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Novel Nanostructures-Nanowires and Nanoshells

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Abstract

Nanowires and nanoshells offer a heap of chances and progressions across different logical and innovative spaces. With their novel properties, including size-subordinate ways of behaving and flexible organizations, these nanostructures have become basic structure blocks in fields like electronics, photonics, energy, biotechnology, and natural checking. Their high viewpoint proportions, enormous surface regions, and customized properties empower novel functionalities and upgraded execution in a large number of utilizations. From empowering cutting-edge electronic gadgets to altering biomedical diagnostics and therapeutics, nanowires and nanoshells keep on pushing the limits of what is conceivable at the nanoscale.

Keywords: Core; Shells, Imaging; Metal; Semiconductor; Optical

Abbreviations

LEDs: Light-Emitting Diodes; MRI: Magnetic Resonance Imaging; SPR: Surface Plasmon Resonance.

Introduction

A construct which lies at the focal point of the size range between microscopic and sub-atomic designs is known as nanostructure which typically lies within the range from 1 to 100 nanometers [1]. Their extraordinary mechanical, electrical, thermal, and optical properties make them suitable to be utilized in next generation upgraded-tech [2]. Nanostructures, including nanowires, nanoshells, are the most demanding class of nanostructures these days [3].

Nanowires

Thin wires of diverse composition such as metals, semiconductors, or carbon-based compounds with diameter less than 100nm are called as nanowires [4]. These nanostructures exhibit unique optical, electronic, mechanical etc. properties due to their nanosize and high aspect ratio which make them suitable in disciplines like nanophotonics, nanosensing, nanoelectronics etc. [5]. There are numerous classes of nanowires, grouped in light of their composition, construction, and properties which are as follows.

- **Semiconductor Nanowires:** These are produced using semiconductor materials like silicon, gallium nitride, or zinc oxide and are widely utilized in electronics and photonics for applications like semiconductors, solar cells, and light-emitting diodes (LEDs) etc. [6].
- **Metal Nanowires:** These are composed of metallic elements like gold, silver, or copper and are utilized in applications like conductive electrodes/films, as catalyst for chemical process etc. [7].
- **Oxide Nanowires:** These nanowires are produced using metallic oxides like titanium dioxide or iron oxide and used as sensors, catalyst, and energy-based storage electronics [8].
- **Carbon Nanotubes:** Hollow nanostructures with properties similar to nanowires. They have applications in electronics, materials science, and biomedical engineering [9].
- **Hybrid Nanowires:** These are composed of diverse

materials, like semiconductor-metal or oxide-semiconductors fusions that exhibits synergistic properties [10].

Fabrication Approaches

Bottom-up Approach: These techniques involve self-assembly of nanowires from nuclear or atomic antecedents including process like molecular beam epitaxy, chemical vapor deposition fume statement and solution-phase synthesis [11].

Top-down Approach: These techniques involve the assembly of dimensional nanowires from bulk materials by means of electrospinning, lithography and etching [12].

Hybrid Approach: A Hybrid technique combines properties of both bottom-up and top-down approaches to attain versatility and flexibility in modifying nanowire characteristics for explicit applications [13].

Nanowires commonly have diameter up to hundred nanometres with varying lengths from micrometres to millimetres and high aspect ratio with lengths greater than their diameters which adds to their unique mechanical, electrical, and optical properties [14].

Applications of Nanowires

Environmental Monitoring: Nanowire-based sensors are used for identifying and evaluating ecological contaminants, poisons, and toxic gases [15]. Their elevated sensitivity, quick reaction times, and scaled down structure factors empowers real-time, on-site detection of environmental hazards [16].

Nanoelectronics/Photonics: Nanowires are utilized in different electronic and photonic gadgets including semiconductors, diodes, sensors, and optoelectronic parts [17]. Their high charge carrying versatility, quantum restriction impacts, and tunable bandgap make them promising contender for cutting edge electronics and photonics [18]. In addition, nanowires have applications in designing bioelectronic gadgets for observing physiological parameters or interacting with biological frameworks and can be coordinated into adaptable or implantable gadgets for applications in biosensing, drug delivery, or neuromodulation [19,20].Besides, nanowires are being investigated for interfacing with neural cells/tissues in order to record electrical signs from neurons or to animate brain movement, offering expected applications in neuroprosthetics, brain-computer interfaces, and understanding neural circuitry [21,22].

