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Semiconductors and Cosmetics

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ABSTRACT
This review investigates the various applications of silver nanoparticles (AgNPs) in cosmetics and semiconductors, bridging the gap between these two diverse industries . It focuses on the utilization of nano silver in both industries, the paper explores how subtle alterations in nanoparticle properties and synthesis methods lead to profound shifts in behavior, allowing the same material to be employed in two extensively different sectors. Offering an up-to-date overview of ongoing activities in this field, the review expresses a shared interest in AgNPs, covering their origin, properties, and applications in cosmetic and semiconductor industry. Additionally, it addresses the crucial aspect of AgNPs' toxicity, exploring its harmful implications for both human health and the environment. Furthermore, the review suggests new research ideas for combining cosmetics and semiconductors. By providing insights into the adaptability and implications of silver nanoparticles, this review serves as a valuable resource for researchers and professionals, offering a scope for future explorations at the intersection of cosmetic and semiconductor technologies.

Keywords: *Nanosilver Nanoparticles, Cosmetics,semiconductors, Toxicity, Application in electronics and semiconductor*

I. INTRODUCTION

The word 'nanotechnology' is made up of two words; the first word is the Greek word 'nano', which means tiny (e.g., of the nanometer length scale of ~1 to 100 nm), and the second word is 'technology' . Nanotechnology possesses immense potential to improve a wide range of materials in research and applications and is therefore capable of gaining considerable attention in cosmetics as well as electronic domains.[1]The advent of improving technology, specifically nanotechnology, has changed the extent of research in the sciences generally and in the life sciences in particular. Gone by are the days when information was stored in piles of books, occupying large fraction of the space. Today, information storage chips also known as semiconductors are as tiny as postal stamps and have storage capacities as large as the Titanic ship and functionalities similar to the processing unit of a high speed computer.[2]

Semiconductors are the substances with characteristics halfway between conductivity and insulativity . As the basis for semiconductor devices like transistors diodes, and integrated circuits, these are essential to modern electronics . Semiconductors are crucial for the manipulation and processing of information in electronic devices because they have the capacity to control the flow of electric current . In the late 20th century the use of silver nano-particles (AgNPs) in semiconductor applications has become extremely important because of their special characteristics and unique blend of properties. These inorganic nano-particles are crucial for developing semiconductor technologies because they provide improved thermal stability, antimicrobial activity, optical properties , increased conductivity and compatibility with current fabrication methods. Their incorporation into semiconductor manufacturing procedures aids the creation of high-performance hardware and the execution of novel applications.[3]

Science has shown its power again by merging nanotechnology and semiconductors with cosmetics as it holds immense potential to revolutionize the cosmetic formulations, offering limitless possibilities in terms of effectiveness, precision and personalization. Imagine makeup that's not just pretty but also super effective and personalized just for you! The demand of skincare and beauty products in the market has expanded exponentially over the years with more inclination towards products that improve overall skin quality. Consumers have been showing interest in products that provide long-term effects and numerous benefits to the skin.[4] One such nano-material is Silver nano-particles(AgNPs) in cosmetics, inorganic nano particles, in particular, are widely used, rather than organic nano particles, because of their hydrophilicity, bio-compatibility, stability, and non-toxicity .One another major advantage is their easy surface modification leading to a wide range of formulations providing cosmetic effects while at the same time reducing the chances of side effects and are able to overcome the concerns of organic nano-particles, particularly less irritation, itching, and allergies to the skin and have higher chemical stability. In conclusion, inorganic nano-particles hold a prominent position in the cosmetic industry as well as in the semiconductor technologies as these are the most stringent segments of the economy worldwide.

II. SILVER NANOPARTICLES

Generally AgNPs are nanoparticles of silver having size range between 1 and 100 nm in size having unique properties such as electrical, optical and magnetic having wide range of applicability [47]. Metallic silver ions are inactive but once it comes in contact with a reducing agent, ionization occurs and it gets converted into its active form. Ionic silver is the active form of silver which binds to cell wall of bacteria leading to major structural changes in cell morphology. AgNPs causes de-naturation of RNA and DNA replication which further leads to cell death. Silver is also called "oligodynamic" due to its bactericidal potential at minimum concentration. That's why it has been largely used in medical products.[13]

III. SYNTHESIS OF SILVER NANOPARTICLE

AgNPs can be prepared by three methods; Physical, Chemical and Biological methods.

