Optoelectronics and Piezo-photoronics

S.S.Manaktala, K.M.Singh

Abstract— Technology which acts as an interface between machine/ human ambient and CMOS technology is the call of time. To achieve these goals piezoelectric Nano devices and integrated systems can be combined together .When external deformation is applied to a piezoelectric semiconductor then it gives rise to piezopotential there by making scope for its implementation in various fields. In other words it can be said piezopotential is a strain induced ionic polarization in piezoelectric strain induced crystal.Pizotronics deals with devices using pizeopotential. When pizeotronics is applied to optoelectronics it is known as pizeophotronics.Pizeophotoronics Performance of optoelectronics device can be optimised through the application of piezo potential and recombination and transport of charge carriers of optoelectronic devices. This paper reviews the concept of pizeotronics and pizeo potoronics and its application in the field like nanowires, nanogenerators and photoanodes etc.

Keywords— piezotroniceffect, piezo-phototronic effect, piezopotential, piezotronics, nanogenertaors, photoanodes

1.INTRODUCTION

Prior researches topics were seldom self dependent electrical mechanical coupling effect in piezotronic systems. The pieztronic devices were studied considering constant elastic modulus without size dependency mechanical properties. While modeling of electronic devices using finite element method it was observed that the mechanical and electrical properties interfered piezo electronic applications. This proved to be fruitful for designing high performance piezotronic nanodevices with proper scaling. [10]
Optoelectronics when electrostatic bias is applied then dynamic manipulation of electronic and optical processes is possible. But wearable optoelectronic devices require functional optoelectronics to be directly regulated by mechanical inputs from their environment . The local band structure and resultant band alignment is related by strain inducedpolarization.[10]

Direct interface between mechanical actions using silica and electronics is not possible without using innovative technique. Earlier signals from strain sensitive transducers could not Performance of electronic components adversely affected by strain induced due to material used. This can be minimized by application of control over silicon electronics strain induced by the substrate on operations of the electronic components. Deformation induced electrical sign als was the buzzword , to control Silicon based electronic. This led to the development of piezotronic and piezo phototronics which led to the development of electronic controlling signals using mechanical actions.[8]

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2. PIEZOTRONICS

To make applications based on semiconductor devices it is important to grasp interfacing and device behavior. This can be understood by example of optoelectronics where device behavior is mostly is influenced by band structure and the final band alignment.[6]

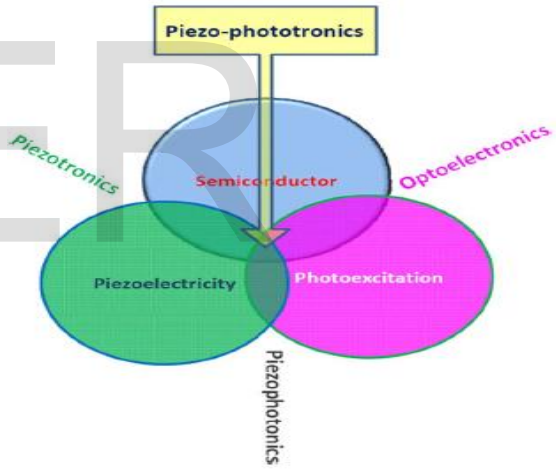

Figure 1: Novel areas of research and piezotronics and piezo-photoronics examples .[10]

Modulation of band structure and its interfacing is possible fabricating the electron transport properties by providing stimulation through external resurce.Thus a lot more research is desired in this novel semiconductor nanodevices field.[7]

3 PIEZOTRONICS IN 1D NANOMAERIALS

This application of piezoelectronics has altered the way gate voltage of quantum piezotronic transistor is influenced by Piezo- electric effect and electrical current fluctuates when Gate voltage reaches threshold owing to Quantum tunneling resonance. The results have shown deep research

scope between Piezo electric polarization and electrons along with design limitation of next-generation quantum is piezo-tronic devices.[10]

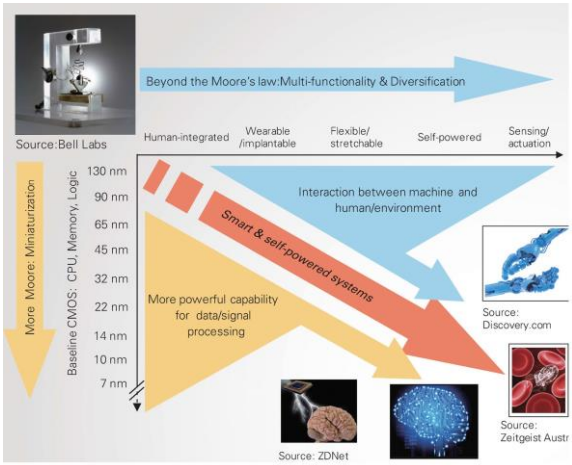

Figure2: Perspective of electronics technology beyond Moore's law. The vertical axis represents the miniaturization of device dimension and the increase of integrated device density for more powerful data/signal processing. The horizontal axis represents the diversification and integration of device functionality for novel applications, such as wearable/implantable human-integrated electronics and self-powered technology for sensing and actuation. The future of electronics is an integration of more powerful data processing and more integrated functionalities. Adapted from [10].

Pieziotronic effect is different from piezoresistive effect in that that it results from change in band gap, charge carrier density, for density of States in conduction band of strained semiconductor material. On the other hand pieziotronic effect is a consequence of polarization of non mobile ions in crystal. Therefore piezoresistive effect is symmetric volume effect without polarity
Whereas piezotronic effect is asymmetric volume and can change polarity as in the case of nanogenerator.

