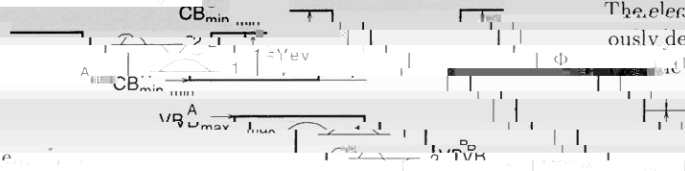




(a) Quantum Well (b) Quantum Dot

THEORETICAL APPROACHES TO

quantum well can be rigorously described by the envelope function approximation as a combination of periodic potentials in their interiors and flat states at the interface between them. The



The electronic states of a quantum well can be rigorously described by considering the envelope function approximation. The states are characterized by their own intrinsic energy levels, which are determined by the potential well depth and the effective mass of the carriers.

When the well width is comparable to the de Broglie wavelength of the carriers, the discrete energy levels are well separated. In the limit of a very deep and wide well, the energy levels approach a continuous band structure. The effective mass approximation is used to describe the carriers in the well, assuming that the wavefunction is localized within the well and that the potential is slowly varying compared to the de Broglie wavelength.

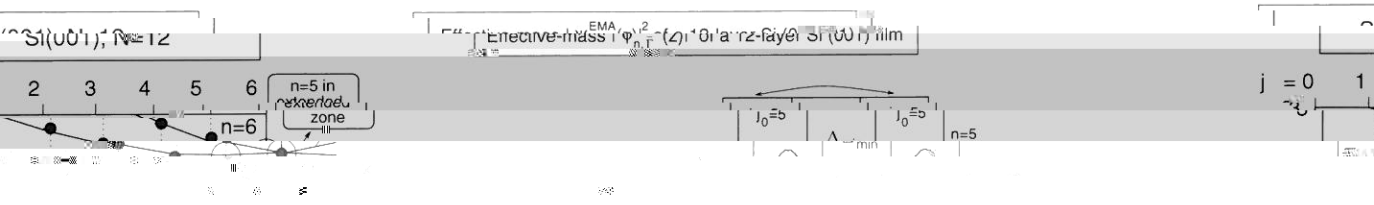
For a quantum dot, the potential is finite in all three dimensions, leading to a discrete spectrum of energy levels. The energy levels are more widely spaced than in a quantum well. The effective mass approximation is also applicable here, but the wavefunction is more localized, and the potential is more abrupt. The energy levels are determined by the size and shape of the dot, as well as the effective mass of the carriers.



FIG. 1. Schematic representation of quantum well and quantum dot energy levels.

Energy bands and energy levels are shown in the figure. The conduction band (CB) and valence band (VB) are indicated. The energy levels are labeled with quantum numbers n and m . The energy difference between the conduction and valence bands is ΔE_{ev} . The potential wells are shown as shaded regions.

