Double injection in nanowire radial *p-i-n* diodes

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Introduction

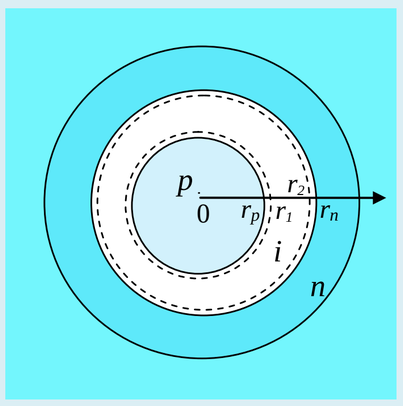
Due to cylindrical symmetry of these structures, their electronic properties acquire a number of peculiarities in comparison with analogous planar devices. In particular, distribution of the nonequlibrium carriers injected into base layer of the radial *p-n* junction diode decays with different rate depending on the injection direction - from the nanowire center to periphery or vice versa [1]. The reason is superimposition of specific concentration falling with radial coordinate related to cylindrical geometry of the structure onto its recombination falling. This circumstance results in, respectively, increasing or decreasing the diode saturation current compared with analogous planar diode.

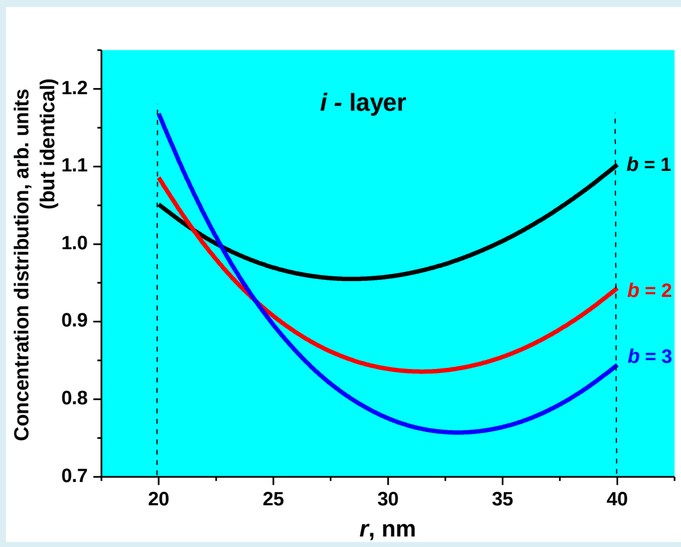
The radial *p-i-n* diodes contain (in the frame of single device) both above mentioned injection directions. Therefore it is of interest to consider their transport properties in whole.

Method and results

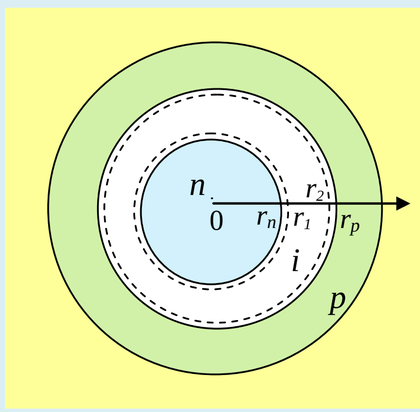
For these structures, system of transport equations in cylindrical geometry have been solved analytically (by scheme from [2]) and the spatial distribution of current carriers injected to middle layer of a radial *p-i-n* diode and its forward current-voltage characteristic are calculated. Two configuration have been considered – *p-i-n* diode and *n-i-p* diode at arbitrary value of ratio *b* for electron and hole mobilities.

