Journal of Electronics and Informatics (2021)
Vol.03/ No.02
Pages: 114-125
https://www.irojournals.com/iroei/
DOI: https://doi.org/10.36548/jei.2021.2.004

Automated Nanopackaging using Cellulose Fibers Composition with Feasibility in SEM Environment

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Abstract: By contributing to the system enhancement, the integration of Nano systems for nanosensors with biomaterials proves to be a unique element in the development of novel innovative systems. The techniques by which manipulation, handling, and preparation of the device are accomplished with respect to industrial use are a critical component that must be considered before the system is developed. The approach must be able to be used in a scanning electron microscope (SEM), resistant to environmental changes, and designed to be automated. Based on this deduction, the main objective of this research work is to develop a novel design of Nano electronic parts, which address the issue of packaging at a nanoscale. The proposed research work has used wood fibres and DNA as the bio material to develop nanoscale packaging. The use of a certain atomic force microscope (ATM) for handling DNA in dry circumstances is demonstrated with SCM wood fibrils/fibers manipulation in a scanning electron microscope (SEM).**Keywords:** Nano electronics, bioelectronics, scanning electron microscope (SEM), packaging, atomic force microscope (ATM)

1. Introduction

The proposed research work presents a nano packaging using automatic bio-nanowires. The major goal involves handling and manipulation of materials like fibrils and fibres of cellulose or DNA [1]. To execute this methodology, this research work has designed a combination of multiple self-assembling strategies by using the automation that has been

ISSN: 2582-3825 (online)
Submitted: 21.05.2021
Revised: 13.06.2021
Accepted: 28.06.2021
Published: 08.07.2021

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DOI: https://doi.org/10.36548/jei.2021.2.004

built on the utilization of microgrippers [2] for atomic force microscope. Here, this research work has presented a methodology to address the issue of nanoscale electronic packaging by properly handling the immobilized DNA along with cellulose fibrils and fibres under dry conditions. In recent years, there has been a lot of focus on the potential uses of nano electronics. It has been identified to be a crucial part of industrial development and it has also found its way into the road maps of industrial growth [3]. Dimensional change plays a vital role in next-generation electronic technologies like molecular electronics and single electron transistor. Hence packaging is highly important to determine the failure or success of the technology. As a result, in addition to fundamental nano electrical device technologies, packaging strategies must be established in order to make various critical decisions based on their commercial viability [4, 5]. To address the issues involved in miniaturization in microelectronics, biomolecules like DNA [6] as well as nano electronics like carbon nanotubes play a crucial part in the future of nano electronics [7].

Based on previous research, it has been determined that the nano wires created by selective metallization are the future of nano electrical devices. As a result, DNA may be identified as the fundamental building component [8] of nano electronics. . Authors in [9] have found that DNA nanoscopic wires with less than 10 nm diameter will serve as the ideal configuration for capitalization [10]. Moreover, the ability of DNA strands to functionalize with other linker molecules paves way to DNA integration with nanostructured [11] or micro-structured electronic circuits. It is also possible to fabricate and metalize the complex DNA structures at a later stage. A number of approaches have been analyzed to design nano electronics with DNA. In the recent years, there has been much research attention and drive towards different ways in which DNA can be handled [12]. Nanotweezers [13], dielectrophoresis [14], laser based detection methods [15], microfluidic handling system [16], magnetic tweezers [17], optical tweezers [18] and glitter graphic structuring [19] are some of the methodologies used for manipulation and handling DNA [20]. These methodologies have been used over the years to address a number of research problems. However in the field of industrial processing cellulose fibre has not been used as a material, since nano bonding is not possible. However it is not possible to automate all of the steps [21]. Moreover the self-assembling technologies can also be utilized to construct the nanostructures with DNA. When considering these techniques and their potential outcomes, it is important to remember that automation is not

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achievable with present methodologies, which is a critical factor for industrial applications. Hence the main purpose of our work is to establish a DNA that can be used as a conductor in the field of industry as a future prospective [22]. Organic materials such as microfibril from wood fibres have gained much attention in the recent years when compared with DNA. Based on the experimental results of authors in [23], it has been identified that organic cellulose can be used for metallization experiments, which makes it possible for Nano and micro systems in order to establish pure metallic bronze with a diameter of over 20 micrometers or even bigger. It is also possible to obtain these cellulose based building blocks from other sources such as bacteria. Some other sources are wood fibres and algae. Technically manufactured cellulose fibres [24] are widely utilized in the textile industry. For huge bundles of wood fibres, the bacterial cell size ranges from 20 nm to hundreds of micrometres. In general industrial fibres are found to be in the size of hundreds of micrometres and can be accessed easily [25].