Physical methods

Using evaporation-condensation method having a tube furnace at environmental temperature these nanoparticles are prepared in physical method. Before this, some conventional methods were used to prepare the nanoparticle, these are: pyrolysis and spark discharging. As no toxic chemicals are used in this method so it is found to be safe. Another advantage is the speed and radiation involved i.e. used as reducing agent. Apart from this some of the disadvantages are: low yield, contamination in solvent, consumption of high amount of energy and sometimes, lack of uniform distribution.

Chemical methods

The AgNPs can be prepared by using either water or some other organic solvents. In this chemical process basically 3 components are there: metal precursors, reducing agent and capping agents. AgNPs can be prepared by "top-down method" and "bottom-up method". In "top-down" method, with the use of colloidal protecting agent there is use of mechanical grinding of large size metals with consequent stabilization. In second method i.e. "bottom-up" method involves chemical reduction, so no decomposition and electrochemical methods are included. The main advantage of chemical method is high yield but the disadvantage is the cost of these methods. Secondly, the materials used for the synthesis of AgNPs using the hemical method are extremely toxic and hazardous in nature.

Green Synthesis Approach (Biological Method)

Green synthesis of silver nanoparticles is preferred because this method is environmental, commercial and a single step method and doesn't need elevated temperature, pressure, force or hazardous chemicals. Natural materials like leaf extract, bark, root, stem, leaf, fungi etc. are used for the synthesis of nanoparticles. Apart from this small molecules like vitamins and amino acids are also used as an alternative to chemical methods for the preparation of not only AgNP but some other nano-particles also. Many of the studies have reported that these AgNPs are prepared without using any toxic or hazardous chemicals and are also cost-effective. In the preparation of AgNPs different types of bacteria are used . Biological synthesis includes 3 main components, which are solvent, reducing agent and the non-toxic material. In the biological method we are able to synthesize nano-particles of controlled size and shape, which is one of the most important requirements for preparation and biological activities of nanoparticle. Advantages of AgNPs include availability of vast resources, less time involvement, stability etc. If we see in literature small size nanoparticles are found to be more effectual as well as they have better properties.[5]

IV. PROPERTIES

Silver nanoparticles (AgNPs) are increasingly used in various fields, due to their unique physical and chemical properties. These include biological and electronic properties. These properties are discussed in detail below:

Biological properties

Silver nanoparticles (AgNPs) act as tiny soldiers against blemishes, possess potent antimicrobial properties, making them naturalpreservatives in cosmetics and game-changers in the industry for anti-acne solutions. Their diverse arsenal, revealed by studies, hints at a cosmetic revolution brewing on the nanoscale. The literature suggests that, while these activities of silver nanoparticles may be due to the release of silver ions, it is also possible that they exhibit additional effects that cannot be explained solely by the release of silver ions in solution.[4]

Antibacterial Activity

One of the exceptional abilities of AgNPs is their strong antibacterial property. Researchers have utilized this property by incorporating AgNPs as active ingredients in the preparation of skincare products, toothpastes and deodorants [Raj et al., 2012; Effiong et al., 2020]. As shown in Fig. 1, AgNPs have the ability to exercise antibacterial features via several mechanisms. Furthermore, in the cell, the silver ions (Ag^+) are released to attack the respiratory chain and cause oxidative stress with an increase in production of reactive oxygen species (ROS). This ultimately leads to protein damage and inhibits the cell growth. As a result, cell growth is disrupted which eventually leads to cell death. Besides the respiratory chain, research have stated that AgNPs also attack the DNA mechanism in the cells. AgNPs seem to be potential antibacterial agents due to their large surface-to-volume ratios and crystallographic surface structure. [6]

Antifungal Activity

AgNPs are found to be prominent against many diseases that are caused due to fungi[7] By inhibiting conidial germination, biologically synthesized AgNPs showed good antifungal activity against Bipolaris sorokiniana. Indoor fungal species such as Penicillium brevicompactum, Aspergillus fumigatus, Chaetomium globosum and Mortierella alpine cultured on agar media are also inhibited by AgNPs.

