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Recent Advances On Electronic Band Structure Of Group Semiconductors

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ABSTRACT:

A modest periodic potential disrupted the free theory and caused bands to develop in the "nearly free electron" model. The characteristics of genuine metals can only be understood by studying their band structure. The free-electron model, however, is unable to account for the variances between elements. In this article, recent advances on electronic band structure of group semiconductors were highlighted.

Keywords: Electronic, Band, Structure, Semiconductors

INTRODUCTION:

Metals can be explained by Summerfield's free electron model, which we examined. According to this theory, electrons in metals may move about freely inside the metal like particles in a box, at least up to a first approximation. This is an example of a free-electron gas since these electrons are fermions. The predictions made by the free electron gas are rather accurate. Fermi energies for metals are predicted to be in the 10 eV region, while Fermi temperatures are predicted to be in the 50,000 K range. Metals are extremely degenerate with just a few states that can be excited at ambient temperature. The heat capacity of electrons in metals is linear in T, as shown by means of the free electron model. For CV at low T, electrons dominate, whereas at high T, electrons' contribution is minimal. Predictions of low temperatures are in line with evidence, whereas predictions of high temperatures show why the electronic component in Dulong and Petit's law may be disregarded. Also, the free electron model accurately predicts metals' bulk modulus. A different way to talk about features of degenerate Fermi gases than by describing all energy levels as excitations of the ground state is to talk about excitations above Fermi level "F and excited states as holes below Fermi level "F," which we discovered when estimating metal heat capacity.

REVIEW OF LITERATURE:

PRACHICHOPADE ET AL (2022) Nanoscale research is now focusing on the development of high-quality nanocrystals that might be used in real-world applications. Because of their optical, optoelectronic, and piezoelectric capabilities, inorganic semiconducting materials have become more popular. Group II–VI direct bandgap semiconducting semiconductor cadmium selenide (CdSe) is essential. Bandgaps for CdSe are 1.797 and 1.712 eV for wurtzite (hexagonal) and zinc blende (cubic) crystal phases respectively. The broad bandgap of CdSe facilitates the absorption throughout the wide range of visible spectrum. CdSe is a promising candidate for a wide range of applications, including photodetectors, field-emitters, solar cells, field-effect transistors, light-emitting diodes, biosensors, biomedical imaging, catalysis, and memory devices, because of its size and shape-dependent properties and flexible processing methods. CdSe nanostructures' material characteristics, as well as the ways in which they are influenced by variables including size, shape and crystal structure, are discussed in this chapter. Nanostructures of CdSe have been greatly improved by modern synthesis techniques, which have helped to adjust their characteristics beyond the use of confinement inducing and size-tunable regimes. Here, chemical, physical, and biological techniques of synthesis have been addressed in depth. The development of CdSe nanostructure-based devices for numerous upcoming applications has also been examined. There have also been discussions on important elements affecting device performance and the difficulties associated with this line of study.

M. WEŁNA ET AL (2022) The low temperature emission characteristics of ZnSeO alloys were studied in depth using photoluminescence, micro-photoluminescence, and time-resolved photoluminescence, as described below.. We demonstrate that the wide photoluminescence spectrum of ZnSeO at low temperatures, which has been ascribed to the recombination of localised excitons, is formed of crisp lines according to specific trapping conditions. The process of nonradiative recombination in ZnSeO alloys is explained using investigations of photoluminescence thermal quenching from individual trapping states and photoluminescence dynamics. The Stokes shift at low temperatures decreases with increasing oxygen concentration, which is contrary to what has previously been found for GaAs-based highly mismatched alloys. It is hypothesised that this impact has a biological basis.

DAVID O. SCANLON ET AL (2022) Electronic characteristics may be enhanced by modulating the bandgap of In_2O_3. X-ray photoemission spectroscopy on ceramic surfaces confirms that a narrowing of the band gap is seen, as we show using ab initio calculations. To ensure that the doped thin films keep their optical transparency in the visible range while simultaneously decreasing the effective mass of the conduction band, the incorporation of Tl was used. In_2O_3's dopability and carrier mobility might be improved by Tl-doping, according to our calculations. EPSRC-funded Center for Innovation (EP/K000144/1 and

EP/K000136/1), UCL Legion HPC Facility, and HECToR supercomputer were all used in this study. The latter was made possible by participation in the UK's HPC Materials Chemistry Consortium and an EPSRC grant (EP/F067496). TCHPC's Kelvin supercomputer was used for the Dublin research, which was funded by SFI under the PI programme (PI Grant Nos 06/IN.1/I92/EC07 and 06/IN.1/I92/EC07). The EPSRC "Access to Research Equipment Initiative: Cardiff XPS" (Grant No. EP/F019823/1) provided funding for the X-ray photoelectron spectroscopy.

