded the greatest TMR percentage of 586% for the 100-mV bias voltage.

3.2 Comparative analysis of the proposed model

A comparison analysis with other MTJs that incorporate MoS2 as the tunnel barrier was developed to validate the robustness and requirement for the constructed MTJ in electronic applications. VS2-MoS2-VS2 [39], VT MTJ [39], and MT MTJ [39] and CrB_3[40], CrI_3 [40], fcc Fe [41], Fe_4N [41], CO_4N [41], and Ni_4N [41] and MoS2/GQD/MoS2 [42], Ni/Gr/h-BN/Gr/Ni [42], and FeRh/MgO/FeRh [42] were the MTJs used in this performance investigation.

The MTJ is designed for the electrical appliance to maximize current polarization. The transmission coefficients verified the spin current polarization in this case. For testing transmission performance, the transmission coefficient range of the spin-up current performance was used.

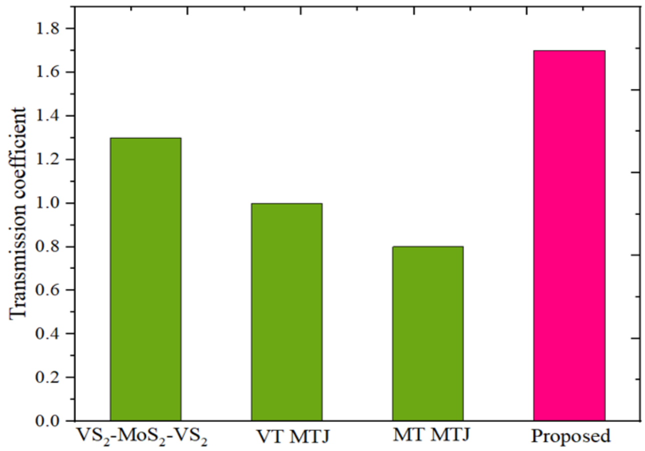

Figure 10: Comparison of the transmission coefficient

Figure 10 depicts the comparison of transmission coefficients. It demonstrated that the provided MTJ is effective in transporting electric characteristics. The transmission coefficient range for the VS2-MoS2-VS2 model was 1.3, the transmission coefficient score for the VT MTJ model was 1, and the transmission coefficient score for the MT MTJ model was 0.8. When these comparisons were made, the suggested graphene-MoS2 had the greatest transmission coefficient value of 1.7.

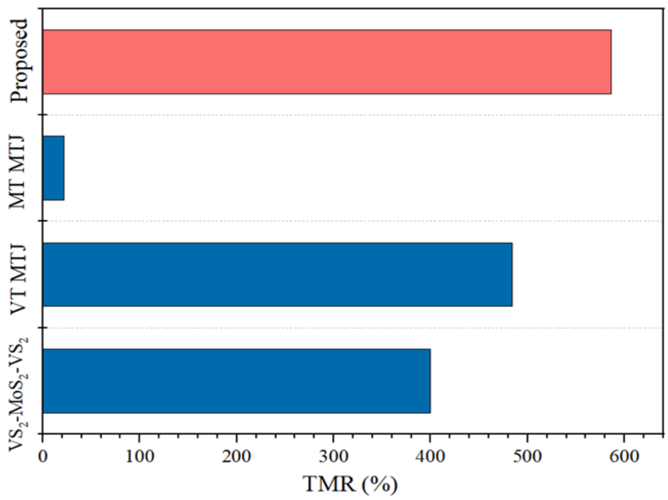

Figure 11: Comparison of TMR

The above figure shows the comparison of the TMR of the proposed model with existing models. The highest average TMR value from the acquired TMR outcome was used to determine the improvement range of the proposed MTJ. Typically, the TMR was steadily raised in the positive bias voltage. As a result, the maximum TMR range for each MTJ was set to 100 mV, and the comparison was carried out. The proposed graphene-MoS2 MTJ has a maximum TMR percentage of 586%. Given this, current models such as the VS2-MoS2-VS2 had the best TMR score of 400%, the VT MTJ had a TMR of 484%, and the MT MTJ model had a TMR of 22%. As a result, when compared to the other MTJs, the reported graphene-MoS2 demonstrated a greater TMR range than the comparison models.

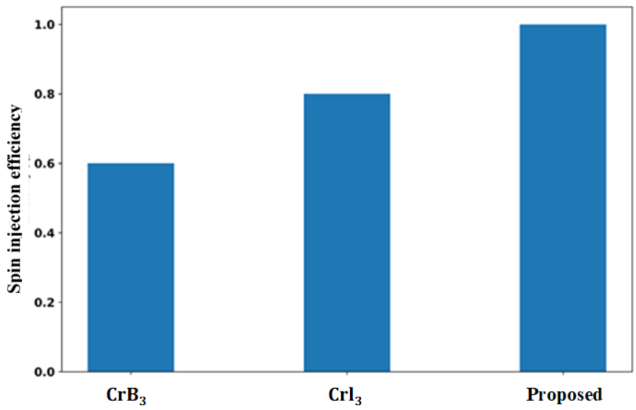

Figure 12: Comparison of spin injection efficiency

The above figure 12 shows the comparison of spin injection efficiency of the proposed model with existing models. The existing models CrB_3 and Crl_3 are achieves a spin injection efficiency value of 0.6 and 0.8 respectively also the proposed model attains a high spin injection efficiency of 0.92. Compared with existing models the proposed model achieves a high spin injection efficiency.