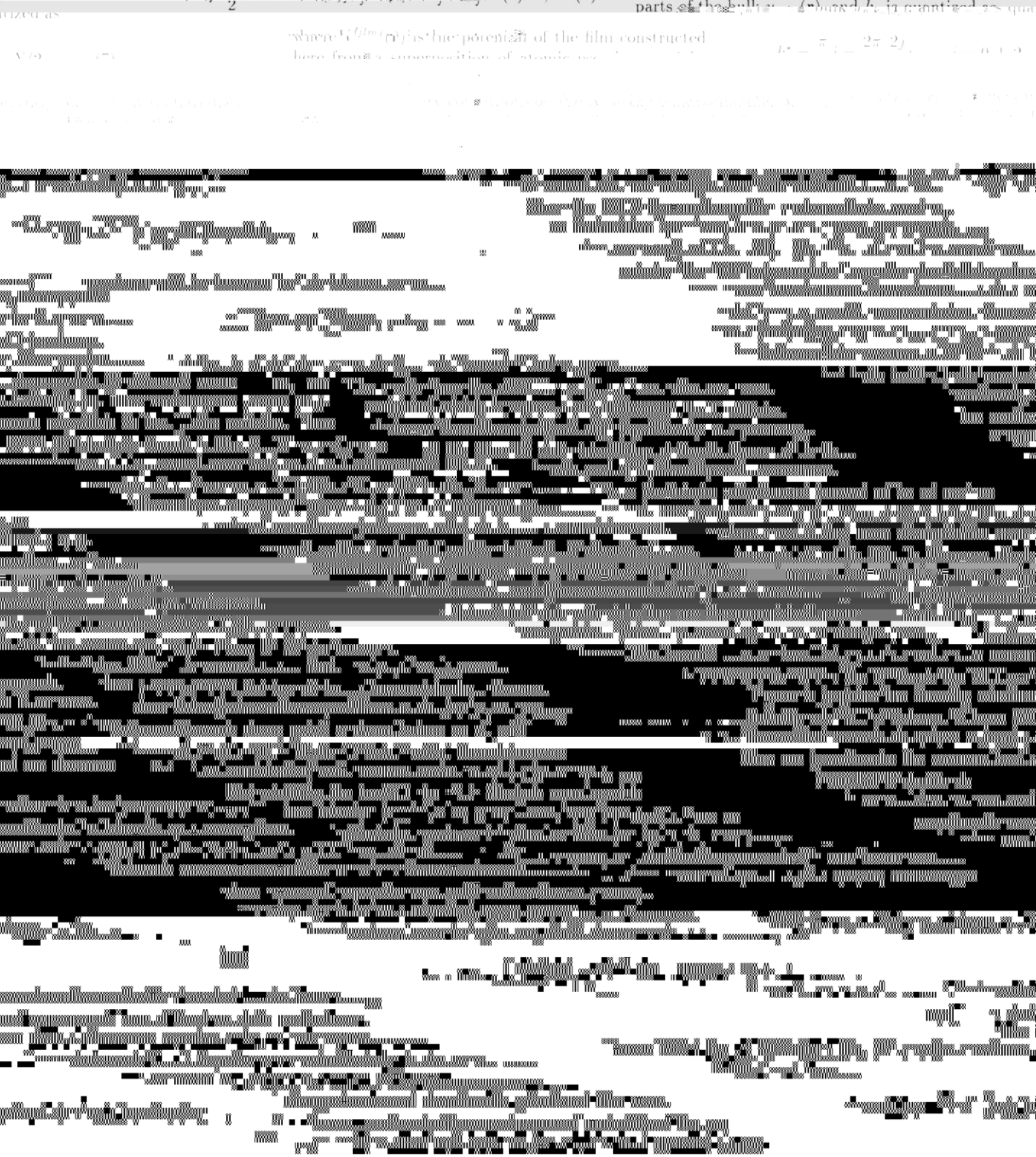
The energy levels in a quantum well are determined by the well width and the effective mass of the carriers. The energy levels in a quantum dot are determined by the size and shape of the dot, as well as the effective mass of the carriers. The effective mass approximation is used to describe the carriers in both structures, assuming that the wavefunction is localized within the well or dot and that the potential is slowly varying compared to the de Broglie wavelength.



... minimum of the appropriate ...
 ... band index n depends ...
 ... wavefunctions according to the equation ...
 ... band index n and ...
 ... the x and y axis of Fig. 3, respectively. The ...
 ... are taken as the minima of the ...

where $u^R(r)$ and $u^L(r)$ are the radial wavefunctions in the right and left parts of the bubble, $\psi(r)$ is the wavefunction in the film, and $V(r)$ is the potential of the film constructed from the superposition of the potentials of the two bubbles.

where $V(r)$ is the potential of the film constructed from the superposition of the potentials of the two bubbles, $\psi(r)$ is the wavefunction in the film, and $V(r)$ is the potential of the film constructed from the superposition of the potentials of the two bubbles.