Nanomedicine: Nanowires are utilized in biomedical and biotechnological applications including biosensing, drug delivery, cellular/ tissue engineering, and neural interfacing [23]. Their high precision, sensitivity, and biocompatibility make them significant apparatuses for propelling medical diagnostics, therapeutics, and regenerative medication [24]. Besides, nanowires can be functionalized with explicit particles to recognize biopolymers like DNA, proteins, or antigens [25]. Nanowires with optical and magnetic properties can be utilized for bioimaging applications, for biosystem visualization or tracing biomolecules in real time, enhancing MRI or X-ray results [26]. Nanowires are also employed in tissue engineering and can be coordinated into frameworks or substrates to mechanical help for cell development, sorting, and tissue recovery [27]. Nanowire-based matrixes can also mimic the extracellular environment, promoting cell adhesion and proliferation [28].

Energy Conversion and Storage: Nanowires are also employed in energy transformation, harvesting and storage devices such solar cells, batteries, and energy units [29]. Their large surface area, short charge transport distances, and productive light retention properties add to further improved device performance [30].

By and large, nanowires hold offers progressing synthetic and biomedical applications at nanoscale. Progressing research keeps on investigating their true capacity in tending to difficulties in medical services, biotechnology, and natural sciences [31]. Surely, Nanowires are nanoscale structures that hold enormous commitment across different fields because of their exceptional properties and flexible applications. Notwithstanding, difficulties like versatility, reproducibility, and cost-viability remain, requiring progressing innovative work endeavours [32]. With novel developments in fabrication procedures, materials designing, and interdisciplinary joint effort, nanowires hold immense potential to strengthened the existing industrial sector [33].

Nanoshells

Spherical nanoparticles are known as "Nanoshell" is comprised of thin metallic gold shell, covering a dielectric center possessing a thickness from 1 to 20 nm [34]. Due to its ability to retain specific light frequencies and transform them into heat, these devices can be used for designated cell killing as well as imaging after being invigorated by close infrared light [35]. Nanoshell has been exhibited in cell line models to give targeted cancer death while saving typical cells from damage [36]. They can likewise be coupled to antibodies for designated organization into cells with wanted properties [37].

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Nanoshells can be synthesized from semiconductors, insulators, metals or metal oxides [38]. Numerous strategies can be utilized to design nanoshells, contingent upon their size and desired applications Types of nanoshells are as follows:

- **Oxides Nanoshells:** One of the novel highlights of oxide nanoshells is that they have a hollow center and a covering made of oxides of silica, Titania, and zirconia. The main use of this kind of nano shell is in the field of atom encapsulation of molecules and spectroscopy [39].
- **Hollow Silica Nanoshells:** There are a couple of advantages of involving silica as a protective agent since silica is unreactive and transparent, therefore it will not affect the responses that happen inside the nanoshell core thus simplifying it to analyze the nanoshell frameworks' spectra [40]. These frameworks of silica nanoshells are useful for exploring the photochemistry of atoms and fluorescent sources [41].

Composition of Nanoshells

- The inside of the ball is known as the core which comprises of different parts, like magnetic materials, carbon or silica, or metals like Gold or silver [42].
- The ball's external layer is known as the shell and frames a defensive layer around the core. Furthermore, different materials, including metals, polymers (like plastic), and even semiconductors (like the material found in microprocessors), can be utilized to make the shell [43].

Properties of Nanoshells

Size: Nanoshells range from 1 to 100 nanometers with high surface area to-volume proportions which is valuable for utilization in delivering drugs and catalysis [44].

Surface Area: Synergist processes, surface-improved spectroscopy, and detecting capability can all profit from the immense surface area of nanoshells, which additionally builds their reactivity and cooperation with encompassing atoms [45].

Surface Plasmon Resonance (SPR): Surface plasmon resonance is seen in metal nanoshells, particularly those made out of gold or silver [46]. This trademark results from the metal shell's electrons' aggregate wavering in response to approaching light [47]. SPR has involves in detecting, imaging, and can be constrained by fluctuating the size and type of the nanoshells [48].

Optical Properties: Nanoshells can show unique optical qualities, for example, adjustable scattering and absorption spectra [49]. These qualities are significant for plasmonic, photonics, and optical detecting applications since they are incredibly delicate to the size, shape, and cosmetics of the nanoshell [50].

