A TERA HERTZ GRAPHENE BASED ANTENNAS FOR INTERNET OF NANO THINGS

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Abstract: The Internet of Things has facilitated various types of objects, sensors, and devices to interact with each other through pervasive networks. An efficient health care monitoring is possible by collecting vital patient parameters and ensures their care through remote monitoring system using internet of Things. The advances in the field of nano technology have led to the invention of many novel materials which has the capability of sensing the data at nano scale. These smart nano sensors can be used for collecting the patient data such as pulse rates, etc., and environmental data related to pathogens and allergens. These devices connected through internet of things can accurately diagnose and monitor patient's health. The IoNT concept was introduced by Ian Akyildiz and Josep Jornet, who has given the architecture for electromagnetic (EM) Nano device communication, including channel modeling, information encoding, and protocols. And this communication was based on graphene based Tera hertz antennas. This paper reviews the general architecture of Internet of nano things and also the possibilities of Tera hertz graphene based antennas to be used for nano communication in near future. And also reports the use of chemically sensitive graphene Field Effect Transistor device that directly modulates a radio frequency (RF) electrical carrier signal when exposed to chemical agents, with a memory effect in its electrochemical history.

***Index terms*: Nano things, Graphene, antennas, FET**

Introduction: As Figure 1 shows, IoNT includes Nano scale networks connecting a many of Nano sensors, devices that interact with the Nano networks and process their information. There are many types of nano communication proposed by researchers here the two most practical communication approaches are considered they are *molecular communication* and *EM communication* (I.F. Akyildiz et al, 2008)· EM communication: In this communication each device would of size from 2 to 6 micrometers. The components—including antennas, EM transceivers, and processors—would all be built at nano scale (I.F. Akyildiz and J.M. Jornet, 2010). The antennas would likely be built from graphene materials and communicate in the THz band (I.F. Akyildiz and J.M. Jornet, 2010). Akyildiz et al. proposes an electromagnetic communication for the IoNT networks in intra body Nano networks for remote healthcare and the interconnected office. The network architecture composes of nano-nodes, nano-routers, nano machines such as nano sensors and nano actuators which implanted in the human body provider the healthcare provider remote accessibility and controlling these nano devices through nano micro interface devices (L.C. Cobo and I.F. Akyildiz, 2010). The interconnected office architecture supports single element with nano transceiver which facilitates permanent connection to the internet. However, each nano network has fundamentals components in the network architecture of the Internet of Nano-Things as following (I.F. Akyildiz and J.M. Jornet, 2010).

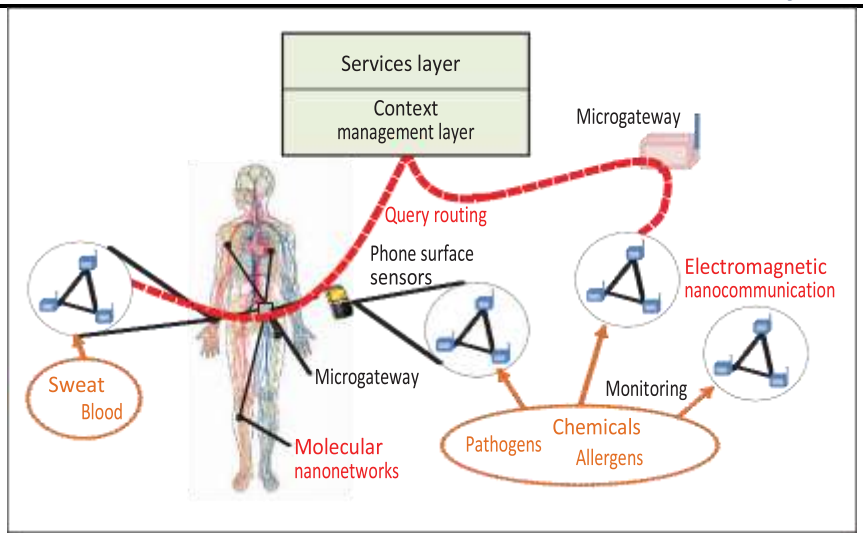


Figure 1. The Internet of Nano Things. The envisioned IoNT includes underlying Nano scale networks connecting a multitude of nano sensors, devices that interact with the Nano networks and process their information in a distributed manner, and context and service management systems.

