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A Study Growth Approach based Unitary Analysis of Zinc - Oxide and Graphene Composite Sensor Electrodes

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***Abstract:** In this paper, the accentuation is made on fundamental development procedure of Zinc Oxide and Graphene based composites. An impetus or seed free development of ZnO on graphene by warm dissipation of Zn within the sight of O2 gas was examined in detail and further investigated. The impacts of substrate positions and graphene thicknesses on the morphological, basic, and optical properties were observed to be extremely articulated. By setting the substrate to be slanted at 90°, the development of ZnO nanostructures, in particular, nanoclusters and nanorods, on single-layer (SL) graphene was effectively acknowledged at temperatures of 600 °C and 800 °C, separately. For the development on multilayer (ML) graphene at 600 °C with a tendency point of 90°, the developed structures demonstrate to a great degree thick and constant group structures when contrasted with the development with substrate's tendency edge of 45°. In addition, the base of nanorod structures developed at 800 °C with a tendency edge of 90° additionally turned out to be thicker when contrasted with 45°, despite the fact that their densities and viewpoint proportions were relatively unaltered. Photoluminescence (PL) spectra of the developed ZnO structures were made out of the UV outflow (378– 386 nm) and the unmistakable discharge (517– 550 nm), and the power proportion of the previous emanation to the last outflow changed, contingent upon the temperature. The structures developed at a low temperature of 600 °C demonstrate the most noteworthy estimation of I-UV of 16.2, which is very nearly multiple times higher than the structures developed on single layer (SL) graphene, showing less auxiliary deformities. The conceivable development system was proposed and depicted which considered both the nucleation and oxidation forms. From the outcomes acquired, it very well may be presumed that temperature beneath 800 °C, substrate position slanted at 90° towards the gas stream, and ML graphene is by all accounts ideal parameters for the development of ZnO structures by warm vanishing in light of the fact that these variables can be utilized to beat the issue of graphene's oxidation that happens amid the development.*
***Keywords:** Graphene, Nanomaterials, chemical sensors, Zinc oxide Nanorod, Nanoclusters, Nano sensor.*

I. INTRODUCTION

The astounding physicochemical properties of fullerenes and Zinc Oxide and Graphene composites (ZnO - Graphene composites) offer new prospects for the improvement of nanotechnologies. As of late, inorganic semiconductor nanostructures and thin movies on graphene is especially fascinating in light of the fact that these structures can offer extra usefulness to graphene for acknowledging progressed electronic and optoelectronic applications in photovoltaic's, nanogenerators, field emanation gadgets, touchy natural and synthetic sensors, effective vitality change and capacity gadgets [1-13]. Graphene has an incredible potential for novel electronic gadgets in view of its remarkable electrical, warm, and mechanical properties, including a bearer versatility surpassing 104 cm2/Vs and a warm conductivity of 103 W/mK [14-18]. In this way, with the incredible electrical and warm qualities of graphene layers, developing inorganic semiconductor nanostructures and thin movies on graphene layers would empower their novel physical properties to be abused in various refined gadget applications [19, 20]. It is important that the nuclear course of action of graphene is like the (111) plane of zinc-blende structure and c-plane of a hexagonal crystalline structure which makes the development of semiconductor nanostructures and thin film on graphene achievable. Since 10 years back, concentrated inquires about have been centered around creating one-dimensional (1D) zinc oxide (ZnO) semiconducting nanostructures in light of the fact that it can give an assortment of essential applications because of their one of a kind morphologies, pieces, and substance/physical properties [21, 22]. For instance, since graphene is a superb conductor and straightforward material, the cross breed structure of ZnO/graphene will prompt a few gadget applications on silicon (Si) substrate as well as on other subjective substrates, for example, straightforward glass [41, 59] and straightforward adaptable plastic [16, 46]. Inferable from the remarkable

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electronic and optical properties of ZnO nanostructures, such half and half structure can be utilized in detecting gadgets [23-25], bright (UV) photograph locators [26], sun based cells [27] and light-emanating diodes [28], and so forth.

II. LITERATURE REVIEW

The most widely recognized technique to develop ZnO on graphene is warm dissipation because of its effortlessness and high development rates. As of late, we detailed the seed/impetus free development of ZnO on multilayer (ML) graphene. By warm vanishing of Zn within the sight of oxygen (O2) gas [3, 35]. The impacts of substrate temperatures were considered where it was discovered that the progressions of morphologies were exceptionally critical. The developed ZnO structures demonstrate three unique structures, i.e., nanoclusters, nanorods, and thin movies at 600°C, 800°C, and 1,000°C, individually. High-thickness vertically adjusted ZnO nanorods equivalent to different techniques, were additionally acquired. Be that as it may, two vital issues still remain which should be tended to. To start with, the development system of nanostructures must be examined, which would build controllability in the morphology and compound and physical properties of nanostructures. Second, uniform and homogeneous development of nanostructures on vast graphene movies would be exceptionally significant for the down to earth use [54-58]. By thinking about these two issues, the impacts of graphene thickness and substrate position have been set to be additionally examined in this paper. As announced before, the tendency edge of the substrate was appeared to give huge impacts regarding the thickness and length of the developed ZnO nanowires on Si because of the distinctions of approaching gas stream designs [47-52]. It is significant that the development strategy and setup are like our work. Inspired by this point, in this work, we tried two sorts of tendency edges which are 45° and 90° as we expect that the huge contrasts ought to be discernible particularly for the development of ZnO on graphene [29].