Antiviral Activity

In the whole world, viral infections and disease are found to be very common, so it's very important to make antiviral agents that results in showing prominent results . AgNPs are found to be prominent in showing such results this is due to their very small size and their shape also. It has been observed that silver is found to be relatively non-toxic towards humans as well as animals and found to be effective against viruses. The antiviral activity nano-Ag incorporated in creams to prevent viral skin infections and used as preservatives in cosmetics. Interestingly, in the presence of AgNPs, virus was capable of adsorbing to cells, and this viral entry is responsible for the antiviral effects of AgNPs.

Anti-Inflammatory Activity

Inflammation is found to give an immunological response that is against some foreign dust particles settling on the face and causing infection. As AgNPs are known to be their antibacterial and anti-microbial activities but their response to act as anti-inflammatory reagent are limited but they also play important role in this anti-inflammatory field. It has been used as an effective topical application for improving wound healing as it's the next process after inflammation. The studies have shown influence of AgNPs in an animal model of wound healing and results showed that wounds treated with silver nanoparticles exerted positive effects to reduce wound inflammation and thus promote wound healing

Anti Aging properties

Ageing is a natural phenomenon among human where there is failure in conservation of homeostasis and possibility of dying escalates. Recently, Incorporation of natural products into nanoparticles is a favorable approach. It is simple, efficient, inexpensive and sustainable . Green synthesis of nanoparticles utilizes the use of microorganisms and plants, and benefit from the ability of these organisms as reducing agents . In addition, AgNPs do not make alterations on living cells. Thereby, they are incapable of causing microbial resistance. Besides, they are able to attach to cell walls and modify cellular respiration . Furthermore, they enhance *in-vitro* activities. Silver nanoparticles were evaluated for its anti-ageing effect in cosmetic preparations in other studies (paper upload)

Antioxident

Free radicals, notorious for causing oxidative stress, threaten cellular well-being by snatching electrons. Silver nanoparticles (AgNPs) emerge as potent defenders, skillfully neutralizing free radicals by donating electrons. Their unique reactivity positions AgNPs as key players in mitigating oxidative damage to cells and tissues. Moreover, AgNPs synergize effectively with traditional antioxidants like vitamins C and E, forming a robust shield against oxidative stress. Such insights pave the way for innovative therapeutic approaches and preventive measures against oxidative stress-related ailments

IV. APPLICATIONS IN COSMETICS

Sunscreens

The skin's structure and composition are altered and oxidative stress is caused by chronic exposure to ultraviolet light from the sun. There are a variety of effects that could occur, from acute changes like erythema, pigmentation, and photosensitivity to long-term effects like premature aging and skin cancer. On the evaluation of the use of biogenic-AgNPs as preservatives and sunscreen cream formulations. Colloidal silver (nano) or (AgNPs) are the most commonly used nanomaterials in cosmetics as chemopreventive agents in sunscreens and as preservative agents in CPs. The Scientific Committee on Consumer Safety (SCCS) considers it a safe preservative. [7]

Toothpastes

silver nanoparticles could provide a safer alternative to conventional antimicrobial agents in the form of a topical antimicrobial formulation. Some special tooth creams for the neck of sensitive teeth contain nanoscale calcium phosphate (apatite) which produces a thin layer similar to natural tooth enamel, which is thus supposed to reduce sensitivity to pain. [8]

Body products

Tiny particles of nanometer-thin pigment can be found in make-up, nanoparticulate silver is used in certain day and night creams to give the skin a fresher appearance. Due to antibacterial properties of silver nanoparticles it can be used as preservatives in cosmetics, and in anti-acne preparation.Antifungicidal activities of Nano silver makes them extremely popular and is used in soaps, toothpastes, wet wipes, deodorants, lip products, as well as face and body foams ,highly sensitive surface-enhanced Raman spectroscopy (SERS) application ,water treatment and textiles, etc., that boost their market value [5]

Cleansers

Nano silver containing cleanser soap was claimed to have bactericidal and fungicidal properties and was found useful in treating acne and sun damaged skin.The nano silver skin gel, which contains 30 times less silver than silver sulfadiazine, is better choice for the skin of burn patients to treat infections. [9]