Biocompatibility: A couple of nanoshells materials have excellent biocompatibility, for example, certain polymers or biocompatible metals like gold, making them fitting for biomedical applications like drug delivery, imaging, and treatment [51].

Mechanical and Thermal Stability: Due to their particular design and nano scale size, nano shells every now and again show unrivaled mechanical and thermal stability when contrasted with mass materials [52].

Nanoshells provide improved protection against collision/crashes and are simple to wear because they weigh less than conventional protection [53]. However, due to their complicated development, they need specific consideration and upkeep. In addition, they probably won't have the option to oppose specific especially troublesome conditions or dangers as effectively as expected [54]. The impacts on human wellbeing and the climate are as yet unclear.

Applications of Nanoshells

Biomedical Imaging

Surface-enhanced raman spectroscopy, optical coherence tomography, and photograph acoustic imaging are among the biomedical imaging approaches that utilization nanoshells, particularly those having plasmonic highlights [55]. They are helpful for further developing imaging variances and awareness in view of their flexible optical qualities and ability to assimilate or dissipate light [56].

Drug Delivery

Designated drug delivery is conceivable by functionalizing nanoshells with focusing on ligands and atoms [57]. Their ability to exemplify drugs, high surface region to-volume proportion, and biocompatibility make them appealing conveyance frameworks for delivering to specific cells or tissues with minimal measure of secondary effects [58].

Cancer Therapy

By utilizing the photographic thermal effect, gold nanoshells can cause limited warming when exposed to infrared light as it utilizes this trademark to fix malignant growth by producing heat by the specific collection of nanoshells in cancers, which obliterates disease cells while safeguarding solid tissue [59].

Catalysis

In view of their huge surface region and unmistakable electrical attributes, metal nanoshells are compelling

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impetuses. They are utilized in different modern cycles and natural remediation synergist responses, including as coupling reactions, oxidation, and hydrogenation [60].

Sensing and Detection

Synthetic and organic detecting applications uses nanoshells as detectors. In light of their plasmonic attributes, target particles can be identified with outrageous awareness utilizing strategies like surface-improved Raman spectroscopy and surface Plasmon reverberation [61]. Nanoshells are helpful for food handling, environmental monitoring, and diagnostics since they might be functionalized with specific receptors or tests for the particular location of analytes [62].

Nano Electronics

Due to their extraordinary electrical and optical attributes, nanoshells are being researched for use in nano gadgets and optoelectronics [63]. For expanded usefulness and productivity, they can be added to gadgets including light-emitting diodes (LEDs), photograph indicators, and field-impact semiconductors [64].

Photonic Devices

Plasmonic waveguides, nanolasers, are instances of photonic gadgets that are created utilizing nanoshells [65]. Their ability to control light at the nanoscale makes it conceivable to improve and decrease the size of optical parts for use in detecting, information capacity, and media communications [66].

Environmental Clean-Up

Contamination identification and cleanup utilizing nanoshells in ecological applications to specifically retain and eliminate toxins from water or air, they can be functionalized with specific ligands or receptors, which will aid in environmental monitoring and purification operations [67].

Future Nanoshells should put multifunctionality first, adding imaging, restorative, and symptomatic elements to advance individualized medical services. For customized connections with natural frameworks and on-request drug discharge, responsive attributes are critical. In biomedical applications, focusing on strategies ought to be improved to boost on track impacts and limit askew results [68]. Besides, for clinical interpretation, intensive examination concerning security profiles and biocompatibility is important. To address the developing interest, versatile blend procedures and creation processes are fundamental. Consolidating state of the art innovations, for example, man-made reasoning and advanced mechanics can empower smart nanoshell frameworks [69]. Moreover, interdisciplinary participation and the augmentation of nanoshell applications to natural remediation will advance development and effectively handle troublesome issues.

Conclusion

Thus, these novel nanostructures i.e. Nanowires and Nanoshells offer promising application in wide variety of disciplines.

References

1. Nasrollahzadeh M, Issaabadi Z, Sajjadi M, Sajadi SM, Atarod M (2019) Types of Nanostructures. Interface Science and Technology 28: 29-80.

2. Ramrakhiani M (2012) Nanostructures and their Applications. Recent Research in Science and Technology 4(8).

3. Farajpour A, Ghayesh MH, Farokhi H (2018) A Review on the Mechanics of Nanostructures. International Journal of Engineering Science 133: 231-263.