A. Field-Emission Property

Starting from 1998, interest in field-emission properties of Zinc Oxide and Graphene composites was increasing explosively all over the world. Today we can speak of thousands of well demonstrated works of nanotechnology phenomena [34]. The minimum threshold electric field for the film samples which we consider to be good is from 0.5 to 1 V/μm, the operating field is from 5 to 10 μV, the current density reaches 0.5 A/cm2 and 2 A/cm2 in the direct-current and pulsed regimes, respectively, and the cathode life exceeds 2000 h [39].

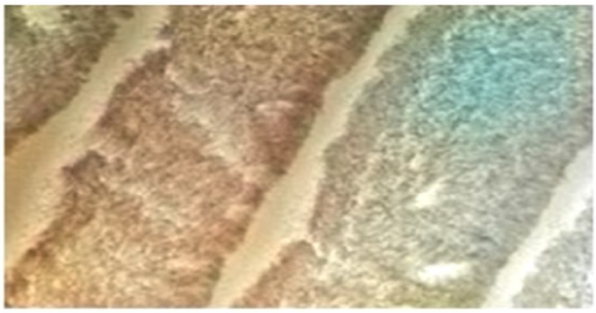


Fig. 1 Photograph of strips of oriented Zinc Oxide and Graphene composites synthesized on a substrate.

The strip width is 20 μm and the gap between the strips is 5 μm [13] where size is observed using the next-neighbour TB Hamiltonian [31, 42]:

$$H = -t \sum_{(i,j),\sigma} C_{i,\sigma}^{\dagger} C_{j,\sigma} + h.c. \quad (1)$$

Where C_i is the annihilation (creation) operator for an electron with spin σ at site i, and t is the hopping integral with a typical value t = 2.7 eV. The previous Hamiltonian can be rewritten with a notation that introduces the bipartite nature of the honeycomb lattice [20]:

$$H = -t \sum_{n,m,\sigma} C_{n,m,\sigma}^{(1)\dagger} \left(C_{n,m,\sigma}^{(2)} + C_{n+1,m,\sigma}^{(2)} + C_{n,m+1,\sigma}^{(2)}\right) + h.c. \quad (2)$$

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On the other hand, an intrinsic band gap can be only obtained with the further confinement of one out of its two dimensions [15].

$$b_{k,\sigma}^{(1)} = \frac{1}{\sqrt{N_s}} \sum_{n,m,\sigma} e^{ik.\boldsymbol{L}_{n,m}^{(1)}} C_{n,m,\sigma}^{(1)} \quad (3)$$

$$b_{k,\sigma}^{(2)} = \frac{1}{\sqrt{N_s}} \sum_{n,m,\sigma} e^{ik.\boldsymbol{L}_{n,m}^{(2)}} C_{n,m,\sigma}^{(2)} \quad (4)$$

$$C_{n,m,\sigma}^{(1)} = \frac{1}{\sqrt{N_s}} \sum_{k,\sigma} e^{-ik.\boldsymbol{L}_{n,m}^{(1)}} b_{k,\sigma}^{(1)} \quad (5)$$

$$C_{n,m,\sigma}^{(2)} = \frac{1}{\sqrt{N_s}} \sum_{k,\sigma} e^{-ik.\boldsymbol{L}_{n,m}^{(2)}} b_{k,\sigma}^{(2)} \quad (6)$$

Substituting back to (4) we get:

$$H = -t \sum_{k,\sigma} e^{-ik.d} \left(1 + e^{-ik.a_1} + e^{-ik.a_2}\right). b_{k,\sigma}^{(1)\dagger}. b_{k,\sigma}^{(2)\dagger} + h.c. \quad (7)$$

Where k is the electron quasi-momentum and N_s is the number of unit cells in the Graphene sheet [43-45].

III.OBSERVATIONS

In the two methods, different technologies yield films of both well oriented and strongly entangled tubes. Our team used CVD methods for synthesizing films of both regularly grown nanotubes as shown in figure 2 and "felt" of entangled fibers. The catalyst, the so-called "ink," was applied to the stamp surface. The ink was a solution containing from 1 to 50 mM of Fe (NO3) and 9H2O. Then nanotubes were grown as a result of acetylene decomposition in argon flow at 700 °C. This is in comparison to the results obtained by E. Kukovitskiy team which developed the technology of synthesis of oriented nanotubes.