This paper can be organized such that the following session gives an outline of the initial concepts of packaging with wood fibrils and DNA at nanoscale [26]. Section 3 involves handling, preparation and manipulation of the material in order to make it suitable for packaging it in an automated manner. Experimental analysis is described in section 4 along with graphical output. Finally, Section 5 concludes the work for determining the efficiency of the proposed automated packaging for nano materials.

2. Methodology

The proposed research work has incorporated the use of two biomaterials. The first material is DNA, which is extremely difficult to manipulate mechanically by utilizing AFM-based or grasping algorithms. They can, however, be utilized to create flexible nanowires with semiconducting properties. Similarly, the usage of wood fibres through cellulose fibrils [27], which are believed to be stiff when compared to DNA but have the disadvantage of having no useful electric characteristics. Metallization is important to utilize them as nanowires. It is also crucial to observe the difference in the materials' raw form. DNA is utilized as lengthy macromolecules that are coiled in liquid solutions, whereas fibrils are used as wooden fibres

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that must be separated before usage. The steps for using the two biomaterials as bonding wires in nanopackaging are described in this section [28].

2.1. Cellulose Fibrils

The steps required for utilizing the cellulose fibrils of wood fibers are as follows:

1. The useful portion is separated from the fibre in this phase. According to our research on gripper-based applications, strong bonding pressures have necessitated the use of specialized methods [29]. Accordingly, the fiber is held in place with the help of metal tips, when it is pulled at different angles. After separating the fibril, it will be kept in the contact pads.
2. The next step is the handling procedure, where fabril and its different properties are taken into account. Symbols are not similar to that of other organic material but they exhibit anisotropic behaviour with mechanical characteristics such as bending stiffness. In order to incorporate automation, proper planned actions along with calculated model are required. Characterizing the fibrils at the early stages of development is required for this sort of nano packing.
3. In the orientation positioning, a fixation step is required and further it can be executed by using electrostatic measures.
4. The final process is metalization, which involves converting the fabric into a nanowire.

2.2 DNA

The DNA is considered to be a primary material used for packaging and bonding at nanoscale. DNA's electrical and physical characteristics make it similar to traditional bonding wires in terms of the ease of use and handling. However, there are a number of processes and procedures that must be followed to get to this stage. This is possible through immobilization, stretching and preparation of the DNA wires. The first step is stretching of DNA, which is

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possible through a number of procedures. The next step involves immobilization of DNA in liquid and dry environment on substrates like Mica and Silicon. Last step involves nanowire preparation, which can be done in two methods namely mechanical cutting and enzymatic cutting of the DNA strand. Here, the enzymatic methodology requires a special step to prepare and hence cannot be fully automated. On the other hand, it is possible to fully automate the mechanical methodology. However, the disadvantage is that the AFM-based approaches require more time and enzymatic cutting requires only a short span of time. However the drawback with this method is that it requires an additional gel electrophoresis step along with splitting of DNA. nanowires need to be sorted using this electrophoresis. Dry conditions in the AFM based approaches are used for handling when the wires are ready to use in the immobilized state. Transportation to the bonding had is the next step in the process and requires binding of DNA with special proteins as an additional function. The nanowire is stretched using the air FM to the contact pad. Now the DNA is kept on the binding site which involves different binding forces depending on the characteristics of the cantilever tip and the contact pads. Negative voltages can be added on the cantilever in order to support DNA removal from the cantilever. Based on the electric circuits, it can either be used as a semiconductor or can be metallized.

3. Manipulation and Handling

Over the past few years, a number of experiments have been conducted to manipulate the DNA strands with AFM. This takes place in a liquid condition and shows extremely good results when incorporating the moving of DNA strands. A higher binding force is possible as the environment gets dryer resulting in better interaction between the surface and the DNA. In order for a proper and reliable design of DNA for nano packaging and nano electronics circuits with DNA, there is need to develop an automated handling in vaccum or at air, which is possible through immobilization of DNA. There are two ways in which it is possible to manipulate DNA given that its takes place in a dry environment.

