Preface

With the advent of modern quantized structures in one, two, and three dimensions (such as quantum wells, nipi structures, inversion and accumulation layers, quantum well superlattices, carbon nanotubes, quantum wires, quantum wire superlattices, quantum dots, magneto inversion and accumulation layers, quantum dot superlattices, etc.), there has been a considerable interest to investigate the different physical properties of not only such low-dimensional systems but also the different nanodevices made from them and they unfold new physics and related mathematics in the whole realm of solid state sciences in general. Such quantum-confined systems find applications in resonant tunneling diodes, quantum registers, quantum switches, quantum sensors, quantum logic gates, quantum well and quantum wire transistors, quantum cascade lasers, high-resolution terahertz spectroscopy, single electron/molecule electronics, nanotube-based diodes, and other nanoscale devices.

At field strengths of the order of 10^8 V/m (below the electrical breakdown), the potential barriers at the surfaces of different materials usually become very thin resulting in field emission of the electrons due to the tunnel effect. With the advent of Fowler–Nordheim field emission (FNFE) in 1928 [1, 2], the same has been extensively studied under various physical conditions with the availability of a wide range of materials and with the facility for controlling the different energy band constants under different physical conditions and also finds wide applications in solid state and related sciences [3–39]. It appears from the detailed survey of almost the whole spectrum of the literature in this particular aspect that the available monographs, hand books, and review articles on field emission from different important semiconductors and their quantum-confined counterparts have not included any detailed investigations on the FNFE from such systems having various band structures under different physical conditions.

The research group of A.N. Chakravarti [38, 39] has shown that the FNFE from different semiconductors depends on the density of states function (DOS), velocity of the electrons in the quantized levels, and the transmission coefficient of the electron. Therefore, it assumes different values for different systems and varies with the electric field, the magnitude of the reciprocal quantizing magnetic field under magnetic quantization, the nanothickness in quantum wells, wires, and dots, the quantizing electric field as in inversion layers, the carrier statistics in various types of quantum-confined superlattices having different carrier energy spectra and other types of low-dimensional field-assisted systems.

The present monograph is divided into three parts. The first part consists of four chapters. In Chap. 1, the FNFE has been investigated for quantum wires of nonlinear optical, III–V, II–VI, bismuth, IV–VI, stressed materials, Te, n-GaP, $PtSb_2$, Bi_2Te_3, n-Ge, GaSb, and II–V semiconductors on the basis of respective carrier energy spectra. Chapter 2 deals with the field emission from III–V, II–VI, IV–VI, and HgTe/CdTe quantum wires superlattices with graded interfaces have been studied. The same chapter also explores the FNFE from quantum wire effective mass superlattices of aforementioned constituent materials. In Chap. 3, the FNFE from nonlinear optical, III–V, II–VI, bismuth, IV–VI, stressed semiconductors, Te, n-GaP, $PtSb_2$, Bi_2Te_3, n-Ge, GaSb, and II–V compounds under strong magnetic quantization has been studied. In Chap. 4, the FNFE from III–V, II–VI, IV–VI, and HgTe/CdTe superlattices with graded interfaces and effective mass superlattices of the aforementioned constituent materials under magnetic quantization have also been investigated.

The Part II contains the solo Chap. 5 and investigates the influence of light waves on the FNFE from III–V compounds covering the cases of magnetic quantization, quantum wires, effective mass superlattices under magnetic quantization, superlattices with graded interfaces in the presence of quantizing magnetic field, quantum wire effective mass superlattices, and also quantum wire superlattices of the said materials with graded interfaces on the basis of newly formulated carrier energy spectra. Chapter 6 of the last part deals with the FNFE from quantum confined optoelectronic semiconductors in the presence of external intense electric fields. It appears from the literature that the investigations have been carried out on the FNFE under the assumption that the band structures of the semiconductors are invariant quantities in the presence of intense electric fields, which is not fundamentally true. The physical properties of nonparabolic semiconductors in the presence of strong electric field which changes the basic dispersion relation have relatively been less investigated [40]. Chapter 6 explores the FNFE from ternary and quaternary compounds in the presence of intense electric fields on the basis of electron dispersion laws under strong electric field covering the cases of magnetic quantization, quantum wires, effective mass superlattices under magnetic quantization, quantum wire effective mass superlattices, superlattices with graded interfaces in the presence of quantizing magnetic field, and also quantum wire superlattices of the said materials with graded interfaces.

Chapter 7 contains different applications and brief review of the experimental results. In the same chapter, the FNFE from carbon nanotubes in the presence of intense electric field and the importance of the measurement of band-gap of optoelectronic materials in the presence of light waves have also been discussed. Chapter 8 contains conclusion and future research. Besides, 200 open research problems have been presented which will be useful for the researchers in the fields of solid state and allied sciences, in general, in addition to the graduate courses on electron emission from solids in various academic departments of many

Institutes and Universities. We expect that the readers of this monograph will not only enjoy the investigations of the FNFE for a wide range of semiconductors and their nanostructures having different energy-wave vector dispersion relation of the carriers under various physical conditions as presented in this book but also solve the said problems by removing all the mathematical approximations and establishing the appropriate uniqueness conditions, together with the generation of all together new research problems, both theoretical and experimental. Each chapter except the last two contains a table highlighting the basic results pertaining to it in a summarized form.

It is needless to say that this monograph is based on the iceberg principle [41] and the rest of which will be explored by the researchers of different appropriate fields. It has been observed that still new experimental investigations of the FNFE from different semiconductors and their nanostructures are needed since such studies will throw light on the understanding of the band structures of quantized structures which, in turn, control the transport phenomena in such **k** space asymmetric systems. We further hope that the readers will transform this book into a standard reference source in connection with the field emission from solids to probe into the investigation of this particular research topic.

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