A. Nanotube Structural Analysis

The nanotube growth process was very sturdy and highly sensitive. The span of contact amid the printing was 3s. Nanotube testimony was finished by the CVD strategy in a standard stream reactor at a temperature of 720◦C. On account of low convergence of impetus (1 mM, Fig. 3), a few single nanotubes are arbitrarily circulated over the printing district. In the first place, permeable silicon was shaped on the surface of a silicon substrate by anode carving and afterward the ferrum film was stored on the last through the shadow veil by electron bar dissipation.

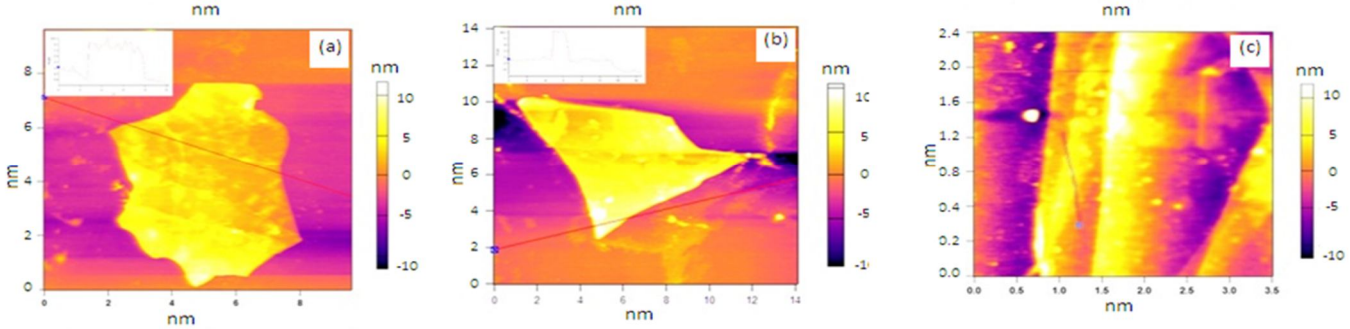


Figure 2: Structural growth of Nanotubes depicting various shapes: Taper, Zig-Zag and Flat beds.

As per the unit cell of Graphene, refer Figure 1 above, the Graphene is a one-atom thick planar sp^2 carbon allotrope system with particular electrical, mechanical and optical characteristics [32,33]. Fundamentally Graphene is a hexagonal honeycomb surface where every carbon particle is covalently fortified with three neighbouring molecules at a separation d of 1.42 ˚A. The crude premise vectors of the hidden Bravais cross section are the essential units that characterize such structures with cone shaped layers [40].

The first phase of the procedure includes polyethylene decay in the primary stove at a temperature of 600 ◦C. At that point, by the helium stream, the vaporous results of pyrolysis are exchanged to the second broiler where nanotubes develop on the nickel thwart impetus at a temperature of 800 to 900 ◦C [36-38].

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B. Growth and Strength Analysis

For the obtained test, the flow thickness was 10 mama/cm2 for the electric field from 4 to 4.5 v/µm. As an immensely growing field, the utilization of carbon strips, cylinders or chains in nano-hardware exhibits a progression of focal points concerning the flow semiconductor innovation: characteristic low-dimensionality, mechanical steadiness and versatility, extraordinary electrical, optical and warm properties to give some examples.

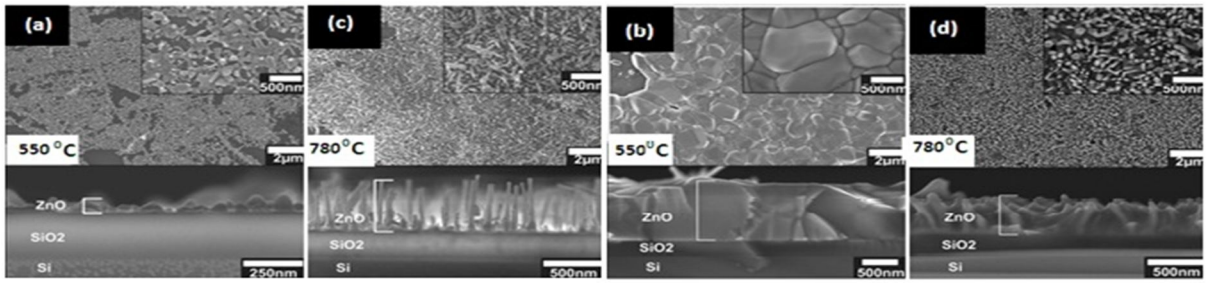


Figure 3: Nanotube development for different centralizations of Zinc Oxide and Graphene composites with Silicon based reactant ink utilizing the antecedent application. Impetus focus in the arrangement was: (a) 1 mM (b) 2 mM (c) 5 mM (d) 10 mM.

The figure is taken from utilizing atomic force microscopy, for the acquired example, so as to think about in detail the natural low-dimensionality, mechanical solidness and flexibility, uncommon electrical, optical and warm properties of the synthesis.

IV. RESULT AND ANALYSIS

It is significant that the development on single-layer (SL) graphene with a substrate's tendency edge of 45° was impractical to acquire in past works [3]. It is guessed that since the thickness of a SL graphene is just a single monolayer, the oxidation or carving rate of SL graphene is significantly noteworthy when contrasted with multi-layer (ML) graphene. Likewise, the little nucleation rate most likely due the substrate position which is set 45° slanted to the stream of O2 gas. So as to understand the development of ZnO structure on SL graphene, the nucleation rate ought to be expanded. It is normal that the difference in the substrate's tendency edge to 90° may understand such circumstance.