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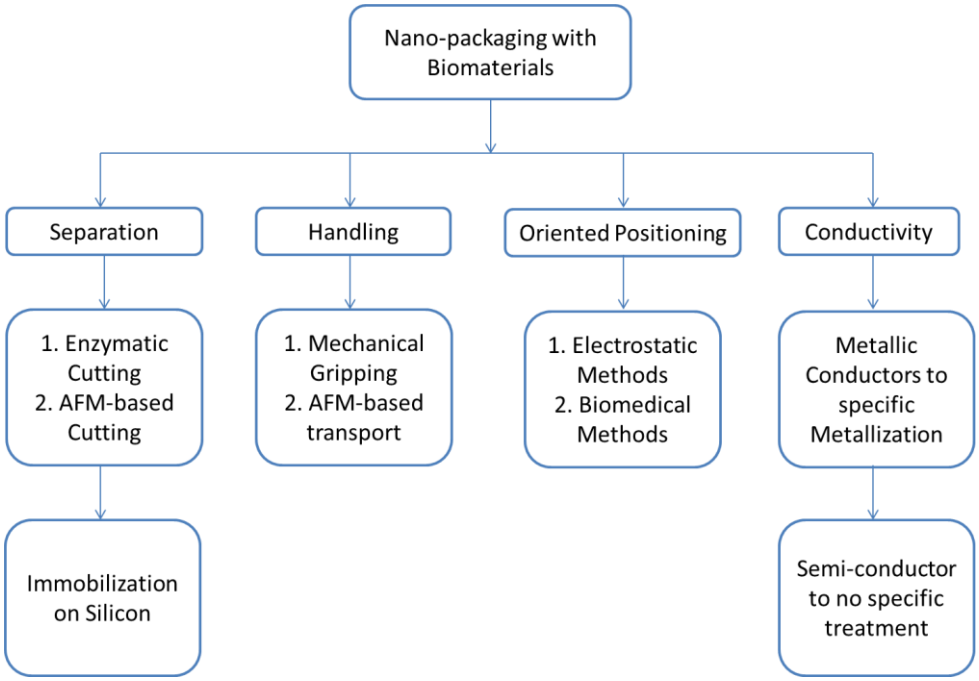

Fig.1. Nano-packaging with DNA as Bonding Wire

1) Sigma Aldrich, Germany have introduced a Double helix λ-DNA with a length of about 16 µm, extracted from Escherichia coli bacteria. It is said to be preserved in a 1 µg DNA / 1 µl water concentration of ultra-pure water substance. AA/MgCl2- buffer (5 mM magnesium chloride with 20 mM ammonium acetate) and TE/MgCl2-Buffer (1 mM EDTA, 10 mM TRIS, with magnesium chloride) with a pH of value near 7. Commercial APTES and mica slices were used for surface modification. To prepare the substances, ethanol and 2-propanol (isopropyl alcohol) was used to clean the silicon surface while the mica substrate was cleaved fresh before every time it was used.
2) TE-MgCl2-buffer (1 µl/1000 µl) was used to dilute the DNA solution. This mixture/buffer was placed on a silicon sheet and allowed to rest for a period of eight minutes. During this period, the DNA strands begin to immobilize on the surface of the silicon. The remaining buffer/ spare DNA solution is removed with the help of a cellulose tissue. Using this process, it is possible to absorb the buffer/DNA mixture from the substrate and using capillary forces, the silicon surface and the DNA are aligned to each other. However, dehydration of the substrate is not required due to

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silicon hydrophobicity. Thus the substrate is properly cleaned on exposure to clear water and nitrogen.

3) To incorporate this proposed work, a NanoWizard II AFM is used. In contact mode cuts and manipulation was established while in the intermittent contact mode, visualization of the substrate is possible. A non-contact, standard, calibrated silicon cantilever is used for this experiment and it is worth noting that it was carried out at dry conditions with 15% humidity and maintaining of temperature between 22 and 30 °C

4. Results and Discussion

The ability of DNA and cellulose fiber to perform as an absorbant is analyzed in Fig.2. It is observed that the Cellulose fiber biomaterial is able to serve as a better absorbant for the wavelength of 600 nm while DNA falls short by few ‘nm’ variations from 600.