V. SEMICONDUCTOR PROPERTIES

Nanoparticles exhibited some extra phenomenon, i.e., random motion of the small particles, quantum tunneling etc. Nanomaterials are changing their electrical, optical, surface-related, mechanical, and magnetic properties at nanoscale and exhibits some prominent effects that are associated with nanoparticles, as mentioned below.[12]

Electrical properties

As the electrons that cannot move freely at nano level and their motion became restricted, this confinement at the nanoscale results in the changes in electrical properties, such as the bulk conductor/semiconductor materials behaving as superconductors or conductors at nanoscale.

As a result nanosilver (of size less than 10 nm) cannot conduct electricity.

Optical properties

- Optical properties of nanomaterials are also size dependent. Electrons cannot move freely at the nanoscale and become restricted. The confinement of the electrons causes them to react to light differently.
- Example Gold appears golden at the macroscale, but the nanosized gold particles are red.
- Quantum dots changes in their optical appearance as the size of the particles decreases creating different colors.

Surface properties

- The surface-dominated properties such as melting point, rate of reaction, capillary action, and adhesion, are controlled by their surface area
- due to high surface area of the nanomaterials, these properties show drastic changes from their bulk counter parts.
- AgNPs exhibit a phenomenon called surface plasmon resonance (SPR) when light interacts with their electrons. This collective oscillation of electrons depends highly on surface area, influencing their optical properties like light absorption and scattering.

Mechanical properties

- At nanolevel, the changes in mechanical properties of the material such as Young’s modulus, tensile strength, more hardness, more brittle, grain boundaries deformations, lower density of dislocation moments, short distance of dislocation moments increases, etc are observed.

Magnetic properties

- For nanomagnetic materials, each spin behaves as a small magnet for nanomaterials. The interaction between neighbouring spins is dominated by the spin exchange interaction.
- Similar to the paramagnets, the nano-super-paramagnets back to zero magnetization upon removing of the field. It happens because of their small size and not due to the inherently weak exchange between the individual moments.

Lotus effect

- nanomaterials show the self-cleaning phenomena that are controlled by various parameters, i.e., surface fractal dimension, surface morphology, and dynamic-wetting behaviors, responsible for the super hydrophobic character in them.

Localized surface plasmon resonance (LSPR)

- When plasmonic material is exposed to sunlight, free electrons of the nanoparticle of noble metals are integrated with the photon energy that produces subwaves and conducting electrons in oscillating mode [7, 8].
- These collective oscillations offer a localized surface plasmonic resonance (LSPR).it enhances the number of active sites and the rate of electron–hole formation by providing a fast lane for charge transfer on the semiconductor surface.
- This phenomenon results in numerous physical effects including tailorable absorption of light (from UV to near-IR), local heating, LSPR-powered e/h generation,enhanced local electric effect, high catalytic effect and proficient charge transfer.
- Therefore, photoexcitation leads to a smooth electron transfer between the semiconductor carrier/supports and the noble-metal NPs. NPs of Ag (< 10 nm), are the most commonly used plasmonic materials.

The quantum confinement effect

- The quantum confinement effect is observed having particle size less than the wavelength of the electron. If the motion of randomly moving electron is to be restricted in a specific energy levels (discreteness) then the motion of electron is confined ,result in the particles having the shape of quantum dots, nanowire/rods and nanosheets, respectively.
- As the size of a particle decreases up to a nanoscale, the decrease in confining dimension makes the energy levels discrete, which widens up their band gap and band gap energy. Although the physical properties of a quantum dots are not affected by quantum confinement, their optical absorption and emission can be tuned via the quantum size effect.

VI. APPLICATION IN ELECTRONICS

Metal nanocatalysts of different shapes and sizes like quantum dots, nanofibres, self-assemble processing devices, nanoparticles have immense significance. They have bright future in broad research areas of high-tech applications in the field of information of storage, computing, medical and biotechnology, energy, sensors and smart materials.[10]

- ***Solar cells***

  AgNPs, with their ability to manipulate light through surface plasmon resonance, can act as tiny light traps within the solar cell. This means they can capture and redirect light within the active layer, increasing the chances of photon absorption and electron excitation for energy conversion.it can be incorporated into the electron transport layer of a solar cell.This allows for better light transmission and potentially opens doors for flexible solar cell designs that can be integrated into diverse applications.[3]

- ***Conductive inkjets***

  AgNP showed great attention in modern technological applications due to their high conductivity; conductive inks based on Ag NPs are widely utilized for electronic applications are based on Ag NPs .Compatible with inkjet, screen, and aerosol printing, making precise patterning on diverse materials a breeze.