Table I
Composition and Conduction Behaviour Investigation

Sr. No.	Percentage	ZnO2 (N/m) composition	Graphene (N/m) composition	Orientation (in degrees)	Structural Science	Conduction Behaviour
1	1.00	0.31	0.22	-1.14	Taper	Semi-conductor
2	1.00	0.31	0.22	-1.25	Zig-Zag	Semi-conductor
3	1.25	0.31	0.22	-0.98	Taper	Semi-conductor
4	1.00	0.32	0.23	-1.23	Zig-Zag	Semi-conductor
5	1.33	0.32	0.23	-0.78	Taper	Semi-conductor
6	1.67	0.32	0.23	1.01	Flat	Semi-conductor
7	1.00	0.33	0.22	-1.29	Zig-Zag	Semi-conductor
8	1.50	0.32	0.23	0.44	Flat	Semi-conductor
9	1.00	0.32	0.22	-1.24	Zig-Zag	Semi-conductor

Figure 2 summarizes the observed surface morphologies of the developed ZnO structures on SL and ML graphene with substrate's tendency point of 90°.

Figure 3a-c demonstrates the after effects of the development on SL graphene at temperatures of 600°C, 800°C, and 1,000 °C, individually. As appeared in Figure 3a, it tends to be plainly observed that non-consistent nanoclusters-like structures were developed at a temperature of 600°C. In the interim, a blend of vertically neutral and adjusted nanorods was developed at a temperature of 800 °C. It is important that for the development at 800°C as appeared in Figure 3b. In addition, a few haphazardly scattered smaller scale groups like structures were watched for the development at a temperature of 1,000°C as appeared in Figure 3c. The after effects of synthesis and conduction behaviour investigations are summarized here for the reference. All through the development procedure, here it very well may be said that the development of ZnO2 structures was relatively unachievable at 1,000°C for the development on SL graphene because of the conceivable extreme oxidation of graphene amid the development [3].

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As we note in table 1, for the ZnO_2 and graphene all permissible combinations are practically obtained. We observed that the minimum orientation is obtained when the composition are with strengths of 0.32 N/m to the 0.22 N/m for ZnO_2 and graphene. The base introduction is acquired for this creation which level auxiliary shape. In spite of the fact that for the diverse arrangements the Zig-cross and decrease auxiliary formed are acquired. The perceptions and later on testing closed one this that all these organization, as depicted in table 1 over, the conduction conduct of the all examples was semi-leading in nature, which legitimizes that ZnO2 and Graphene turns out to be the best semiconducting materials, which can be utilized for the assortment of various application. It was likewise affirmed by the EDX estimation that no carbon (C) component was distinguished at the zone without ZnO structures. From these outcomes, it tends to be basically reasoned that the nucleation of ZnO was accomplished at a tendency point of 90° for the development on SL graphene. Figure 2d– f demonstrates the consequences of the development on ML graphene with a tendency edge of 90° at temperatures of 600°C, 800°C, and 1,000°C, separately. As detailed in our past work [3], the developed ZnO structures on ML graphene with a tendency edge of 45° show three unique structures, i.e., non-constant nanoclusters, nanorods, and thin movies at 600°C, 800°C, and 1,000°C, separately. On a fundamental level, such comparable essential structures were additionally watched for a tendency edge of 90°, as appeared in the relating Figure 2d– f. As appeared in Figure 2d, it tends to be unmistakably observed that ceaseless ZnO groups with bigger grain measure and thicker layer structures than those of structures developed with a tendency edge of 45° [3] were acquired. As appeared in Figure 2e, nanorods with comparative morphological structures (see Table 1) was acquired for the development at a substrate temperature of 800°C when contrasted with nanorods developed at a similar temperature with a tendency edge of 45° [3]. Be that as it may, as appeared in Figure 2f, the morphologies of developed structures at 1,000°C with a tendency point of 90° don't demonstrate noteworthy distinction with the structure developed at a similar temperature with a tendency edge of 45° [3] where the structures were as thin film structures. From the development on ML graphenes at both tendency edges, it tends to be reasoned that the essential structures of ZnO firmly rely upon the substrate temperatures. In light of these outcomes, it likewise appears to just demonstrate that a tendency point of 90° will in general increment or advance the nucleation of ZnO structures. It is accounted for that the nucleation of ZnO on graphene is by and large accomplished at the areas of "scratch pit" where the breaking of C-C bonds happens [3].