NADEEM AHMED AND FARAZ AHMED INAM (2022) One of the most promising new approaches to quantum emitter enhancement and directionality is based on hyperbolic metamaterials (HMMs). High-k hyperbolic modes are provided by HMM for radiation produced by a quantum emitter contained inside the HMM. In order to overcome the huge mismatch between free-space modes and high-momentum hyperbolic HMM modes, an antenna is used. Cylindrical metallic antennas have recently been shown to be the most successful in resolving this momentum mismatch problem. What we're interested in here is the free-space out-coupling of emission from a quantum emitter implanted within the HMM, with a cylindrical plasmonic antenna on the HMM's top surface (or wavelength). To make it work with a cylindrical antenna, researchers discovered that HMM mode hyperbolicity increases with increasing emission wavelength. However, the plasmonic cylindrical antenna's absorption cross section was shown to be considerable at high excitation wavelengths. As a result of the plasmonic antenna's higher radiation losses, the coupled system's collection and quantum efficiency suffer. The highest collection and quantum efficiency of the HMM linked cylindrical plasmonic antenna were found to exhibit a Gaussian envelope type profile, with a peak performance in the region of 1000–1100 nm.

UNNIKRISHNAN ET AL (2022) In the past few years, there has been a dramatic rise in research into the use of TMDs as semiconductors. As a TMD, MoS2 has received much attention for its exceptional properties, such as its ability to go from an in-band to an out-of-band band gap with a change in size. Optoelectronics and flexible electronics have benefited from MoS2's capacity to change its electrical and dielectric characteristics by changing its layer thickness, mechanical strain, and other variables. The characteristics and uses of MoS2's three phases vary widely. Novel materials and synthesis processes with custom-tailored qualities are discussed in detail in this chapter. In addition, we address the physical, electrical, and optical features of MoS2. Among other things, it explains how semiconductors may be used in electronics/optoelectronics, batteries, supercapacitors, photovoltaic cells, photocatalysis, and sensing platforms. Finally, we look at the MoS2's potential and limitations in light of the most recent research.

ASHISHTIWARI ET AL (2022) Nanoparticles made from metal sulphide semiconductors have been widely studied by scientists because of their potential use in nanoscale systems.

Light-sensitive systems are affected significantly by nanoscale silver sulphide (Ag2S). For the purposes of this chapter, we'll look at how Ag2S semiconducting nanoscale compounds provide a varied spectrum of nanostructures and have distinct chemical/physical/electronic phenomena. To put it another way, little is known about how Ag2S nanostructures arise. The characteristics of charge carriers in nanoscale compounds will also be discussed, as well as how to manage and produce different morphologies in Ag2S nanostructures We'll go through all of the many ways to make Ag2S nanostructures, heterostructures, and hybrids in great detail. Ag2S nanoscale compounds' chemical, physical, and optical characteristics will be discussed in detail, as well as recent improvements. It is time to look at some of the most exciting uses for photocatalysis and other related technologies in varied fields such as biophotonics and photocatalysis.

PRAGATIKUMAR (2022) For NIR and infrared optoelectronics, solution processed PbSe colloidal quantum dots (CQDs) are unbeatable. They are able to generate ultra-efficient multiple exciton systems for single photon absorption and size-tunable inter- and intraband transitions experimentally because of their tiny band gap and unique electronic structure. The focus of this chapter is on efficient PbSe CQDs, beginning with a short introduction to the material and progressing through a variety of synthesis approaches used throughout time. There will be separate subsections for discussing the crucial role played by surface treatments and ligand exchange in the synthesis process for CQD emission, electrical and electronic characteristics. First, we'll examine the as-synthesised CQDs' characterisation and characteristics, and then we'll look at the variables that influence those qualities, both of which will inform us about the problems and provide us with solutions. PbSe CQDs' strength in different NIR optoelectronic devices is discussed in the last part, which covers everything from device manufacturing to performance, as well as obstacles and the field's future potential.

R. RAKESHKUMAR ET AL (2022) A lot of research is being done on nanocomposites of oxide materials, which may find use as photocatalysts, lasers and light emitting diodes, among other things. As an added benefit, nanocomposites open up new fields of use and revenue prospects. ZnO–TiO_2 nanocomposites are among the most promising oxide nanocomposites because of the unique properties of ZnO and TiO_2. ZnO and TiO2 have comparable bandgaps, however ZnO is less expensive, nontoxic, ecofriendly, and has better chemical and thermal stability. We describe the synthesis and characterisation of several ZnO–TiO_2 nanocomposites, including core–shell, coaxial and heterostructure nanocomposites, as well as heterojunctions and urchin-like nanocomposites. At the conclusion of the chapter, the prospective uses and problems of ZnO–TiO_2 nanocomposites in optoelectronics are discussed.