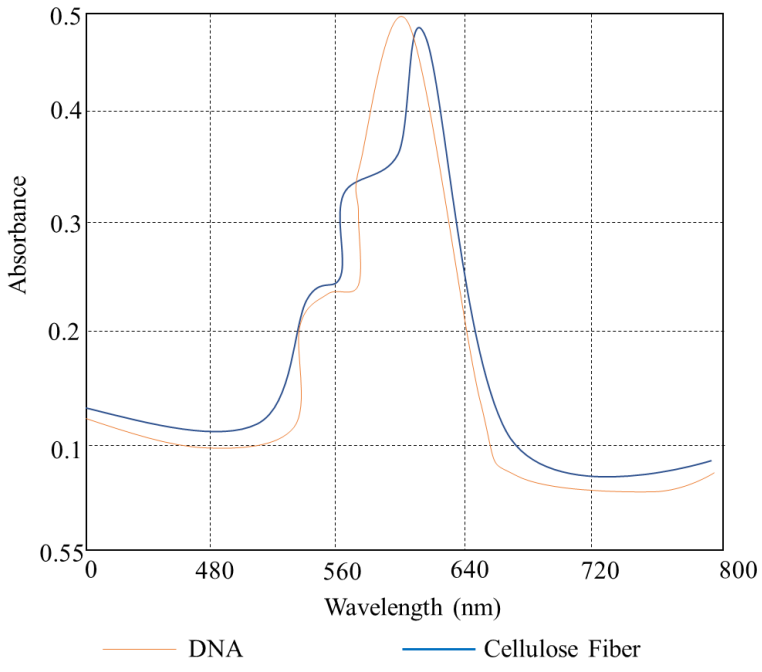

Fig.2. Absorbance in DNA and Cellulose Fibre

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Fig.3 shows the impact of thermal disturbance on the DNA and cellulose fibre. It is found that, DNA offers higher resistance to thermal disturbance when compared to that of cellulose fibre. The use of Cellulose fiber provides a better binding factor and is hence a popular choice of biomaterial for the purpose of nanopackaging.

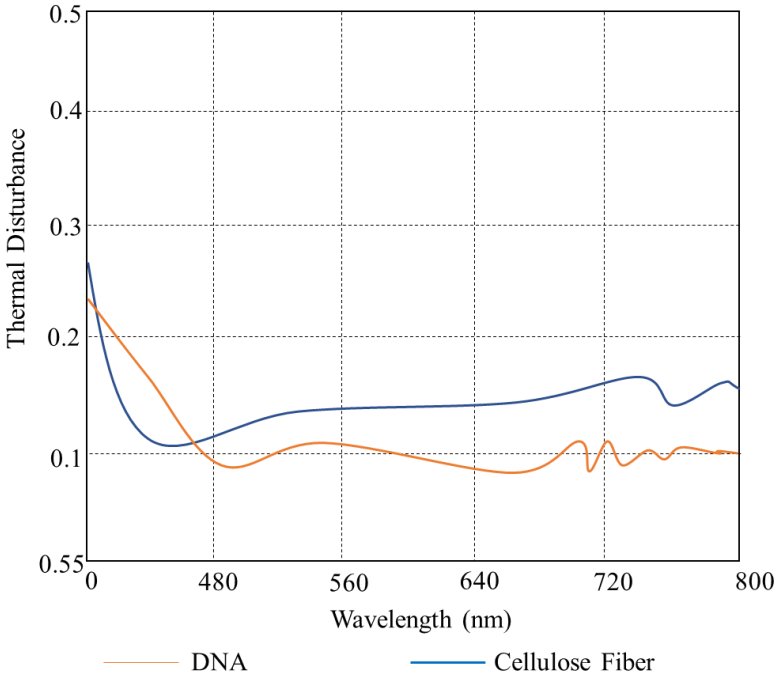

Fig.3. Thermal Disturbance in DNA and Cellulose Fiber

5. Conclusion

This paper has introduced a novel methodology for handling the biomaterials. This paves way to the implementation of such methodology in various scientific as well as industrial researches. Substrate handling is concerned the experimental results indicate that it in dry ambient conditions it is possible to manipulate DNA as per the requirement. Clean silicone surface as well as modified maker substrate provide good opportunity to ensure DNA manipulation in a proper manner. Removing, pushing and cutting DNA strands from the substrate surface is possible. Using this experimental observation along with nanorobots and