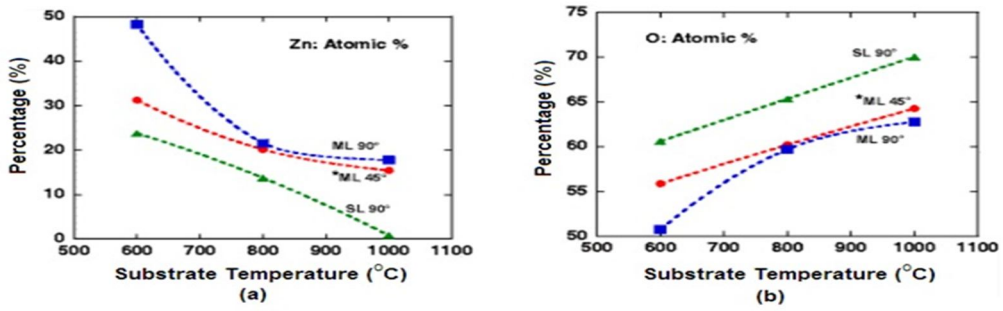


Figure 5: The structural dimensions (in percentage) v/s temperature of: (a) Zn, (b) O_2 grown on graphene substrate.

The breaking of C-C bonds of graphene is acknowledged by the oxidation procedure that additionally happens amid the development. Other than that, the nucleation of ZnO on ML graphene is additionally elevated when contrasted with SL graphene likely because of the stacking structure of ML graphene where graphene edges give additional nucleation locales to the ZnO development [5]. In this manner, in view of the acquired outcomes, it tends to be inferred that the substrate temperature as well as the substrate position and graphene thickness give critical impacts in the development of ZnO structures. The Figure 5 indicates variety in the conductivity of a semiconducting single-divider nanotube with the door voltage provided to the leading substrate. In the present work the Microscope tests and nanomanipulators Single Zinc Oxide and Graphene composites are utilized as tests for nuclear and burrowing power magnifying lens. In this setup the present application is supported by a firmly expanded geometric shape and one of kind mechanical properties of Zinc Oxide and Graphene composites. The proportion of the nanotube length to its width can surpass a thousand [6]. It is simple seen that the each cylinder is in contact with metal cathode. Estimations demonstrate that the ideal opportunity for perception amid activity ought to be at any rate 10−15s. At long last it ought to be noticed that a further exertion so as to plan and actualize scaling and improvement strategies in quantum transport bearers requires steadiness examination, which is vital for a progressively proficient use of hypothetical models over trial information. In this field, desires are high because of their exceptional and vigorous nature. The advancement of Zinc Oxide and Graphene composite-based sensors has huge extension later on to come and will be a potential field to be investigated further. All together the advancement in different ways of Zinc Oxide and Graphene composite gadgets is definitely of incredible significance.

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V. CONCLUSIONS

In conclusion, the effects of substrate position and graphene thickness on the morphological, structural, and optical properties were found to be very pronounced. Substrate position with an inclination angle of 90° is by all accounts one of the compelling control parameters to expand the nucleation rates which were demonstrated by the capacity to develop ZnO nanostructures on SL graphene and also the development of thick and ceaseless ZnO group structures and thick base structures of ZnO nanorods on ML graphene. The structures developed at a low temperature of 600 °C demonstrate less basic imperfections. The conceivable development component is proposed and portrayed which considered both the nucleation and oxidation forms. Temperature as well as substrate position and graphene thickness assume critical job in deciding the properties of the developed ZnO structures by warm dissipation on the grounds that these components can be abused to conquer the issue of graphene oxidation that happens amid the development. Along these lines, it is inferred that The Zinc Oxide and Graphene composites are the cutting edge materials for the future developments, sensor and gadget manufactures. It is worth to specify here that the creation of gadgets and machines is yet at the dimension of research examples and numerous undertakings of improvement of Zinc Oxide and Graphene composite based incorporated circuits and clusters are still concepts. Nevertheless, we are sure that Zinc Oxide and Graphene composite electronics has great future.