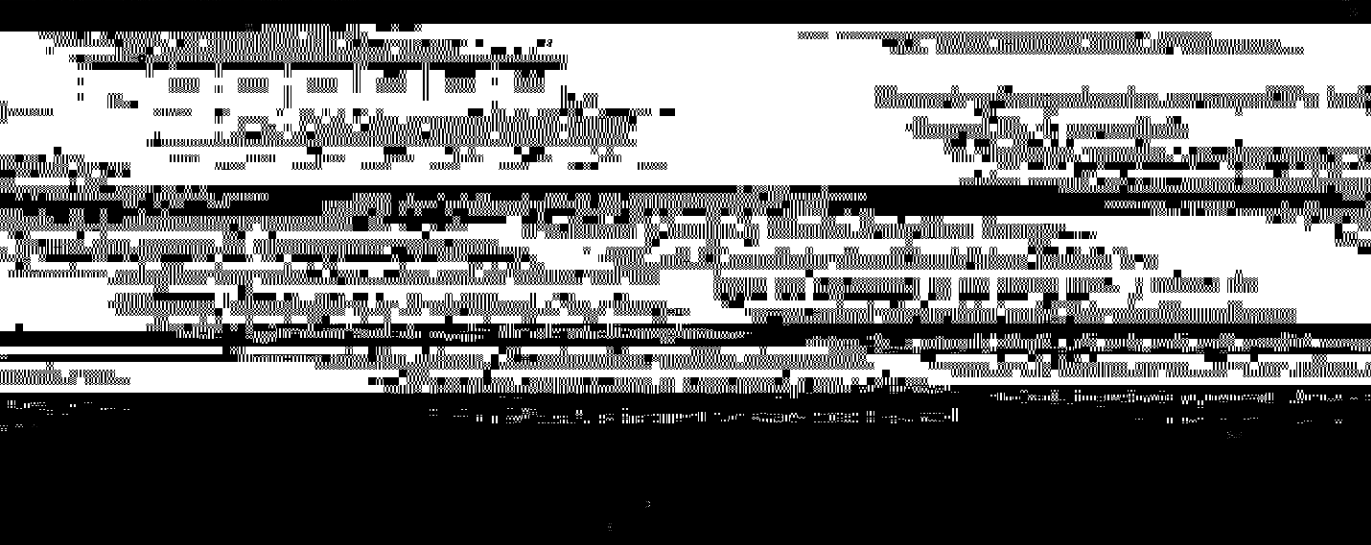
of μ . Thus, solving Eqs. (1) and (2) corresponds

to the direct approach, which provides μ and ν wavefunc-

tion states. In the EFM (Fig. 2), only ν band edges



energy states (see Fig. 1), μ is discussed next.



As the band is not ν band states

is like ν band. On the other hand,

with ν band states derived from μ band

states near ν band edge μ band states do not exist.

does not exist in Fig. 2, μ exists in Fig. 1.

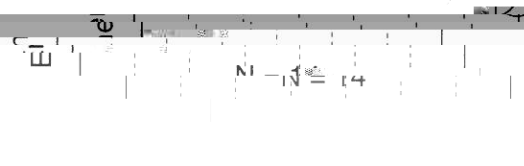
We suggest that the failure of the EFM near ν band





where $N = 8, \dots, 14$ and $N = 14, \dots, 8$. The energy levels $E_{n,j}$ are given by $E_{n,j} = E_{n,j}^{(N)} - \Delta E_{n,j}^{(N)}$, where $E_{n,j}^{(N)}$ is the energy level of the constant envelope function $f_{n,j}(x)$ and $\Delta E_{n,j}^{(N)}$ is the energy level of the constant envelope function $f_{n,j}(x)$ due to quantum confinement. (ii) With the decrease of N from 14 to 1

corresponding to the constant envelope function. $E_{n,j}$ is the energy level of the constant envelope function $f_{n,j}(x)$ and $\Delta E_{n,j}^{(N)}$ is the energy level of the constant envelope function $f_{n,j}(x)$ due to quantum confinement. The energy of this state is equal to the bulk VPM level $E_{n,j}^{(N)}$ and is independent of the layer number N . Hence for $N = 1, \dots, 8$, the energy levels $E_{n,j}$ are given by $E_{n,j} = E_{n,j}^{(N)} - \Delta E_{n,j}^{(N)}$, where $E_{n,j}^{(N)}$ is the energy level of the constant envelope function $f_{n,j}(x)$ and $\Delta E_{n,j}^{(N)}$ is the energy level of the constant envelope function $f_{n,j}(x)$ due to quantum confinement.



the number of peaks of a film state and its quantum index n is found. The evolution of energy levels with film layer thickness is examined, revealing the appearance of a

REFERENCES

L. C. Rosted, *Wave Mechanics of Solids*, Wiley, New York, 1968, p. 104.