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AFM, it is possible to automate Nano packaging. Taking this into consideration future work ok will involve immobilization of the removed DNA and also incorporation of the proposed work along with nanorobots and AFM. When checking into consideration cellulose fibres there is need for a more proficient analysis of the fibril-fibre structure that's will result in in better comprehension of the proposed work in future applications. At this point it is also prominent that cellulose fibres of goods and similar sources we require manipulation test and characterization in order to determine the required changes in manipulating systems and tools. It is also possible to properly fixate the fibre by prior integration of the metal ore additional gripper within the chamber which can hold the wood fibre. This will also remove the impact of combined blending of fibril bundle or fibril with the fibre. DNA proves an inexhaustible and economic source of bio-nanowires which is proven by the experimental analysis. This establishes the fact that DNA serves as an excellent technology for nano-handling. Moreover, some of the applications that might use this material include biomass recalcitrance and polymer nanocomposites, which play a crucial role in biofuel production.

References

[1] Bashar, D. A. "Review on sustainable green Internet of Things and its application." J. Sustain. Wireless Syst 1, no. 4 (2020): 256-264.

[2] Emamifar, A., Kadivar, M., Shahedi, M., & Soleimanian-Zad, S. (2010). Evaluation of nanocomposite packaging containing Ag and ZnO on shelf life of fresh orange juice. *Innovative Food Science & Emerging Technologies*, *11*(4), 742-748.

[3] Singh, Devendra, Pawan Kumar Pant, Himanshu Pant, and Dinesh C. Dobhal. "Robust Automated Machine Learning (AutoML) System for Early Stage Hepatic Disease Detection." In Intelligent Data Communication Technologies and Internet of Things: Proceedings of ICICI 2020, pp. 65-76. Springer Singapore, 2021.

[4] Reynaud, P., Thuaire, A., Sordes, D., Rauer, C., Hartmann, J. M., Moriceau, H., ... & Cheramy, S. (2016). Nanopackaging solution from clean room to UHV environment: hydrogen passivated Si (100) substrate fabrication and use for atomic scale investigations and self-assembled monolayer grafting. *Procedia Engineering*, *141*, 121-129.

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https://www.irojournals.com/iroei/
DOI: https://doi.org/10.36548/jei.2021.2.004

[5] Pavithra, B. S., and KA Radhakrishna Rao. "BS6 Violation Monitoring Based on Exhaust Characteristics Using IoT." In Intelligent Data Communication Technologies and Internet of Things: Proceedings of ICICI 2020, pp. 77-88. Springer Singapore, 2021.

[6] Kolmer, M., Godlewski, S., Zuzak, R., Wojtaszek, M., Rauer, C., Thuaire, A., ... & Szymonski, M. (2014). Atomic scale fabrication of dangling bond structures on hydrogen passivated Si (0 0 1) wafers processed and nanopackaged in a clean room environment. *Applied Surface Science*, *288*, 83-89.

[7] Koleshwar, Ankita S., S. S. Sherekar, V. M. Thakare, and Aniruddha Kanhe. "Analytical Classification of Sybil Attack Detection Techniques." In Intelligent Data Communication Technologies and Internet of Things: Proceedings of ICICI 2020, pp. 89-98. Springer Singapore, 2021.

[8] Rai, M., Ingle, A. P., Gupta, I., Pandit, R., Paralikar, P., Gade, A., ... & dos Santos, C. A. (2019). Smart nanopackaging for the enhancement of food shelf life. *Environmental Chemistry Letters*, *17*(1), 277-290.

[9] Kalturi, Amrutha, Anjali Agarwal, and N. Neelima. "Smart and Autonomous Door Unlocking System Using Face Detection and Recognition." In Intelligent Data Communication Technologies and Internet of Things: Proceedings of ICICI 2020, pp. 99-108. Springer Singapore, 2021.

[10] Shirley, D. R. A. (2014, July). Systematic diagnosis of power switches. In 2014 International Conference on Embedded Systems (ICES) (pp. 32-34). IEEE.

[11] Janisha, R. S., D. Vishnu, and O. Sheeba. "Frequency Reconfigurable Circular Patch Antenna." In Intelligent Data Communication Technologies and Internet of Things: Proceedings of ICICI 2020, pp. 109-118. Springer Singapore, 2021.

[12] Wolter, K. J. (2012). System integration by advanced electronics packaging. In *Bio and nano packaging techniques for electron devices* (pp. 31-48). Springer, Berlin, Heidelberg.