Components of Internet of Nano things:

Nano Nodes: Nano nodes are the nano machines in the nano network architecture that performs simple computation tasks assigned to them. The limitation in their communication capabilities and consumption energy, allows them to transmit for short range distances. Nano nodes can be deployed in things such as books, keys, paper folders, or inside the human body as biological nano sensor nodes.

Nano Routers: Nano routers collects the information coming from nano machines. The nano routers controls the nano nodes through some specific commands such as on/off switching, read value, sleep, etc.

Nano-micro Interface Devices: Nano-micro interface devices acts as transceiver which enables the work of receiving/sending the information coming from nano routers to the micro scale device or system and vice versa. Nano-micro interface devices are the hybrid devices able to communicate in the nano scale using the classical communication paradigms in conventional communication networks and new communication paradigm for nano devices network.

Gateway: Gate way provides the remote connection of the entire system over the Internet. For example, in a patient monitoring network, a cellphone forwards the received information from nano-micro interface device to the health care provider. It works very similar to Modem router in conventional networks.

Internet of Nano-Things demands the redesign and development of new communication paradigms and networking concepts that will be compatible for nano scale machines. The IoNT puts forth many challenges in the physical layer of nano machines to the nano networking protocols.

Graphene based antennas for Nano-transceivers:

The operating frequency band of Nano antennas in Nano communication faces many opportunities and challenges. These antennas used with Nano transceiver are predicted to be fabricated using novel material such as Graphene (I.F. Akyildiz and J.M. Jornet, 2010). In particular, Lin et al. found that a 1 µm long Graphene-based nano antenna built either by graphene nano ribbon (GNR) or carbon nanotube (CNT) produces EM signals in Tera Hertz range as demanded by the antennas in Nano communication networks using Graphene FET (I.F. Akyildiz and J.M. Jornet, 2010).

Graphene being the novel material of the decade exhibits attractive electrical, electronic and mechanical properties. The coupling of these properties of Graphene with the CMOS devices promises many useful devices for wireless nano communication networks. One such graphene patch antenna with low noise and high speed communication are reported by Rajni bala et al. The carrier concentration and chemical potential in graphene based antennas can be adjusted through bias voltage which tunes the characteristics of these devices which makes it highly suitable for high speed applications. Rajni bala et al reports edge fed micro strip line graphene based rectangular patch antenna operating at 2.67-2.92 THz with silicon nitride being used as substrate material. The performance of graphene antenna is

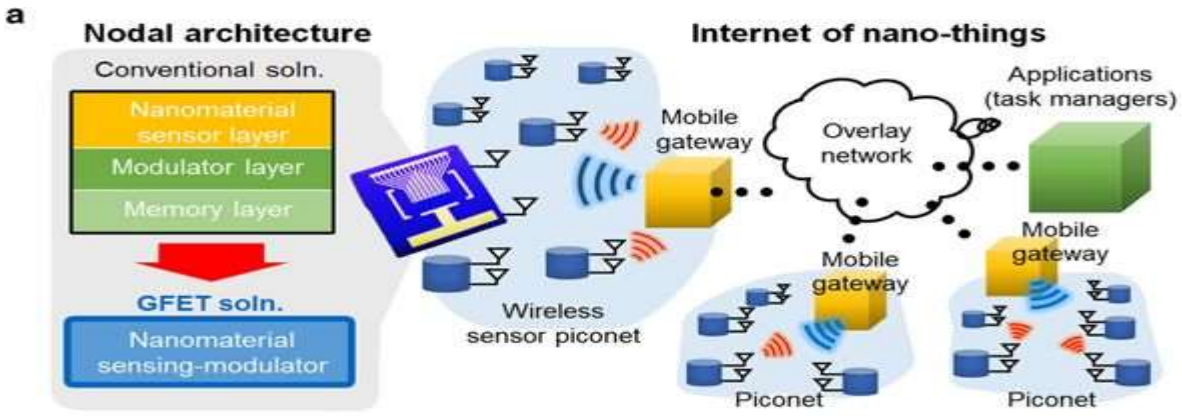
investigated on the basis of return loss, voltage standing wave ratio, absorption cross section, and band width and radiation efficiency (Rajni Bala, Anupama Marwaha, 2016).