4. Dresselhaus MS, Lin YM, Rabin O, Black MR, Kong J, et al. (2010) Nanowires. Springer Handbook of Nanotechnology pp: 119-167.

5. Fasol G (1998) Nanowires: Small is Beautiful. Science 280(5363): 545-546.

6. Lu W, Lieber CM (2006) Semiconductor Nanowires. Journal of Physics D: Applied Physics 39(21): R387.

7. Jiu J, Suganuma K (2016) Metallic Nanowires and their Application. IEEE Transactions on Components Packaging and Manufacturing Technology 6(12): 1733-1751.

8. Comini E, Sberveglieri G (2010) Metal Oxide Nanowires as Chemical Sensors. Materials Today 13(7-8): 36-44.

9. Ebbesen TW (1994) Carbon Nanotubes. Annual Review of Materials Science 24(1): 235-264.

10. Yuan J, Xu Y, Walther A, Bolisetty S, Schumacher M, et al. (2008) Water-Soluble Organo-Silica Hybrid Nanowires. Nat Mater 7(9): 718-722.

11. Arjmand T, Legallais M, Nguyen TTT, Serre P, Perez M, et al. (2022) Functional Devices from Bottom-Up Silicon Nanowires: A Review. Nanomaterials (Basel) 12(7): 1043.

12. Kim K, Lee JK, Han SJ, Lee S (2020) A Novel Top-Down

 Copyright© Khan NT.

Fabrication Process for Vertically-Stacked Silicon-Nanowire Array. Applied Sciences 10(3): 1146.

13. Liu H, Cui S, Guo Y, Li Y, Huang C, et al. (2009) Fabrication of Large Area Hybrid Nanowires Arrays as Novel Field Emitters. Journal of Materials Chemistry 19(7): 1031-1036.
14. Karlsson LS, Dick KA, Wagner JB, Malm JO, Deppert K, et al. (2007) Understanding the 3D Structure of Nanowires. Nanotechnology 18(48): 485717.
15. Li H, Zhu YJ (2021) Nanowires: Synthesis and Energy/Environmental Applications. Energy & Environmental Materials 4(4): 544-561.
16. Pham TA, Qamar A, Dinh T, Masud MK, Zadeh M, et al. (2020) Nanoarchitectonics for Wide Bandgap Semiconductor Nanowires: Toward the Next Generation of Nanoelectromechanical Systems for Environmental Monitoring. Adv Sci (Weinh) 7(21): 2001294.
17. Ramos D, Santos E, Malvar O, Llorens JM, Pini V, et al. (2013) Silicon Nanowires Where Mechanics and Optics Meet at the Nanoscale. Sci Rep 3(1): 3445.
18. Goodnick S, Nemnich R, Korkin A (2018) Focus on Electronics, Photonics and Renewable Energy. Nanotechnology 29(36): 360201.
19. Cheng G, Liu H, Geng X, Chen J (2010) InN Nanowire Transistors: Growth Electronics & Photonics. International Nanoelectronics Conference IEEE pp: 1206-1207.
20. Chen R, Hochbaum AI, Murphy P, Moore J, Yang P, et al. (2008) Thermal Conductance of thin Silicon Nanowires. Physical Review Letters 101(10): 105501.
21. Whang D, Jin S, Lieber CM (2004) Large-Scale Hierarchical Organization of Nanowires for Functional Nanosystems. Japanese Journal of Applied Physics 43(7S): 4465.
22. Wang G, Park J, Kong X, Wilson PR, Chen Z, et al. (2008) Facile Synthesis and Characterization of Gallium Oxide (β-Ga_2O_3) 1D Nanostructures: Nanowires, Nanoribbons, and Nanosheets. Crystal Growth & Design 8(6): 1940-1944.
23. Berthing T, Birger SC, Jesper N, Laurence MK (2009) Applications of Nanowire Arrays in Nanomedicine. Journal of Nanoneuroscience 1(1): 3-9.
24. Patolsky F, Zheng G, Lieber CM (2006) Nanowire Sensors for Medicine and the Life Sciences. Nanomedicine 1(1): 51-65.
25. Wang Z, Lee S, Koo KI, Kim K (2016) Nanowire Based Sensors for Biological and Medical Applications. IEEE Transactions on Nanobioscience 15(3): 186-199.
26. Wang J (2009) Biomolecule Functionalized Nanowires from Nanosensors to Nanocarriers. ChemPhysChem 10(11): 1748-1755.
27. Rahong S, Yasui T, Kaji N, Baba Y (2016) Recent Developments in Nanowires for Bio-Applications from Molecular to Cellular Levels. Lab on a Chip 16(7): 1126-1138.
28. Varadan VK, Chen L, Xie J (2008) Nanomedicine: Design and Applications of Magnetic Nanomaterials, Nanosensors and Nanosystems. John Wiley & Sons.
29. Yu K, Pan X, Zhang G, Liao X, Zhou X, et al. (2018) Nanowires in Energy Storage Devices Structures Synthesis, and Applications. Advanced Energy Materials 8(32): 1802369.
30. Zhou G, Xu L, Hu G, Mai L, Cui Y (2019) Nanowires for Electrochemical Energy Storage. Chemical Reviews 119(20): 11042-11109.
31. Logeeswaran VJ, Oh J, Nayak AP, Katzenmeyer AM, Gilchrist KH, et al. (2011) A Perspective on Nanowire Photodetectors Current Status Future Challenges and Opportunities. IEEE Journal of Selected Topics in Quantum Electronics 17(4): 1-31.
32. Anand G, Santhosh N, Vishvanathperumal S (2023) Future Perspectives of Nanowires. In Nanowires. CRC Press pp: 395-409.
33. Nana ABA, Marimuthu T, Kondiah PP, Choonara YE, Toit LC, et al. (2019) Multifunctional Magnetic Nanowires: Design Fabrication and Future Prospects as Cancer Therapeutics. Cancers 11(12): 1956.
34. Hirsch LR, Gobin AM, Lowery AR, Tam F, Drezek RA, et al. (2006) Metal Nanoshells. Ann Biomed Eng 34(1): 15-22.
35. Bardhan R, Lal S, Joshi A, Halas NJ (2011) Theranostic Nanoshells from Probe Design to Imaging and Treatment of Cancer. Acc Chem Res 44(10): 936-946.
36. Hao E, Li S, Bailey RC, Zou S, Schatz GC, et al. (2004) Optical Properties of Metal Nanoshells. Journal of Physical Chemistry B 108(4): 1224-1229.
37. Brongersma ML (2003) Nanoshells Gifts in a Gold Wrapper. Nature Materials 2(5): 296-297.
38. Xu X, Karami B, Janghorban M (2021) On the Dynamics of Nanoshells. International Journal of Engineering Science