[13] Shrestha, Sujan, and Subarna Shakya. "A Comparative Performance Analysis of Fog-Based Smart Surveillance System." Journal of trends in Compu ter Science and Smart technology (TCSST) 2 02 (2020): 78-88

[14] Gutiérrez, T. J., Ponce, A. G., & Alvarez, V. A. (2017). Nano-clays from natural and modified montmorillonite with and without added blueberry extract for active and

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DOI: https://doi.org/10.36548/jei.2021.2.004

intelligent food nanopackaging materials. *Materials Chemistry and Physics*, *194*, 283-292.

[15] Suma, V. "Community Based Network Reconstruction for an Evolutionary Algorithm Framework." Journal of Artificial Intelligence 3, no. 01 (2021): 53-61.

[16] Xu, F., Liu, Y., Shan, X., & Wang, S. (2018). Evaluation of 1-methylcyclopropene (1-MCP) treatment combined with nano-packaging on quality of pleurotus eryngii. *Journal of food science and technology*, *55*(11), 4424-4431.

[17] Joe, Mr C. Vijesh, and Jennifer S. Raj. "Location-based Orientation Context Dependent Recommender System for Users." Journal of trends in Computer Science and Smart technology (TCSST) 3, no. 01 (2021): 14-23.

[18] Xu, F., Liu, Y., Shan, X., & Wang, S. (2018). Evaluation of 1-methylcyclopropene (1-MCP) treatment combined with nano-packaging on quality of pleurotus eryngii. *Journal of food science and technology*, *55*(11), 4424-4431.

[19] Smys, S. "A Survey on Internet of Things (IoT) based Smart Systems." *Journal of ISMAC* 2, no. 04 (2020): 181-189.

[20] Morris, J. E. (2018). Nanopackaging: Nanotechnologies and electronics packaging. In *Nanopackaging* (pp. 1-44). Springer, Cham.

[21] Smys, S., and Jennifer S. Raj. "Analysis of Deep Learning Techniques for Early Detection of Depression on Social Media Network-A Comparative Study." Journal of trends in Computer Science and Smart technology (TCSST) 3, no. 01 (2021): 24-39.

[22] Alfei, S., Marengo, B., & Zuccari, G. (2020). Nanotechnology application in food packaging: A plethora of opportunities versus pending risks assessment and public concerns. *Food Research International*, 109664.

[23] Vijayakumar, T., Mr R. Vinothkanna, and M. Duraipandian. "Fusion based Feature Extraction Analysis of ECG Signal Interpretation–A Systematic Approach." Journal of Artificial Intelligence 3, no. 01 (2021): 1-16.

[24] Shekarchizadeh, H., & Nazeri, F. S. (2020). Active nanoenabled packaging for the beverage industry. In *Nanotechnology in the Beverage Industry* (pp. 587-607). Elsevier.

[25] Hariharakrishnan, Jayaram, and N. Bhalaji. "Adaptability Analysis of 6LoWPAN and RPL for Healthcare applications of Internet-of-Things." Journal of ISMAC 3, no. 02 (2021): 69-81.

ISSN: 2582-3825 (online)
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Revised: 13.06.2021
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Vol.03/ No.02
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https://www.irojournals.com/iroei/
DOI: https://doi.org/10.36548/jei.2021.2.004

[26] Abeyratne-Perera, H. K., Basu, S., & Chandran, P. L. (2021). Shells of compacted DNA as nanocontainers transporting proteins in multiplexed delivery. *Materials Science and Engineering: C*, *127*, 112184.

[27] Manoharan, Samuel. "Early diagnosis of Lung Cancer with Probability of Malignancy Calculation and Automatic Segmentation of Lung CT scan Images." Journal of Innovative Image Processing (JIIP) 2, no. 04 (2020): 175-186.

[28] Marvizadeh, M. M., Oladzadabbasabadi, N., Nafchi, A. M., & Jokar, M. (2017). Preparation and characterization of bionanocomposite film based on tapioca starch/bovine gelatin/nanorod zinc oxide. *International journal of biological macromolecules*, *99*, 1-7.

[29] Smys, S., Abul Bashar, and Wang Haoxiang. "Taxonomy Classification and Comparison of Routing Protocol Based on Energy Efficient Rate." Journal of ISMAC 3, no. 02 (2021): 96-110.

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Submitted: 21.05.2021
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