- ***Nanofibers***

  As a noble metal, Ag NPs show a Localized Surface Plasmon Resonance (LSPR) which make them valuable in other applications such as catalyst, microelectronics, medical, imaging, health products, and waste management. Moreover, the nanofibre used in water disinfectant treatment can be very effective in attracting and trapping small particles because it is “sticky” due to its large surface area. This makes nanofibres excellent materials for use in filtration.

- ***Photoelectrical devices***

  Silver nanoparticles contributes to enhance the energies above the band gap of a semiconductor. The size, shape, and composition of plasmonic NP affects the optical properties figure .recent research has exposed the new prospectives by utilizing this energy in the areas such as in photothermal heat generation, photovoltaic devices, photon energy conversion and solar steam generation.

- ***Microelectronic applications***

Ag NPs are employed in microelectronic materials due to significantly reduced melting points with increased surface energy. Ag NPs show a promising ability for microelectronic applications and can be applied as a conductive filler in electronically conductive adhesives. The lower surface roughness of Ag NPs is an important feature to reduce the electrical losses at a higher frequency. Thus, the electrical conductors assembled with a thick film of silver nanoparticle reduce the electrical loss, giving better packing and fabricating antennas .

VII. COMMON TRAITS

Despite diverse applications in electronics and cosmetics, silver nanoparticles (AgNPs) share a common origin: their synthesis method. Choosing the right method dictates their size, shapes, and surface to volume ratio etc ultimately shaping their properties and behavior. Even slight tweaks in synthesis can dramatically alter AgNP performance.
following are the key atributies which I believe by modifing remotely can change the whole dynamics of the agnps which , highlights its critical role in unlocking their full potential across 2 different industries-cosmetics and semiconductors.

Attributes	*Cosmetics*	*Semiconductors*
Surface to volume ratio	• the studies states that nanoparticles which has got the larger surface area to volume ratios and smaller particles size have greater antibacterial effect • potentially promoting wound healing by stimulating cell regeneration (further research needed).	• Larger surface area binds selectively to target analytes for specific and sensitive detection in applications like biosensing or immunoassays • Ag NPs are employed in microelectronic materials due to increased surface energy and reduced melting points
Crystalline structures	• antibacterial agents show properties due to their crystallographic surface structure • Specific crystalline structures(Fcc,Hcp,twinned) making them potential alternatives to synthetic dyes in cosmetics.	• Conductivity, light manipulation, and catalytic activity in certain devices depend on the crystal structure and precise control over size and shape.
Concentration	• Finding the sweet spot for concentration is crucial for balancing effectiveness, safety, and product aesthetics. • Higher concentrations can offer stronger UV blocking capability, but their potential impact on skin needs careful evaluation.	Depending on the device functionality you can precisly tailor the concertration so that the perfomance is improved • Optimal concentration can maximize conductivity in circuits and sensors, while too much can lead to short circuits or decreased efficiency.
Stability	• AgNPs in cosmetics need to be stable against oxidation, aggregation, and leaching from the product to ensure consistent performance and minimize potential skin irritation. • Unstable AgNPs can lose their effectiveness, change color, or even release harmful silver ions.	• AgNPs stability in circuits and sensors is crucial for performance,longevity and get a reliable device. • Unstable AgNPs can lead to decreased conductivity, corrosion, and device failure.
Purity and contamination	• Skin irritation and allergies: Impurities or inappropriate capping agents can irritate the skin and trigger allergic reactions. • Long-term health risks: Concerns exist about the potential for impurities or nanoparticles themselves to penetrate the skin and enter the bloodstream, leading to unknown long-term health effects.	• Corrosion and degradation: Impurities can accelerate the corrosion of AgNPs, shortening the lifespan of electronic devices and potentially introducing harmful byproducts. • Unpredictable behavior: Contamination can introduce variability in the properties of AgNPs, making them unreliable for

