IOSR Journal of Applied Chemistry (IOSR-JAC)
e-ISSN: 2278-5736.Volume 12, Issue 1 Ser. I (January. 2019), PP 01-03
www.iosrjournals.org

An Introduction to Nanophotonics and its Various Applications

Vinod kumar Singh
Asstt. Prof. & Head Of Deptt. (Deptt. Of Chemistry)
Shivpati Postgraduate College, Shohratgarh, Siddharth Nagar
Affiliated to Siddharth University , Kapilvastu, Siddharth Nagar , U.P. (INDIA)
Corresponding Author: Vinod kumar Singh

Abstract: *Group III-nitride semiconductor materials especially AlGaN are key-emerging candidates for the advancement of ultraviolet (UV) photonic devices. Numerous nanophotonics approaches using nanostructures (e.g., nanowires, nanorods, and quantum dots/disks) and nanofabrication (e.g., substrate patterning, photonic crystals, nanogratings, and surface-plasmons) have been demonstrated to address the material growth challenges and to enhance the device efficiencies of photonic devices operating at UV wavelengths. Here, we review the progress of nanophotonics implementations using nanostructured interfaces and nanofabrication approaches for the group III-nitride semiconductors to realize efficient UV-based photonic devices. The existing challenges of nanophotonics applications are presented. This review aims to provide analysis of state-of-the-art nanophotonic approaches in advancing the UV-photonic devices based on group III-nitride semiconductors.*

Date of Submission: 27-12-2018 Date of acceptance: 13-01-2019

I. Introduction

Nanophotonics or **nano-optics** is the study of the behavior of light on the nanometer scale, and of the interaction of nanometer-scale objects with light. It is a branch of optics, optical engineering, electrical engineering, and nanotechnology. It often (but not exclusively) involves metallic components, which can transport and focus light via surface plasmon polaritons.

The term "nano-optics", just like the term "optics", usually refers to situations involving ultraviolet, visible, and near-infraredlight (free-space wavelengths from 300 to 1200 nanometers).

II. Principles

Plasmons and metal optics-

Metals are an effective way to confine light to far below the wavelength. This was originally used in radio and microwave engineering, where metal antennas and waveguides may be hundreds of times smaller than the free-space wavelength. For a similar reason, visible light can be confined to the nano-scale via nano-sized metal structures, such as nano-sized structures, tips, gaps, etc. This effect is somewhat analogous to a lightning rod, where the field concentrates at the tip.

This effect is fundamentally based on the fact that the permittivity of the metal is very large and negative. At very high frequencies (near and above the plasma frequency, usually ultraviolet), the permittivity of a metal is not so large, and the metal stops being useful for concentrating fields.

Many nano-optics designs look like common microwave or radiowave circuits, but shrunk down by a factor of 100,000 or more. After all, radiowaves, microwaves, and visible light are all electromagnetic radiation; they differ only in frequency. So other things equal, a microwave circuit shrunk down by a factor of 100,000 will behave the same way but at 100,000 times higher frequency. For example, researchers have made nano-optical Yagi-Uda antennas following essentially the same design as used for radio Yagi-Uda antennas.

Metallic parallel-plate waveguides (striplines), lumped-constant circuit elements such as inductance and capacitance (at visible light frequencies, the values of the latter being of the order of femtohenries and attofarads, respectively), and impedance-matching of dipole antennas to transmission lines, all familiar techniques at microwave frequencies, are some current areas of nanophotonics development. That said, there are a number of very important differences between nano-optics and scaled-down microwave circuits. For example, at optical frequency, metals behave much less like ideal conductors, and also exhibit interesting plasmon-related effects like kinetic inductance and surface plasmon resonance. Likewise, optical fields interact with semiconductors in a fundamentally different way than microwaves do.

III. Relaionship To Other Fields

Classical optics

Photonics is closely related to optics. Classical optics long preceded the discovery that light is quantized, when Albert Einstein famously explained the photoelectric effect in 1905. Optics tools include the refracting lens, the reflecting mirror, and various optical components and instruments developed throughout the 15th to 19th centuries. Key tenets of classical optics, such as Huygens Principle, developed in the 17th century, Maxwell's Equations and the wave equations, developed in the 19th, do not depend on quantum properties of light.

Modern optics

Photonics is related to quantum optics, optomechanics, electro-optics, optoelectronics and quantum electronics. However, each area has slightly different connotations by scientific and government communities and in the marketplace. Quantum optics often connotes fundamental research, whereas photonics is used to connote applied research and development.

The term photonics more specifically connotes:

- The particle properties of light,
- The potential of creating signal processing device technologies using photons,
- The practical application of optics, and
- An analogy to electronics.