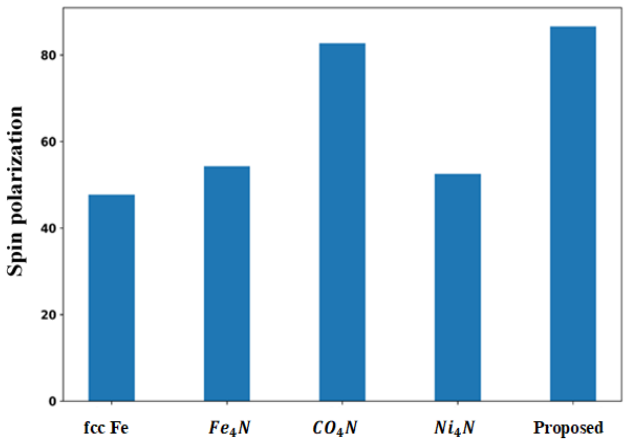

Figure 13: Comparison of spin polarization

The above figure 13 illustrates the comparison of spin polarization of the proposed model with existing models. The existing models such as fcc Fe, Fe_4N, CO_4N, and Ni_4N achieves a spin polarization of 48, 55, 82, and 54 respectively. The proposed MTJ model achieves a high spin polarization value of 87. Compared with the existing models the proposed model achieves a high spin polarization.

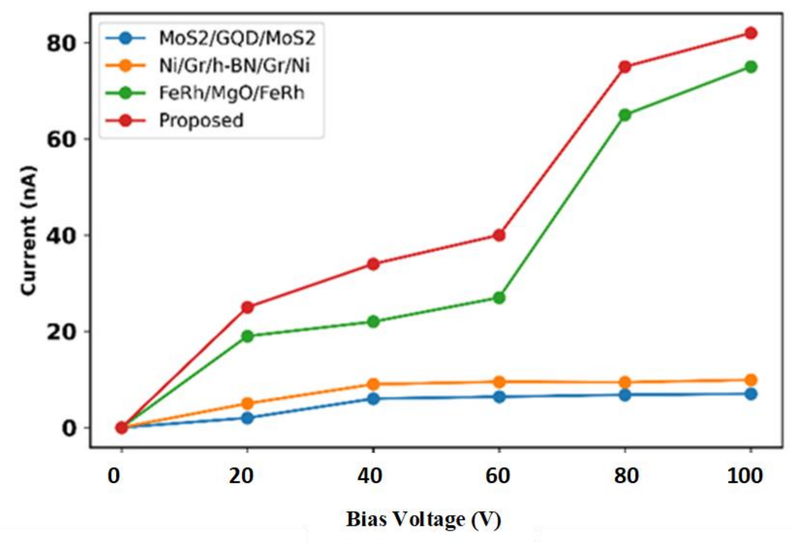

Figure 14: Comparison of spin current

The above figure 14 illustrates the comparison of spin current of the proposed model with existing models. When the bias voltage is 20 V, the proposed framework obtains a minimal spin current value of 22nA, whereas existing models such as MoS2/GQD/MoS2, Ni/Gr/h-BN/Gr/Ni, and FeRh/MgO/FeRh achieve a lowest spin current value of 1nA, 5nA, and 20nA. When the bias voltage is 100 V, the proposed framework obtains a maximal spin current value of 80nA, whereas existing models such as MoS2/GQD/MoS2, Ni/Gr/h-BN/Gr/Ni, and FeRh/MgO/FeRh achieve the highest spin current value of 6nA, 8nA, and 78nA. The existing models. The proposed framework achieves a high spin current value.

Overall, in the proposed model the variable conductance is measured for both SpinUp and SpinDown at voltages ranging from 0 to 16 V. Compared with existing models the proposed model achieves a maximum TMR percentage of 586% and the greatest transmission coefficient value of 1.7. This proves that the proposed model performed well when compared to other existing techniques.

4. Conclusion:

The most essential electronic application job for minimizing resource costs is optimized behavior analysis for MTJs. As a result, the unique RBMBF was run in the MATLAB environment to investigate the behavior of the developed graphene-MoS2 MTJ. When compared to the statistical-based prediction model, the deep network-based behavior analysis offered the best results. Furthermore, the MTJ's performance was evaluated in two phases, as were the SP and SaP models. In this case, the existence of the hyperparameter in the deep network aided in producing the best MTJ result by setting the ideal MTJ characteristics. The proposed graphene-MoS2 MTJ achieved a maximum TMR of 586%, which was 30% higher than the maximum TMR of existing MoS2 tunnel barrier MTJs. Furthermore, when compared to other models, the proposed MTJ's present transmission behavior improved by 0.7%. As a result, the developed MTJ is appropriate for the electronic spin device for regulating polarization between dual bridges in linked electronic devices.

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