	• Ethical considerations: Consumers increasingly demand transparency and ethical sourcing of ingredients, raising concerns about the environmental impact and potential toxicity of chemicals used in traditional AgNP synthesis	applications requiring precision, such as in high-end electronics or medical devices. • Reduced conductivity: Impurities can act as insulators, disrupting the flow of electrons within circuits and sensors made with AgNPs, leading to decreased performance and efficiency which can make it ethically incorrect to sell
Size of particle	• Antibacterial efficiency of Silver nanoparticles increases exponentially due their smaller size • Due to Larger size ,SPR can cause discoloration and raise skin irritation concerns.	• AgNPs, due to their smaller size, are mainly used in diagnostics devices leading to an increase in brightness and a clearer image • Large AgNPs in semiconductor junctions create pathways for unwanted leakage current due to tunneling effects at their interfaces. This leakage current can lead to energy loss.
Effect Of Shape	• the skin permeability of the spherical silver nanoparticles (SNPs), rod-shaped silver nanoparticles (RNPs) and triangular silver nanoparticles (TNPs), it was found that RNPs had the highest penetration capability whereas TNPs has the lowest thus they have unique interactions with viruses • specific shapes enhances SPR, increasing UV blocking efficiency in sunscreens.	• Elongated shapes like nanorods offer higher conductivity due to efficient charge transport along their length, ideal for electrodes and wires. • Specific shapes like spheres or cubes can enhance localized surface plasmon resonance (SPR), enabling applications like light modulation in sensors and optical devices.

TOXICITY IN HUMANS AND ENVIRONMENT

- *By cosmetics*
  There are conflicting claims and counter claims and lack of agreement between researchers on safety for dermal use. Because of their size, these nanoparticles can easily permeate in skin, then to the various organs. They may damage the cellular structures and DNA rendering the organ dead. However a group of scientists at the University of California Santa Barbara claimed that, silver nanoparticles get flushed away, from blood stream, reducing toxicity considerably. It is also reported that silver nanoparticles can protect some skin disease like atopic dermatitis . The explanation of the protective effects is still not understood. It is suggested that silver can disrupt the bacterial cell wall. At minimal and reasonable concentration of silver, there are no side effects on human health . It is necessary to consider various parameters like sizes, methods of preparation, variations in evaluation tests while building up evidence of possible Silvernano toxicity.

- *Potential Release of AgNPs in the Environment*
  From Washing our faces through tap water to release of agNPs from factories into the environment, AgNPs can easily travel through soil and water due to their small size. They can be absorbed by plants and microbes, moving up the food chain and potentially accumulating in larger organisms.As we know, at the cellular level, it can interact with proteins and DNA, producing oxidative stress and bacterial damage, but at what cost? It can also kill healthy bacteria. This can cause cell death, inflammation, and reduced organ function in exposed species.as for the aquatic environment they can harm beneficial bacteria and algae, affecting nutrient cycling and food webs. they can be toxic to fish and other organisms, impacting reproduction and survival animals which in turn can disrupt the delicate balance of ecosystems.

RESEARCH IN FUTURE
Silver nanoparticles (AgNPs) have gained widespread applications in electronics, medicine, and cosmetics. Green synthesis offers a sustainable alternative to traditional methods, addressing environmental and toxicity concerns. With tailored approaches, this eco-friendly production of AgNPs holds promise for semiconductors and cosmetics, fostering innovation while prioritizing environmental responsibility and consumer safety.[11]

Merging cosmetics and semiconductors using silver nanoparticles (AgNPs) holds exciting potential, pushing the boundaries of both fields.one of the main examples are

1) Antibacterial semiconductors

The photoinduced antibacterial mechanism exploits light-activated semiconductors to eradicate bacteria via a targeted, non-invasive approach. Light stimulates intrinsic fluorophores within these materials, converting their energy into heat or reactive oxygen species (ROS), both of which possess potent bactericidal activity. Silver nanoparticles (AgNPs), with their high surface area due to small size, exhibit excellent antibacterial efficacy by directly disrupting bacterial membranes. Research investigating the near-infrared photothermal efficiency of AgNPs nanosheets suggests their potential as highly promising photothermal antibacterial agents. This synergistic approach, combining the controlled action of light-activated semiconductors and the inherent anti-microbial properties of nanoparticles, offers a versatile and potentially safe solution for diverse antibacterial applications.