GAJENDRA KUMARINWATI ET AL (2022) Optical, electrical, sensing, and catalytic characteristics of semiconducting nanoparticles are also discussed in this chapter, as are their applications in advanced material sciences and nanotechnology. Because of their regulated shape and various chemical compositions, functionalized semiconductors have recently been acknowledged as a vital tool with improved processing. A variety of elements have been added to metal oxides like SiO_2 and WO_3 to create a new generation of semiconductors, such as SiZnO, CuO, Y_2O_3, and ZrO_2. The doping (codoping) of metals and ions in semiconductors has been used to alter their work functions and performance. As a result, we have presented an overview of semiconducting materials with specific transitional and rare earth element dopings in order to promote their amazing properties. As an added bonus, new articles claim to have described an efficient synthesis method for hybrid semiconductors, as well as the characterisation of these materials and their unique chemical compositions. For the development of efficient solar cells, light emitting diodes, biomedical, and photocatalytic applications, we have addressed a variety of selective metal-doped semiconducting nanostructures and their defects chemistry.

SONAL P. GHAWADE ET AL (2022) We can't imagine our everyday lives without the advancements made possible by science and technology, which have permeated every facet of our existence. In recent years, nanoscience and nanotechnology have developed rapidly. Many researchers and practitioners believe that nanomaterials hold enormous promise for a variety of future endeavours. Zinc sulphide is the substance in which we are primarily interested (ZnS). In solar energy conversion, light-emitting diode, photocatalysis, emission, fuel cells, and so on, it's a crucial semiconductor material. Comparison of fluorescence enhancement properties between ZnS nanocomposites and pure ZnS. Nanoparticles, their production and characteristics, and a comprehensive review of the literature on semiconductor nanoparticles are all covered in length in this chapter. In addition to its optical, mechanical, electrical and thermal capabilities, Graphene is an emerging star in the field. Adding graphene to ZnS semiconductors allows us to fine-tune their characteristics.

VIJAY B. PAWADE ET AL (2022) Nanocrystals made of graphene have recently shown key properties such as band gap tuning, effective light harvesting and stable properties that are critical for the manufacture of light emitting diodes, photovoltaic devices and other types of devices that use semiconductors. Thus, the usage of graphene and semiconductor nanocrystals composite architectures improves their electrical and optical characteristics with nanoscale semiconductor structures. This means that the creation of brand-new graphene-based semiconductors needs an understanding of the fundamental characteristics of materials based on the impacts of size and shape, which may be valuable in developing novel devices with unique features and functionalities for a variety of applications. The introduction of graphene into optoelectronics devices and its features, as well as a full

examination of numerous kinds of graphene-based semiconductor materials and their device performance, are the main topics covered in this chapter.

PROMODKUMAR ET AL (2022) Graphene-based semiconducting nanocomposites for environmental remediation are the focus of this chapter, which provides an overview of recent breakthroughs in their manufacture and use. There has been a surge in interest in graphene, a two-dimensional carbon allotrope whose unusual structure, physicochemical qualities, and large specific surface area have made it an international scientific sensation. In current science and technology, they have a wide range of applications because of their exceptional qualities. Graphene is regarded an efficient cocatalyst for semiconductor photocatalysts because of its outstanding electron mobility and high specific surface area. The semiconductor photocatalysts and their surface morphologies are largely responsible for photocatalyst performance. Multifunctional graphene-based semiconducting nanomaterials composite is discussed in detail here in terms of production, characterisation, and potential environmental applications. To address environmental challenges such as organic pollutants, heavy metal ion removal, and antibacterial applications, graphene-based semiconductor nanocomposites are examined in this chapter. In the end, the current difficulties and future potential are examined.

JAN KOPACZEK ET AL (2021) Using both experimental and theoretical approaches, we examine how the electrical band structure of the Mo1–xWxSe2 alloy with tungsten content changes over time. It was possible to see both direct and indirect transitions at high and beyond high-symmetry points of the Brillouin zone by using spectroscopic methods such as photoreflectance, photoacoustic spectroscopy, and photoluminescence (BZ). These two excitons (A and B) were seen in conjunction with additional optical transitions (C and D) linked with the band nesting process. In addition, we were able to locate the crystals' indirect transition. All transition energies were monitored with tungsten content and compared to density functional theory computations. In addition, optical transitions were allocated to distinct BZ areas based on the aforementioned comparison. To conclude, we have determined the bowing parameters for features that were seen in thin-film samples: b(A) = 0.13 eV, and the bowing parameters for features that were observed in thin-film samples are as follows.

ARCHIT DHINGRA ET AL (2021) Various 5d iridates (iridium oxides) were compared in this review to see whether there were any commonalities or variances in their electrical structures. An angle-resolved photoemission spectroscopy (ARPES) study and first-principles band structure computations have been presented in detail. ' In this way, it is clear that the electronic structures and magnetic characteristics of the high-Z 5d transition iridates are determined by the complex interaction of strong electron correlation, strong (relativistic) spin–orbit coupling and lattice distortion. According to the dimensionality

crossover, at the thin film limit, $SrIrO_3$ has a metal–insulator transition that looks like that of bulk Sr_2IrO_4.