Graphene based Nano Modulators:

Haiyu Huang et al reports novel paradigm for nano sensing modulators: A graphene field-effect transistor device is used to directly modulate a radio frequency (RF) carrier signal when exposed to chemical agents, with a memory effect in its electrochemical history. Haiyu Huang et al also reports the graphene-based sensing Frequency modulator capable of achieving modulation in a cycle consisting of alternating phases of air exposure and ethanol or water treatment (Haiyu Huang et al, 2016).

Mixed modulation concept based on the chemical gating of graphene reported by Haiyu Huang et al

Figure 2b illustrates the basic operation principle of the proposed device: the carrier signal is a single-tone sinusoidal (RF) wave applied at the back gate of a GFET, which is compatible with high-speed tera hertz nano communication systems. Under a given drain bias, the output drain current waveform consists of harmonic frequency components are modulated by the chemical gating. The adsorption of p-type substances (for example, oxidizer-type gas molecules) will cause a gradual decrease in the amplitude of both tones at the output. By contrast, the adsorption of n-type substances (for example, electron-donor-type chemical agents) will cause gradual increase in the amplitudes of both the tones at the output, restoring it to its original condition. These two phases forming a complete chemical modulation cycle can be utilized for sensing and for the neutralization of the sensor. For instance, in the sensing of oxidizing materials, materials with abundant electron donors may be used to reset the sensor. Similarly, in the sensing of electron-donating materials, an oxidizing material may serve as the reset agent.



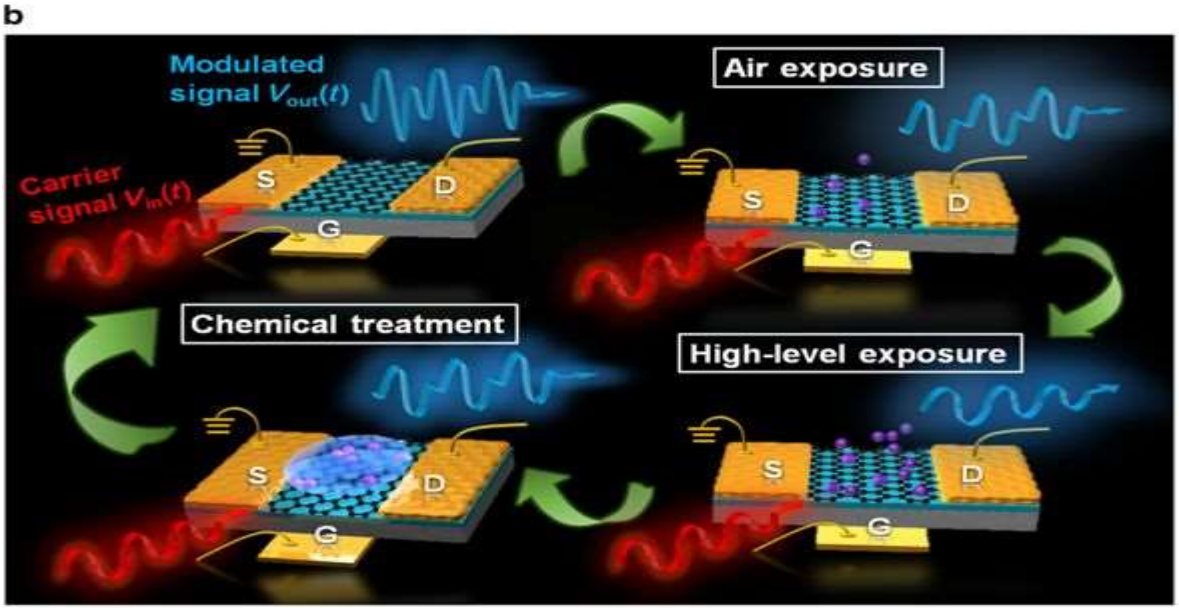


Figure 2: (**a**) the nodal architecture of an Internet of Nano Things consisting of nanomaterial sensing modulators. (**b**) Conceptual illustration of the chemical gating modulation of a single graphene device, in which a high-frequency input carrier signal is applied at the back gate without any DC gate bias and the modulated output at the drain varies throughout a modulation cycle consisting of alternating phases of gas exposure and wet chemical treatment.

Conclusion:

Nanotechnology has proposed many novel approaches in solving a wide variety of problems, especially in the manufacturing and healthcare domains. The researchers are coming with nano devices based on novel material embedded in the environment to support nano communication networks to envision internet of nano things. The more promising new communication paradigms between nano device and also between nano and micro devices used on a daily basis can be realized in near future.

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