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New optimum laser photoionization procedure schemes for semiconductor material cleaning and preparing the films pure at atomic level

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The paper is aimed at the search for optimum schemes of laser photoionization technology for control and cleaning of semiconductor substances and computer simulation of such schemes. The optimum scheme has been proposed first for the laser photoionization procedure in preparation of extra pure films taking the formation of 3-D hetero structure superlattices (GaAs layers). The photoionization process of Ga^+ ions obtaining and optimum procedure for the pure film preparation are considered. Basing on new quantum-mechanic models, optimum realization parameters have been calculated numerically for the selective excitation and further ionization of Ga^+ ions by electric field in Rydberg states.

Работа посвящена поиску и компьютерному моделированию оптимальных схем фотоионизационного метода для контроля и очистки полупроводниковых материалов. Впервые предложена оптимальная схема лазерной фотоионизационной технологии приготовления пленок особо чистого состава на примере создания 3D гетероструктурных сверхрешеток (слои GaAs). Рассмотрен фотоионизационный процесс получения ионов Ga^+ и оптимальная схема его реализации. На основе новых квантово-механических моделей численно рассчитаны параметры оптимальной реализации процессов селективного возбуждения и дальнейшей ионизации ионов Ga^+ электрическим полем в ридберговых состояниях.

Realization of effective methods for obtaining special purity substances or their control and cleaning of impurities [1–3] is considered to be one of actual problems in modern technology of semiconductors and other materials. In particular, the matter is to control Al, B, and other 3rd Group acceptor elements impurities in Ge at a level of 10^{-8}–10^{-10} %. In some cases, such sensitivity may be provided by traditional analytical methods [1] or their modifications. However, its sensitivity is limited to the level of 10^{-7} % in most cases. Selective photophysical methods [2, 3] provide a new basis for solution of isotope separation tasks and also make it possible to develop a new approach to obtaining procedures of pure substances at atomic levels. Its successful realization depends, first of all, on ensuring the optimum multistep photoionization schemes for different elements and, second, on the availability of UV and visible range lasers of sufficient efficiency and high average power. This communication is devoted to our works on the search for the optimum schemes of laser photoionization procedures for control and cleaning of semiconductor substances and computer simulation thereof. We have developed first the optimum laser photoionization procedure scheme for preparation of pure films taking the formation of the 3-D hetero structure superlattices (10 E wide $Ga_{1-x}Al_xAs$ layers and 60 E wide GaAs ones).

A possible scheme of the special purity film preparation using the two- stage selective ionization of atoms was proposed by V.Letokhov. Such a scheme was not checked experimentally, however, it is quite logical. At the same time, it is obvious that the two-stage laser ionization scheme is not optimum one (see explanation below). The