The term optoelectronics connotes devices or circuits that comprise both electrical and optical functions, i.e., a thin-film semiconductor device. The term electro-optics came into earlier use and specifically encompasses nonlinear electrical-optical interactions applied, e.g., as bulk crystal modulators such as the Pockels cell, but also includes advanced imaging sensors.

Emerging fields

Photonics also relates to the emerging science of quantum information and quantum optics. Other emerging fields include:

- Optoacoustics or photoacoustic imaging where laser energy delivered into biological tissues will be absorbed and converted into heat, leading to ultrasonic emission.
- Optomechanics, which involves the study of the interaction between light and mechanical vibrations of mesoscopic or macroscopic objects;
- Opto-atomics, in which devices integrate both photonic and atomic devices for applications such as precision timekeeping, navigation, and metrology;
- Polaritonics, which differs from photonics in that the fundamental information carrier is a polariton. Polaritons are a mixture of photons and phonons, and operate in the range of frequencies from 300 gigahertz to approximately 10 terahertz.
- Programmable photonics, which studies the development of photonics circuit that can be reprogrammed to implement different function in the same fashion as an electronics FPGA

IV. Application

A sea mouse (Aphrodita aculeata), showing colorful spines, a remarkable example of photonic engineering by a living organism

Applications of photonics are ubiquitous. Included are all areas from everyday life to the most advanced science, e.g. light detection, telecommunications, information processing, photonic computing, lighting, metrology, spectroscopy, holography, medicine (surgery, vision correction, endoscopy, health monitoring), biophotonics, military technology, laser material processing, art diagnostics (involving InfraRed Reflectography, Xrays, UltraViolet fluorescence, XRF), agriculture, and robotics.

Just as applications of electronics have expanded dramatically since the first transistor was invented in 1948, the unique applications of photonics continue to emerge. Economically important applications for semiconductor photonic devices include optical data recording, fiber optic telecommunications, laser printing (based on xerography), displays, and optical pumping of high-power lasers. The potential applications of photonics are virtually unlimited and include chemical synthesis, medical diagnostics, on-chip data communication, laser defense, and fusion energy, to name several interesting additional examples.

- Consumer equipment: barcode scanner, printer, CD/DVD/Blu-ray devices, remote control devices
- Telecommunications: optical fiber communications, optical down converter to microwave
- Medicine: correction of poor eyesight, laser surgery, surgical endoscopy, tattoo removal
- Industrial manufacturing: the use of lasers for welding, drilling, cutting, and various methods of surface modification

- Construction: laser leveling, laser rangefinding, smart structures
- Aviation: photonic gyroscopes lacking mobile parts
- Military: IR sensors, command and control, navigation, search and rescue, mine laying and detection
- Entertainment: laser shows, beam effects, holographic art
- Information processing
- Metrology: time and frequency measurements, rangefinding
- Photonic computing: clock distribution and communication between computers, printed circuit boards, or within optoelectronic integrated circuits; in the future: quantum computing
- Microphotonics and nanophotonics usually includes photonic crystals and solid state devices.

References

[1]. Hewakuruppu, Y., et al., Plasmonic " pump – probe " method to study semi-transparent nanofluids Archived March 3, 2016, at the Wayback Machine., Applied Optics, 52(24):6041-6050

[2]. Assefa, Solomon; Xia, Fengnian; Vlasov, Yurii A. (2010). "Reinventing germanium avalanche photodetector for nanophotonic on-chip optical interconnects". Nature. **464** (7285): 80–4. Bibcode:2010Natur.464...80A. doi:10.1038/nature08813. PMID 20203606.

[3]. Jump up to:[a b] "Research Discovery By Ethiopian Scientist At IBM at Tadias Magazine". Tadias.com. Retrieved 2010-03-15.

[4]. "Avalanche photodetector breaks speed record". physicsworld.com. Retrieved 2010-03-15.

[5]. Themistoklis P. H. Sidiropoulos, Robert Röder, Sebastian Geburt, Ortwin Hess, Stefan A. Maier, Carsten Ronning, Rupert F. Oulton (2014). "Ultrafast plasmonic nanowire lasers near the surface plasmon frequency". Nature Physics. **10**: 870–876. Bibcode:2014NatPh..10..870S. doi:10.1038/nphys3103. Press release Archived December 25, 2016, at the Wayback Machine.

[6]. Hand, Aaron. "High-Index Lenses Push Immersion Beyond 32 nm".

[7]. Liang Pan et al. (2011). "Maskless Plasmonic Lithography at 22 nm Resolution". Scientific Reports. **1**.

Vinod kumar Singh" An Introduction to Nanophotonics and its Various Applications " IOSR Journal of Applied Chemistry (IOSR-JAC) 12.1 (2019): 01-03.