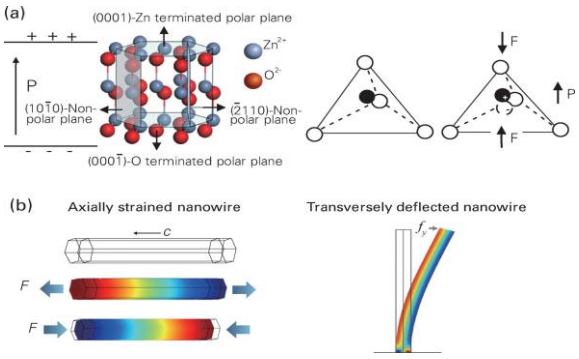

Figure 3: Piezopotential in a wurtzite crystal.[10]

Stop hidden polarity of Piezio potential a piezotronic transistor depends on local stress of force resulting in direct control over local schottky barrier height and hence corresponding transport characteristics of piezo transistor by induced strain.[9]
Materials lacking inversion symmetry the electromechanical coupling/ interaction is obtained by variations of applied pressure/ stress. Such materials which produce electrical potential upon variation of applied pressure/ stress are known as piezoelectric materials and electricity thus generated in numerous materials can widely be used for effective mechanical sensing actuating and energy harvesting .It is also used for electrically insulating and hence is less useful for building electronic devices .Due to its brittle nature it has imposed issues on
Understanding it as a trustworthy and persisting for long duration thus restricting its biomedical application . reliability durability and long term sustainability thereby On other hand materials wurtzite –structured semiconductor materials like Zno, GaN, IaN and CdS also posses electric properties not popular in electric sensors and actuators because of their comparatively small piezoelectric coefficient. [5]

4 NANOSENSORS ENHANCED BY THE PIEZOTRONIC EFFECT

Array of flexible pressure sensors are used in tactile sensing capabilities of human skin these sensors consists of traditional planer field effect transistors which act as read-out elements for detecting pressure-induced property changes in pressure sensitive media. The scheme of pressure sensing is achieved by complicated system of integration of heterogeneous components. This phenomena lacks direct and active interfacing between electronics and mechanical actuations

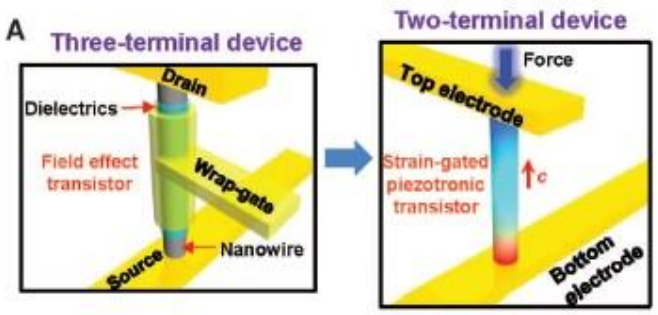

Figure 4:Device transformation as piezotronic transistor[8]

. Moreover it is very difficult to fabricate gate electrode and to control the device with high density metrics.[4]

5 PIEZOPHOTONICS IN PHOTODETECTORS

The other application of piezo phototronics is photoanodes.

Recently by physically deflecting the photoanode the photo current density changes as a consequence of hetro junction piezophotronic effect. This has been termed as oxygen evolution reaction . In This case the charges at the junction drive additional photo excited careers towards the interface for the OER. In future business to earn more in new route for improving the performance of inexpensive catalyst for solar fuel production.[10]

6 PIEZOPHOTONICS FOR ACTIVE OPTOELECTRONICS

These transistors/ strain gated transistors used as pieziotronic logic devices to perform stations for information carried by mechanical stimulus.Strain induced Charge Carriers generation separation and recombination can be easily controlled through application of appropriate potential in optoelectronic devices built from is piezo electric semiconductors. The coupling among piezoelectricity properties and optical process is referred to as

7 NANOWIRES AND NANOGENERATOR

Generation of electricity due to change of pressure is known as piezoelectricity. Nanogenerator is a device for converting mechanical energy into electricity. A nanogenerator a strained electric crystal is connected at its two polar ends with electric load. This generates a potential which in turn creates a drop in Fermi levels at the to contact ends of the strained electric crystal thereby resulting in the free flow of electrons from one side to the other to reach a new equilibrium thereby generating current in the load. The alternating flow of electrons is achieved if dynamic stress is applied across the Crystal. The nanogenerator gives continuous output power when applied stresses is wearing. Nanogenerator mainly finds its use in output power to drive a LCD, LED and laser diode.It also plays an important role in energy harvesting proving it to be self sufficient power source for micro/ nanosystems.[3]

In a nanogenerator the working is accentuated as a result of the flow of electrons in the external load materials when they are subjected to mechanical deformation. The distribution of Piezo potential is classified based on two typical configurations of nanowire devices first the Traversly deflected nanowires and second the axially strained nanowires . Travesty deflected nanowires are generally utilised in energy harvesting applications on the other hand Nanowires which are axially strained are suitable for piezotronic applications using flexible substrate. Efficiency of solar cell aur LED can we significantly improved with application of piezotronics in charging and recombination of charge carriers.[3]

8.PIEZOPHOTONICS IN LED LUMINESCENCE APPLICATION

While considering light illumination Piezo electricity behaviour induces coupling and electronic semiconductor material shows excellent photoexcitation characteristics of semiconductors are considered together. In such cases even Piezoelectric polarization capable of controlling and changing the mechanism of charge carrier generation , separation and transportation at junction of superior optoelectronics. Electrostatic equations, current density equations, continuity equation and piezoelectric equations are the basis of characterizing piezo phototronicdevices.[1],[2]

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