2) Smart Skincare:

- ***Interactive makeup:***
  Imagine interactive makeup that adjusts tint and coverage to match environmental conditions or personal mood, powered by AgNPs' light-responsive properties. we can infuse agnps in cosmetics which could respond to environmental changes like light or temperature, adjusting color, shine, or coverage for personalized looks. This opens doors to bespoke cosmetic experiences that enhance not just appearance, but also personal expression.

- ***Biosensing patches:***
  Patches embedded with AgNPs could monitor skin health in real-time, measuring hydration, pH, toxin levels, and even blood sugar. This data could then be used to personalize skincare routines and alert users to potential health concerns.

- ***Smart tattoos:***
  Tattoos using AgNPs could act as biosensors, monitoring vital signs like glucose, heart rate, or even stress levels. This could offer continuous health data in a non-invasive way, blurring the lines between beauty and wellness.

3) Enhanced Beauty Treatments:

- .Nanoplasmonics for skin rejuvenation:
  With a huge demand on laser treatments ,AgNPs with tailored optical properties could be used in light therapy devices for acne treatment, wrinkle reduction, and collagen stimulation. By manipulating light at the nanoscale, they could offer targeted and effective treatments.

- Microcurrent therapy with AgNPs:
  Integrating AgNPs into microcurrent devices could enhance their anti-aging and skin-tightening effects by promoting cell regeneration and collagen production.

4) Wearable Electronics for Beauty:

- Smart jewelry with skincare functions:
  Earrings or necklaces with AgNPs could emit calming vibrations or release essential oils based on stress levels or sleep patterns, fostering well-being and radiating outward as healthy, glowing skin

- Interactive nail art with AgNPs:
  Imagine nail polish that changes color based on your mood or reflects different patterns under specific lighting conditions, using AgNPs' light interaction properties.

VIII. CONCLUSIONS

In conclusion, the review paper underscores the diverse applications of silver nanoparticles in distinct industries. In cosmetics, the unique properties of silver nanoparticles, including antibacterial, antifungal, and anti-inflammatory attributes, make them promising candidates for skin care formulations. Conversely, in electronic devices, their electrical, magnetic, and lotus effect properties showcases their versatility in 2 completely different industries . this review paper mainly dwelles on the divergence in behavior arises from the synthesis process, where minute alterations in nanoparticle characteristics lead to distinct functionalities. Our detailed analysis highlights the impact of varying attributes on the performance of silver nanoparticles in cosmetics and semiconductors. Future studies are imperative to comprehend the potential toxicity associated with synthesis and its impact on human health and the environment. Research endeavors should focus on developing preventive measures to mitigate potential harm. This study unveils a various of possibilities, providing a foundation for future endeavors that integrate semiconductors and cosmetics, offering innovative solutions and opening new avenues for interdisciplinary applications.

In conclusion, our study unequivocally demonstrates the diverse applications of silver nanoparticles across industries, showcasing their unique properties in cosmetics and electronic devices. The nuanced behavior of these nanoparticles in distinct environments arises from the intricacies of their synthesis process, emphasizing the profound impact of minute alterations in attributes such as shape, size, and concentration. This study provides a comprehensive analysis of how these variations influence the functionality of silver nanoparticles in cosmetics and semiconductors, highlighting their potential to act as distinct entities despite originating from the same material.

While our findings open new horizons for interdisciplinary applications, we acknowledge the imperative for further research. Understanding the potential toxicity associated with different synthesis methods and its repercussions on human health and the environment is a crucial avenue for future investigation. Additional research endeavors should focus on devising preventive measures to mitigate any adverse effects and pave the way for responsible implementation of silver nanoparticles in diverse applications.

This study not only contributes to the scientific understanding of silver nanoparticles but also serves as a foundation for future innovations, suggesting a promising convergence of semiconductor technology with cosmetics for transformative applications across industries.

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