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[1]I. Chikina, [2]V. Shikin

[1]IRAMIS, Lions, UMR 3299 CEA-CNRS NIMBE, CEA-Saclay, F-91191 Gif sur Yvette Cedex, France
[2]Institute of Solid State Physics, Russian Academy of Sciences Chernogolovka,
Moscow District, 2 Academician Ossipyan str., 142432 Russia

Mechanisms of self-screening in intrinsic semiconductors

Electron-hole pairs (proton-hydroxyl pairs in water) thermally activated in intrinsic semiconductors interact through Coulomb forces which necessarily results in some self-screening that should either be accounted for in a proper way or shown to be negligible. Possible mechanisms of self-screening are considered in this work.

Key words: self-shielding, intrinsic semiconductor, method of Debye-Hyukelya.

И. Чикина, В. Шикин

Механизмы самоэкранирования в собственных полупроводниках

Термически активированные электронно-дырочные пары (протон-гидроксильные пары в воде) в собственных полупроводниках взаимодействуют посредством Кулоновских сил, необходимым следствием этого является некоторое самоэкранирование, которое следует или должным образом учитывать, или считать пренебрежимо малым. Возможные механизмы самоэкранирования рассмотрены в настоящей работе.

Ключевые слова: самоэкранирование, собственный полупроводник, метод Дебая-Хюкеля.

И. Чикина, В. Шикин

Меншік жартылай өткізгіштерде өздігінен экрандалу механизмдері

Меншік жартылай өткізгішті жартылай өткізгіштерде термиялық белсендірілген электронды-кемтікті жұптар (судағы протон-гидроксильді жұптар) Кулон күшінің әсерімен өзара әсерлеседі, бұның қажетті нәтижесі ескерілуге тиісті немесе елемейтіндей аз деп есептейтіндей өздігінен экрандалу болып табылады. Өздігінен экрандалудың бұндай механизмдері осы жұмыста қарастырылған.

Түйін сөздер: өздігінен экрандалу, меншік жартылай өткізгіш, Дебая-Хюкель әдісі.

Electron-hole pairs (proton-hydroxyl pairs in water) thermally activated in intrinsic semiconductors interact through Coulomb forces which necessarily results in some self-screening that should either be accounted for in a proper way or shown to be negligible. Possible mechanisms of self-screening are considered in this work.

1. One of the scenarios for development of self-screening is as follows (the Debye-H¨uckel approach [1]). One of the ions is placed into the origin of the coordinate system, all other ions are allowed to screen it. Then the electric potential $\phi(r)$ satisfies the following equation:

$$\phi(r) = e\exp(-\kappa dr)/r, \qquad (1)$$

where ² is the medium dielectric constant and κ is the donor density.

In the expansion of $\phi(r)$ for small r

$$e\phi\ (r)\ `\ -e^2k + \ldots\ U_{corr} \sim e^2k_{aq} \qquad (2)$$

thefirst term is the self-energy of the central ion, while the second term represents.

[1] the correlation correction U_{corr} we are searching for. Eqs. (1,2) are the starting point for all correlation phenomena in classical systems with Coulomb interaction.

2. An interesting alternative estimate for Ucorr can be taken from the theory of ion lattices [2]. If the charges arising due to dissociation are arranged into a regular lattice suitable for the application of

the Ewald rules, then the correlation energy per pair of ions Ucorr can be written as

$$U_{corr} \sim \gamma e^2 / R_{aq},\ R_{aq} \sim (\alpha_{aq} n_{aq})^{-1} \qquad (3)$$

where γ is a Madelung constant.

The estimates (2) and (3) for the correlation energy U_{corr} have different structures and are substantiated in different ways. Discussed in the present paper are the reasons underlying these differences.

References

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