Copyright© Khan NT.

158: 103431.

39. Kalele S, Gosavi SW, Urban J, Kulkarni SK (2006) Nanoshell Particles: Synthesis Properties and Applications. Current Science 1038-1052.

40. Tserkezis C, Gantzounis G, Stefanou N (2008) Collective Plasmonic Modes in Ordered Assemblies of Metallic Nanoshells. Journal of Physics Condensed Matter 20(7): 075232.

41. Wang YC, Rheaume E, Lesage F, Kakkar A (2018) Synthetic Methodologies to Gold Nanoshells an Overview. Molecules 23(11): 2851.

42. Kustov EF (2009) Composition and Space Structure of Nanoshells. Journal of Computational and Theoretical Nanoscience 6(3): 692-705.

43. Daneshfar N, Bazyari K (2014) Optical and Spectral Tunability of Multilayer Spherical and Cylindrical Nanoshells. Applied Physics 116: 611-620.

44. Kustov EF, Nefedov VI (2008) Nanostructures Compositions Structure and Classification. Russian Journal of Inorganic Chemistry 53(14): 2103-2170.

45. Wang L, Ebina Y, Takada K, Sasaki T (2004) Ultrathin Hollow Nanoshells of Manganese Oxide. Chemical Communications 9: 1074-1075.

46. Puebla RA, Ross DJ, Nazri GA, Aroca RF (2005) Surface-Enhanced Raman Scattering on Nanoshells with Tunable Surface Plasmon Resonance. Langmuir 21(23): 10504-10508.

47. Jain PK, Sayed MA (2007) Surface Plasmon Resonance Sensitivity of Metal Nanostructures Physical Basis and Universal Scaling in Metal Nanoshells. Phys Chem C 111(47): 17451-17454.

48. Halas N (2005) Playing with Plasmons Tuning the Optical Resonant Properties of Metallic Nanoshells. Mrs Bulletin 30(5): 362-367.