JUAN ARTURO ALANIS, ET AL (2021) A vertical cavity semiconductor optical amplifier (VCSOA) based photonic synaptic element is described in this study, which uses brief (150 ps-long) and low-energy (W peak power) light pulses. Our technology allows comprehensive weight tuning of sub-ns input light pulses by using VCSOA nonlinear gain capabilities when exposed to external optical injection. Applied weight factors >1 are one further feature of the VCSOA-based synapse that allows it to fine-tune the intensity of incoming optical pulses. This basic technique, however, enables weight tweaking at high speeds (ns rates) with up to an 11.6-bit accuracy, which we demonstrate. Commercially available and affordable vertical cavity surface emitting lasers are used to achieve these findings at the major telecom wavelengths of 1300 and 1550 nm, making our technique compatible with optical network and data centre technologies. Photonic synaptic linkages using this VCSOA-based technology have a great potential for usage in future neuromorphic optical devices since it is hardware friendly while also being low-energy and fast.

CARNEMOLLA, E. G., ET AL (2021) Operating in the NZI domain, when the true refractive index of the system under examination approaches zero, may greatly amplify optical nonlinearities. In this study, we establish the existence of semi-degenerate four-wave mixing (FWM) in aluminium zinc oxide thin films, which produces radiation that can be tuned in the visible spectrum. A visible idler wave (530–620 nm) was generated using an intensive pump (787 nm) and a seed adjustable in the NIR window (1100–1500 nm). A signal-to-pump detuning of 360 nm has been seen in experiments, which demonstrate a 2% improvement in frequency conversion efficiency. The pump-to-signal time delay has also been used to show effective idler wavelength adjustment.

MD. ABDUL MOMIN, MD. AMINUL ISLAM, ABHIJIT MAJUMDAR (2021) ZnS quantum dot (QD) fluorescence tunability following efficient doping of transition metal iron (Fe) has been investigated in this article. Local density approximation in a density functional theory framework has been used to optimise the structural, electrical, and optical characteristics of Fe doped ZnS QDs and pure ZnS QDs. For both the doped and un-doped systems, the optimised lattice volumes demonstrate a satisfactory agreement with previously acquired experimental and theoretical data. In contrast to the pure system, the crystal structure changes from cubic to tetragonal when Fe is doped into ZnS, and the band gap narrows to a negative value. In addition, the absorption peak extends from the ultraviolet to the blue (visible) spectrum, with a low-intensity peak observable in the infrared. Detection of virus-like SARS CoV-2 might benefit from an improvement in fluorescence capability as a consequence of our studies.

SIMASAEIDI VARNOOSFADERANI ET AL (2021) The magnetic characteristics of thin-film multilayer devices are influenced by the structure and chemical roughness of the interfaces. The use of low-dose ion-beam irradiation to manipulate the topology of buried interfaces without altering their morphology has seen a spike of attention over the last two decades, with the goal of controlling the magnetic characteristics of multilayer heterostructures as a result. In the recent past, intriguing achievements in the newly developing field of spin-orbitronics have piqued interest in this area. Ion beam irradiation's potential for modifying thin-film heterostructures' magnetic characteristics is examined in this chapter.

KO-WEILIN ET AL (2021) Deposition and alteration of microstructure, composition and magnetic properties of thin films may be achieved by using low- and high-energy oxygen ion-beam assisted deposition and oxygen ion implantation. For example, atomic force microscopy, XRD, electron energy loss, transmission electron microscopy (TEM), and SQUID magnetometry are used to characterise five sample model systems. These technologies are all state of the art. For example, in nanostructured Fe/Cu thin films, by adjusting the proportion of interfacial Fe-Cu alloy, the temperature of magnetic ordering and the type of the dynamical freezing processes of nanocrystallites have been controlled using this technique. When the interface roughness was decreased and the interface texture was modified to a striped arrangement, the exchange coupling was improved in NiFe/NiO bilayers. As Co thickness was lowered, the magnetic anisotropy of [Pt/Co]/NiO multilayers could be recognized as emanating from mixed CoPt phases caused by negative heat of mixing. When ion implantation was used to change Mn to MnO in Mn/NiFe thin films, the magnetic characteristics of the films were altered.

CONCLUSION:

Using the tight-binding paradigm, we are look at semiconductors, one of the most significant technical advances of the twentieth century. Every facet of modern life is made possible by semiconductors, which enable very energy-efficient and powerful computers. The tight-binding model's band image helps us comprehend how PN junctions and transistors function, and then we go on to talk about how transistors lead to computers.

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