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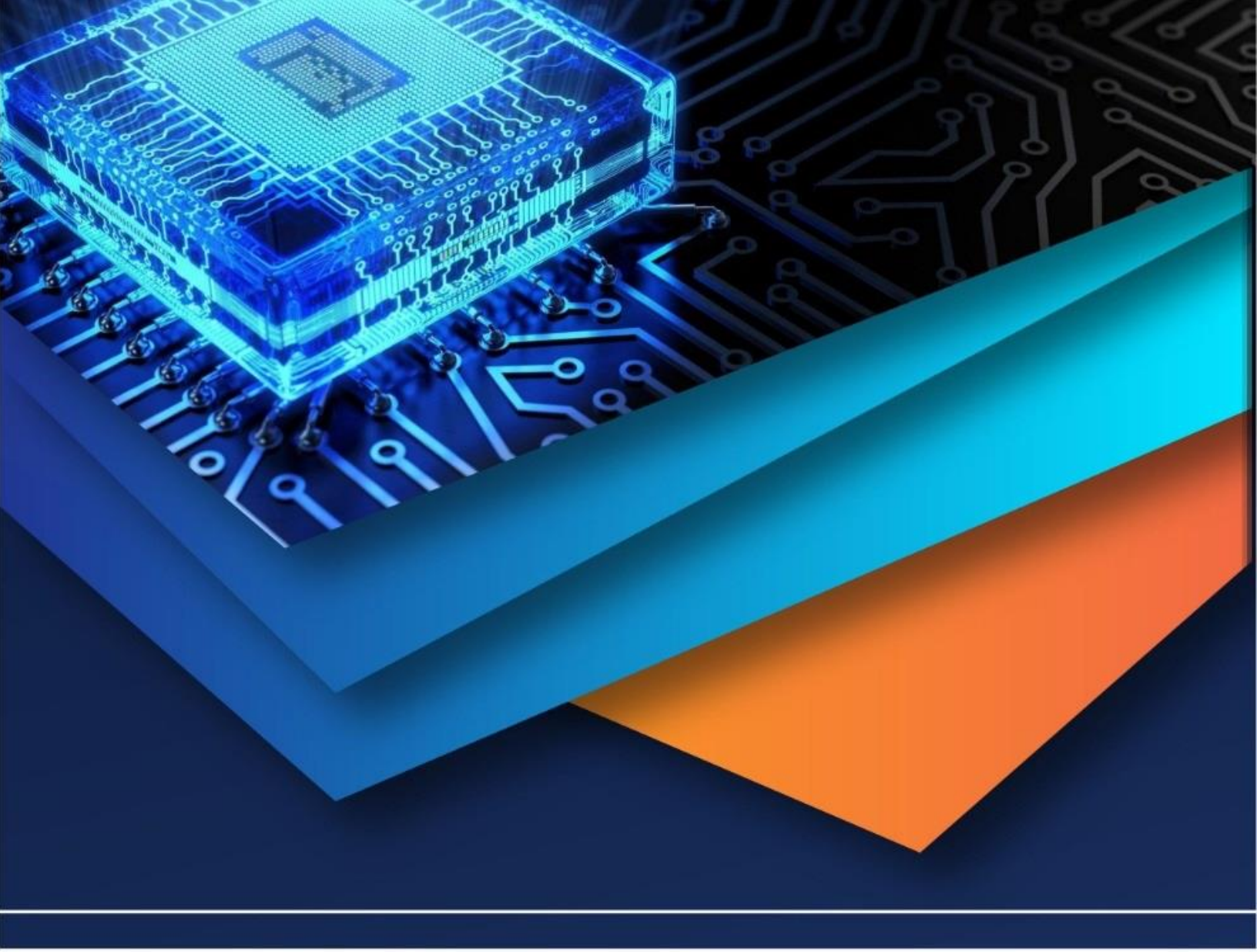
REFERENCES

[1] S.H. Yoon, S. Lim, Y. Song, Y. Ota, W.M. Xiao, A. Tanaka, I. Mochida: KOH activation of carbon nanofibers, Carbon 42, 1723–1729 (2004).
[2] Kim Y-J, Lee J-H, Yi G-C. Vertically aligned ZnO nanostructures grown on graphene layers. Appl Phys Lett. 2009, 95:21-31.
[3] Lee KY, Kumar B, Park H-K, Choi WM, Choi J-Y, Kim S-W. Growth of high quality ZnO nanowires on graphene. J Nanosci Nanotechnology. 2012, 12:1551–4.
[4] Ahmad NF, Rusli NI, Mahmood MR, Yasui K, Hashim AM. Seed/catalyst-free growth of zinc oxide nanostructures on multilayer graphene by thermal evaporation. Nanoscale Res Lett. 2014, 9:83.
[5] Aziz NSA, Mahmud MR, Yasui K, Hashim AM. Seed/catalyst-free vertically growth of high density electrodeposited zinc oxide nanostructures on a single-layer graphene. Nanoscale Res Lett. 2014, 89:95.
[6] Aziz NSA, Nishiyama T, Rusli NI, Mahmood MR, Yasui K, Hashim AM. Seedless growth of zinc oxide flower-shape structures on multilayer graphene by electrochemical deposition. Nanoscale Res Lett. 2014, 9:337.
[7] Kim YJ, Hadiyamarman, Yoon A, Kim M, Yi GC, Liu C. Hydrothermal grown ZnO nanostructures on few-layer graphene sheets. Nanotechnology. 2011, 22:24603-10.
[8] Choi WM, Shin KS, Lee HS, Choi D, Kim KH, Shin HJ, et al. Selective growth of ZnO nanorods on SiO2/Si substrate using a graphene buffer layer. Nano Res. 2011, 4:440–7.
[9] Xu C, Lee J-H, Lee J-C, Kim B-S, Hwang SW, Whang D. Electrochemical growth of vertically aligned ZnO nanorod arrays on oxidized bi-layer graphene electrode. Cryst Eng Comm. 2011, 13:6036–9.