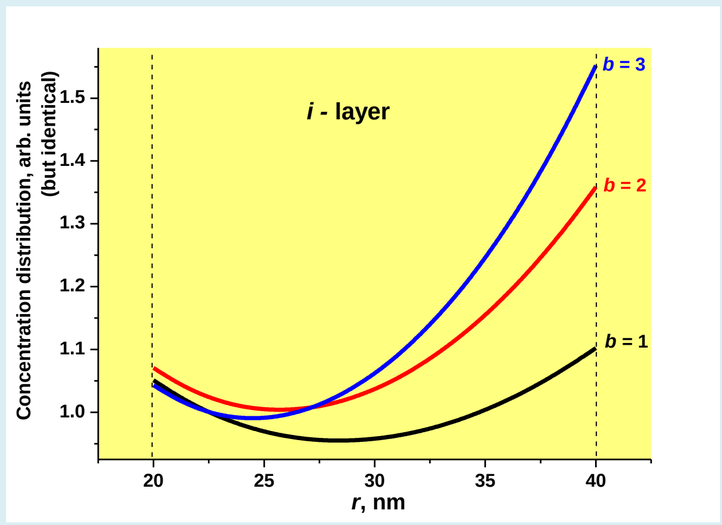
p-i-n diode





n-i-p diode

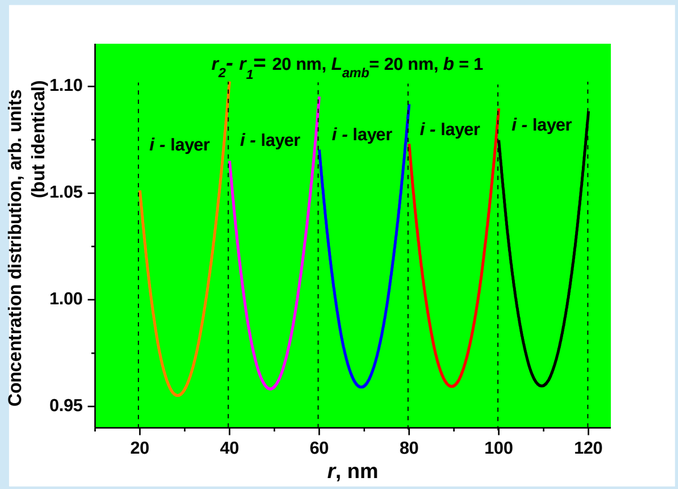


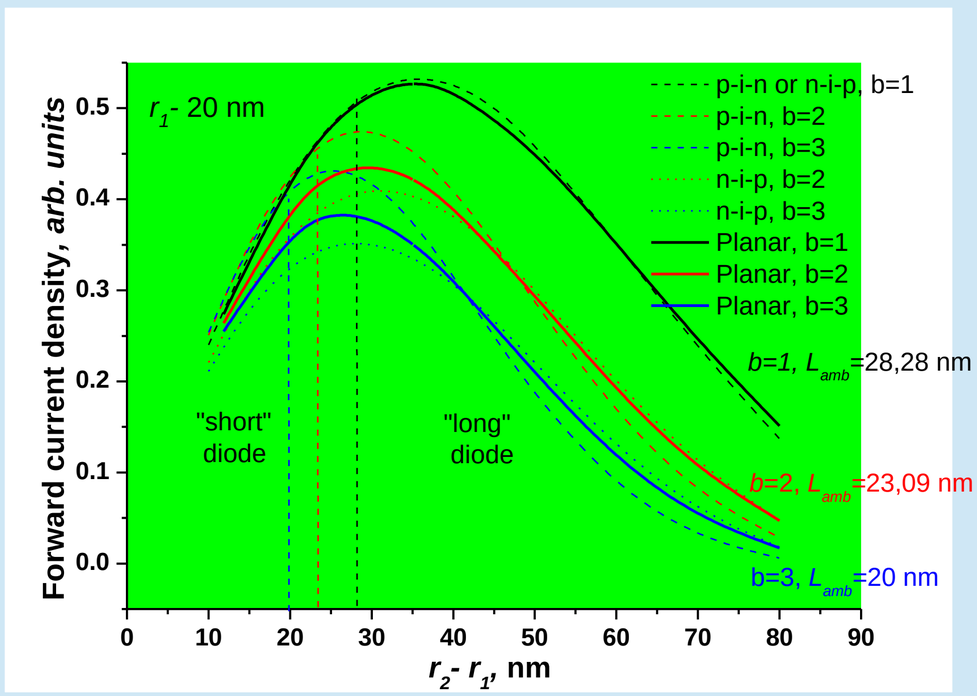


The calculation results have revealed that cylindrical geometry of the structure gives rise to specific asymmetry of concentration distribution for the carriers injected to the *i*-layer. Addition asymmetry due to inequality of carriers' mobilities proves to be of opposite type in *p-i-n* diode and of the same type in *n-i-p* diode .

Dependence of current density on radial thickness of the *i*-layer demonstrates maximums at the thicknesses close to bipolar diffusion length L_{amb}.

This specific asymmetry of concentration distribution enlarges when the *i*-layer goes to nanowire center.





Conclusion

From the point of view of obtaining highest current density, just radial *p-i-n* structure proves to be preferable even in comparison with analogous planar structure (under other equal conditions).

References

1. *Borblik V.L.* Effect of circular *p-n* junction curvature on the diode current density // *J. Electron. Mater.*-2016.**-45.-**P. 4117-4121..
2. *Benda H.and Spenke* E. Reverse recovery processes in silicon power rectifiers. *Proc. IEEE*, 1967. **55**, No 12. P. 1331-1354.