49. Hao E, Li S, Bailey RC, Zou S, Schatz GC, et al. (2004) Optical Properties of Metal Nanoshells. The Journal of Physical Chemistry B 108(4): 1224-1229.

50. Averitt RD, Westcott SL, Halas NJ (1999) Linear Optical Properties of Gold Nanoshells. JOSA B 16(10): 1824-1832.

51. Koktysh DS, Liang X, Yun BG, Pastoriza SI, Matts RL, et al. (2002) Biomaterials by Design Layer by Layer Assembled Ion-Selective and Biocompatible Films of TiO2 Nanoshells for Neurochemical Monitoring. Advanced Functional Materials 12(4): 255-265.

52. Ansari R, Gholami R, Norouzzadeh A (2016) Size-Dependent Thermo Mechanical Vibration and Instability of Conveying Fluid Functionally Graded Nanoshells Based on Mindlin's Strain Gradient Theory. Thin-Walled Structures 105: 172-184.

53. Tang J, Huang C, Liu Y, Wang T, Yu M, et al. (2023) Metal-Organic Framework Nanoshell Structures: Preparation and Biomedical Applications. Coordination Chemistry Reviews 490: 215211.

54. Geng W, Wang L, Jiang N, Cao J, Xiao YX, et al. (2018) Single Cells in Nanoshells for the Functionalization of Living Cells. Nanoscale 10(7): 3112-3129.

55. Ahmadi A, Arami S (2014) Potential Applications of Nanoshells in Biomedical Sciences. J Drug Target 22(3): 175-190.

56. Chatterjee K, Sarkar S, Rao KJ, Paria S (2014) Core/Shell Nanoparticles in Biomedical Applications. Adv Colloid Interface Sci 209: 8-39.

57. Singhana B, Slattery P, Chen A, Wallace M, Melancon MP (2014) Light Activatable Gold Nanoshells for Drug Delivery Applications. AAPS PharmSciTech 15(3): 741-752.

58. Ariga K, Lvov YM, Kawakami K, Ji Q, Hill JP (2011) Layer-by-Layer Self-Assembled Shells for Drug Delivery. Adv Drug Deliv Rev 63(9): 762-771.

59. Morton JG, Day ES, Halas NJ, West JL (2010) Nanoshells for Photothermal Cancer Therapy. Methods Mol Biol 101-117.

60. Gao C, Lyu F, Yin Y (2020) Encapsulated Metal Nanoparticles for Catalysis. Chem Rev 121(2): 834-881.

61. Raschke G, Brogl S, Susha AS, Rogach AL, Klar TA, et al. (2004) Gold Nanoshells Improve Single Nanoparticle Molecular Sensors. Nano Letters 4(10): 1853-1857.

62. Ochsenkuhn MA, Jess PR, Stoquert H, Dholakia K, Campbell CJ (2009) Nanoshells for Surface-Enhanced Raman Spectroscopy in Eukaryotic Cells Cellular Response and Sensor Development. Acs Nano 3(11): 3613-3621.

63. Li C, Jin Y (2021) Shell-Isolated Plasmonic Nanostructures for Biosensing Catalysis and Advanced Nanoelectronics. Advanced Functional Materials 31(7): 2008031.

64. Prinz VY (2003) A New Concept in Fabricating Building Blocks for Nanoelectronic and Nanomechanic Devices.

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Microelectronic Engineering 69(2-4): 466-475.

65. Loo C, Lin A, Hirsch L, Lee MH, Barton J, et al. (2004) Nanoshell Enabled Photonics Based Imaging and Therapy of Cancer. Technol Cancer Res Treat 3(1): 33-40.

66. Tserkezis C, Stefanou N, Gantzounis G, Papanikolaou N (2011) Photonic Surface States in Plasmonic Crystals of Metallic Nanoshells. Physical Review B 84(11): 115455.

67. Chang K (2005) Tiny is Beautiful Translating Nano into Practical. The New York Times 22.

68. Ramanan G, Pandian A, Raghunandan A (201) Effects of Nanotechnology on Health and Environment. In International Conference on Nanoscience Engineering and Technology pp: 280-284.

69. Brinson BE, Lassiter JB, Levin CS, Bardhan R, Mirin N (2008) Nanoshells Made Easy Improving Au Layer Growth on Nanoparticle Surfaces. Langmuir 24(24): 14166-14171.

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