[10] Astuti B, Tanikawa M, Rahman SFA, Yasui K, Hashim AM. Graphene as a buffer layer for silicon carbide-on-insulator structures. Materials. 2012,5:2270-9.
[11] D.H. Renecker, A.L. Yarine, H. Fong, S. Koombhongse, Bending instability of electrically charged liquid jets of polymer solutions in electro spinning, J. Appl. Phys. 87, 4531 (2000).
[12] S.H. Yoon, C.W. Park, H.J. Yang, Y. Korai, I. Mochida, R.T.K. Baker, N.M. Rodriguez, Novel carbon nanofibers of high graphitization as anodic materials for lithium ion secondary batteries, Carbon 42, 21–32 (2004).
[13] S. Junya, Calibration Methods of Carbon Nanotube Gas Sensor for Partial Discharge Detection in SF6. IEEE Transactions on Dielectrics and Electrical Insulation; 13(1): 107-11 (2006).
[14] N.M. Rodriguez, A review of catalytically grown carbon nanofibers, J. Mater. Res. 8, 3233–3250 (1993).
[15] M. Endo, Y.A. Kim, T. Fukai, T. Hayashi, K. Oshida,M. Terrones, T. Yanagisawa, S. Higaki, M.S. Dresselhaus, Structural characterization of cup stacked type nanofibers with an entire hollow core, Appl. Phys. Lett. 80, 1267–1269 (2002).
[16] O. Mengxing, Constant- Power Operation of Functionalized Carbon. Nanotube Sensors for Alcohol Vapor Detection. 3rd IEEE International conference on Nano/Micro Engineered and Molecular Systems (2008).
[17] Ahmad M, Sun H, Zhu J. Enhanced photoluminescence and field-emission behavior of vertically well aligned arrays of In-doped ZnO nanowires. ACS App. Matter Interfaces. 2011, 3:1299-305.
[18] S. Iijima, Helical microtubules of graphitic carbon, Nature, 1991, 354, 56–58.
[19] G.G. Tibbetts, Vapor-grown carbon fibers: Status and prospects, Carbon 27, 745–747 (1989).
[20] Q.F. Liu, W.C. Ren, Z.G. Cheng, Semiconducting properties of cup-stacked carbon nanotubes, Carbon, 2009, 47, 731–736.

