sponding to the formation of a P+ layer near the silicon surface, which was observed before in bulk silicon too [13, 14]. In the latter case, however, there was already complete metallization of the surface layer at maximum ruby laser intensities, first mentioned in [13] and confirmed in [12] and a number of other papers having noted the important role of nonlinear surface optical effects, the raising of the effective temperature of the lattice, etc.

**LITERATURE CITED**


**INTERBAND OPTICAL ABSORPTION IN SEMICONDUCTORS WITH MICROCRYSTALLINE STRUCTURE**

V. D. Iskra

UDC 535.343.2

The simplest model concepts are used to calculate the binary correlation function of the intrinsic random field of a semiconductor with microcrystalline structure. The frequency dependence of the absorption coefficient of light in the region of the optical tail formed by the intrinsic random field is investigated.

**1. INTRODUCTION**

To explain a number of experimental data, one has lately been obliged to assume that some amorphous semiconductors may, depending on the technology of their preparation, be ordered to a considerably higher degree than the usual amorphous materials possessing only short-range order [1-3].

In this connection, the idea of an intermediate order was advanced [3]. In [4, 5] the simplest structural models taking into account the presence of an intermediate order in an amorphous semiconductor were assumed.

However, besides the intermediate order, other types of local ordering are possible. Thus, for example, in amorphous Si : H : F crystallites with linear dimensions of the order of 10 Å [3] (the authors call them "pseudomicrocrystals") were discovered.

In the present paper a semiconductor with elements of microcrystalline structure is investigated. We shall consider it as an aggregate of crystallites having a "rigid" atomic lattice embedded in an amorphous medium. The spatial distribution of atoms in such a semiconductor will be described by a "radial" distribution
function \( g(\mathbf{r}_1, \mathbf{r}_2) \). The latter has the following meaning. If some atom is located at point \( \mathbf{r}_1 \), then \( g(\mathbf{r}_1, \mathbf{r}_2) \) defines the probability density to find another atom at point \( \mathbf{r}_2 \). In an ideal crystal with a "rigid" lattice this function would have the form

\[
g_{cr}(r) = \frac{\Omega_0}{\Omega} \sum_n \delta (r - a_n),
\]

(1.1)

where \( r = \mathbf{r}_2 - \mathbf{r}_1 \); \( \Omega_0 \) is the atomic volume; \( a_n \) are lattice vectors; the prime of the sum symbol denotes the absence of the term corresponding to the site located at the origin.

Let us note that on a microscopic scale the material being considered is spatially inhomogeneous. The ordered (crystallites) and disordered (amorphous medium) regions, interchanging with each other, form a system with "mixed" order (we use here the term "mixed" in order to underline its principal difference from the intermediate order considered before in a microscopically uniform system [4, 5], when the radial distribution function depends only on the difference in the arguments, \( g(\mathbf{r}_1, \mathbf{r}_2) = g(\mathbf{r}_1 - \mathbf{r}_2) \); in our case the function \( g(\mathbf{r}_1, \mathbf{r}_2) \) depends on each argument separately).

In the present paper we consider the simplest model of a semiconductor with microcrystalline structure. We used this model to investigate its intrinsic random field and to determine the frequency dependence of the absorption coefficient of light in the region of the optical tail due to the intrinsic random field.

2. Simplest Model of a Semiconductor with Microcrystalline Structure

Let us consider first a covalent semiconductor. For the sake of simplicity, we assume that all the crystallites have a spherical shape and that their dimensions are the same. We shall assume that the distribution of atoms in the space between the crystallites is completely chaotic. We shall neglect the correlation between individual crystallites with regards to the disposition of the crystal axes. Such a model corresponds to a radial distribution function of the following form

\[
g(\mathbf{r}_1, \mathbf{r}_2) = 1 + \sum_i \{b_0 \sum_n \delta [\mathbf{r}_1 - \mathbf{r}_2 - (a_n - \mathbf{r}_i)] - 1\} \cdot \frac{\theta (r_o - |\mathbf{r}_1 - \mathbf{r}_i|)}{\theta (r_o - |\mathbf{r}_2 - \mathbf{r}_i|)}.
\]

(2.1)

Here, \( r_o \) is the crystallite radius; \( b_0 \) is a constant; \( i \) is the number of the crystallite; \( \mathbf{r}_i \) is the radius vector of its center; \( a_n \) is the radius vector of the lattice sites; the prime on the sum symbol denotes the absence of the term corresponding to \( a_n = \mathbf{r}_i \).

According to (2.1), for any two points \( \mathbf{r}_1 \) and \( \mathbf{r}_2 \) belonging to one of the crystallites, \( g = g_{cr} \) (see (1.1)); if, however, the points \( \mathbf{r}_1 \) and \( \mathbf{r}_2 \) belong to different crystallites or even if one of them lies in the space between the crystallites, there is no correlation between the locations of the atoms and \( g = 1 \). The model under consideration is illustrated for the two cases in Fig. 1.

The system described by the radial distribution function (2.1) is, generally speaking, spatially inhomogeneous. However, it can be considered as macroscopically homogeneous on scales comprising a sufficiently large number of crystallites. The respective binary correlation function of atoms \( w(\mathbf{R}_1, \mathbf{R}_2) \) is related to \( g(\mathbf{r}_1, \mathbf{r}_2) \) by

\[
w(\mathbf{R}_1, \mathbf{R}_2) = \frac{\Omega}{\Omega} \int \frac{d\mathbf{r}_1}{(k_0)} \int \frac{d\mathbf{r}_2}{(k_0)} g(\mathbf{r}_1, \mathbf{r}_2).
\]

(2.2)

Here, \( \Omega \) is the volume of the system; \( \delta \mathbf{R}_1 \) and \( \delta \mathbf{R}_2 \) are physically infinitely small volumes in the vicinity of the points \( \mathbf{R}_1 \) and \( \mathbf{R}_2 \), respectively (see Fig. 2). The function \( w(\mathbf{R}_1, \mathbf{R}_2) \) depends only on the difference \( (\mathbf{R}_1 - \mathbf{R}_2) \) if \( \delta \mathbf{R}_1, \delta \mathbf{R}_2 \gg 1 \), \( \delta \mathbf{R}_1, \delta \mathbf{R}_2 \gg 1 \), where \( n_c \) is the concentration of crystallites. Having carried out the integration in (2.2) we obtain for the model (2.1)

\[
w(\mathbf{R}_1 - \mathbf{R}_2) = \frac{\Omega}{\Omega} \left\{ \begin{array}{ll} 0 & \text{with } R_1 = R_2, \\ n_c \Omega \{b_0 \left( \frac{\Omega_b}{\Omega} - 1 \right) - \Omega_b \} & \text{with } R_1 \neq R_2. \end{array} \right.
\]

(2.3a)

(2.3b)

where \( \Omega_b = \frac{4\pi}{3} r_b^3 \) is the volume of a crystallite.

Combining (2.3a) and (2.3b), we find

\[
w(\mathbf{R}_1 - \mathbf{R}_2) = n_c \sum \left\{ b_0 \left( \frac{\Omega_b}{\Omega} - 1 \right) - \Omega_b \right\} \delta (\mathbf{R}_1 - \mathbf{R}_2).
\]

(2.4)