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[21] M. Kosaka, T.W. Ebbesen, H. Hiura, K. Tanigaki, Annealing effect on carbon nanotubes. An ESR study, Chem. Phys. Lett. 233, 47–51 (1995).
[22] J.F. Despres, E. Daguerre, K. Lafdi, Flexibility of graphene layers in carbon nanotubes, Carbon, 1995, 33, 87–89.
[23] B.Q. Wei, R. Vajtai, P.M. Ajayan, Reliability and current carrying capacity of carbon nanotubes, Appl. Phys. Lett. 79, 1172–1174 (2001).
[24] K. Kaneko, J. Imai, Adsorption of NO2 on activated carbon fibers, Carbon 27, 954–955 (1989).
[25] R.J. Nemanichi, S.A. Solin, First- and secondorder Raman scattering from finite-size crystals of graphite, Phys. Rev. B 20, 392–401 (1970).
[26] Kim S-W, Park H-K, Yi M-S, Park N-M, Park J-H, Kim S-H, Epitaxial growth of ZnO nanowall networks on GaN/sapphire substrates. Appl Phys Lett. 2007, 90: 94-107.
[27] Hosono E, Fujihara S, Honma I, Zhou H., The fabrication of an upright-standing zinc oxide nanosheet for use in dye-sensitized solar cells. Adv Mater., 2005, 17:2091–4.
[28] Wang X, Ding Y, Li Z, Song J, Wang ZL, Single-crystal mesoporous ZnO thin films composed of nanowalls. J Phys Chem. C., 2009, 113:1791–4.
[29] Wong FR, Aziz NSA, Yasui K, Hashim AM. Graphene as a template layer for the growth of Ga-based compound materials [abstract]. International Conference on Solid State Devices and Materials; 2014, 338–339.
[30] Novoselov KS, Geim AK, Morozov SV, Jiang D, Katsnelson MI, Grigorieva IV, Two-dimensional gas of mass less Dirac fermions in graphene. Nature. 2005, 438:197–200.
[31] Zhang Y, Tan Y-W, Stormer HL, Kim P., Experimental observation of the quantum Hall effect and Berry's phase in graphene. Nature. 2005, 438:201-4.
[32] Kim KS, Zhao Y, Jang H, Lee SY, Kim JM, Kim KS, Large-scale pattern growth of graphene films for stretchable transparent electrodes. Nature, 2009, 457:706–10.
[33] Balandin AA, Ghosh S, Bao W, Calizo I, Teweldebrhan D, Miao F, et al. Superior thermal conductivity of single-layer graphene. Nano Lett. 2008; 8:902–7.
[34] Rahman SFA, Kasai S, Hashim AM., Room temperature nonlinear operation of a graphene-based three-branch nanojunction device chemical doping. Appl Phys Lett. 2012, 100:1931-61.
[35] A. Oberlin, M. Endo, T. Koyama, Filamentous growth of carbon through benzene decomposition, J. Cryst. Growth 32, 335–349 (1976).
[36] L. Schlapbach, A. Zuttel, Hydrogen-storage materials for mobile applications, Nature 414, 353–358 (2001).
[37] S.H. Joo, S.J. Choi, I.W. Oh, J.Y. Kwak, Z. Liu, O. Terasaki, R. Ryoo, Ordered nanoporous arrays of carbon supporting high dispersions of platinum nanoparticles, Nature, 412, 169–172 (2001).
[38] E. Zussman, A.L. Yarin, A.V. Brazilevsky, R. Avrahami, M. Feldman, Electrospun PAN/PMMA-derived carbon nanotubes, Adv. Mater., 18, 348–353 (2006).
[39] M. Winter, J.O. Besenhard, M.E. Spahar, P. Novak, Electrode materials for rechargeable lithium batteries, Adv. Mater., 10, 725–763 (1998).
[40] M. Endo, C. Kim, K. Nishimura, T. Fujino, K. Miyashita, Recent development of carbon materials for Li ion batteries, Carbon, 38, 183–197 (2000).
[41] Xie JL, Guo CX, Li CM, Construction of one-dimensional nanostructures on graphene for efficient energy conversion and storage. Energy Environ Sci. 2014, 7:2559–79.
[42] Shao Y, Wang J, Wu H, Liu J, Aksay IA, Y. Lin, Graphene based electrochemical sensors and biosensors: a review, Electroanalysis. 2010, 22:1027–36.
[43] Rusli NI, Tanikawa M, Mahmood MR, Yasui K, AM. Hashim, Growth of high-density zinc oxide nanorods on porous silicon by thermal evaporation, Materials, 2012, 5:2817–32.
[44] Ahn MW, Park KS, Heo JH, Park JG, Kim DW, Choi KJ, Gas sensing properties of defect-controlled ZnO-nanowire gas sensor. Appl Phys Lett., 2008, 93:2631-43.
[45] Yi J, Lee JM, Park WI, Vertically aligned ZnO nanorods and graphene hybrid architectures for high-sensitive flexible gas sensors, Sens Actuat B-Chem. 2011, 155:264–9.
[46] Liu J-y Y, X-x ZG-h, Y-k W, Zhang K, Pan N, X-P. Wang, High performance ultraviolet photodetector fabricated with ZnO nanoparticles-graphene hybrid structures. Chin J Chem Physics, 2013, 26:225–30.
[47] Yang K, Xu C, Huang L, Zou L, H. Wang, Hybrid nanostructure hetero-junction solar cells fabricated using vertically aligned ZnO nanotubes grown on reduced graphene oxide, Nanotechnology, 2011, 22:405401.
[48] Lee JM, Yi J, Lee WW, Jeong HY, Jung T, Y. Kim, ZnO nanorods-graphene hybrid structures for enhanced current spreading and light extraction in GaN-based light emitting diodes. Appl Phys Letters, 2012, 100:061-107.
[49] Lu Z, Heng X, Chakraborty A, C. Luo, Growth of ultra-long ZnO microtubes using a modified vapor-solid setup, Micromachines, 2014, 5:1069–81.
[50] Mahmood K, Park SS, HJ. Sung, Enhanced photoluminescence, Raman spectra and field-emission behavior of indium-doped ZnO nanostructures. J Mater Chemicals, 2013, 1:3138–49.
[51] Huang MH, Wu Y, Feick H, Tran N, Weber E, P. Yang, Catalytic growth of zinc oxide nanowires by vapor transport. Adv Materials, 2001, 3:113–6.
[52] F. Frackowiak, F. Beguin, Electrochemical storage of energy in carbon nanotubes and nanostructured carbons, Carbon, 40, 1775–1787 (2002).
[53] D. Weidong, H.Ryota, O. Kohei, Analysis of PD-generated SF6 Decomposition Gases Adsorbed on Carbon Nanotubes. IEEE Transactions on Dielectrics and Electrical Insulation, 13:637-40, 2006.
[54] I. Kiminobu, D. Weidong, O. Kohei , S. Junya, H. Ryota, H. Masanori, Low-Temperature Fabrication Method of Carbon Nanotubes-Based Gas Sensor. IEEE Transactions on Dielectrics and Electrical Insulation, 14:137-40, 2007.
[55] W. Chatchawal, Nano - structured Gas Sensors by Electron Beam Evaporation. 8th International Conference in Electrical Engineering/ Electronics, Computer, Telecommunications and Information Technology, ECTI, 2011.
[56] J. Yingqi, Contact and Sheet resistances of carbon nanotube forest in gas sensing applications. IEEE 24th International Conference on Micro Electro Mechanical Systems, 2011.
[57] T.J. Yoon, A Novel micro-gas sensor using laterally grown carbon nanotubes, 12th International Conference on Transducers, Solid-state Sensors, Actuators and Microsystems, 2003.
[58] M. Kosaka, T.W. Ebbesen, H. Hiura, K. Tanigaki: Annealing effect on carbon nanotubes. An ESR study, Chem. Phys. Lett. 233, 47–51 (1995).
[59] J.F. Despres, E. Daguerre, K. Lafdi: Flexibility of graphene layers in carbon nanotubes, Carbon, 33, 87–89 (1995).

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