Calculation of the Fermi wavevector for the thin films, quantum wires and quantum dots

T. Balcerzak

Department of Solid State Physics, University of Łódź
Pomorska 149/153, 90-236 Łódź, Poland

It is known that in the frame of the free-electron model, various physical properties of the bulk material, for instance, the electrical, magnetic, thermal and optical properties, can be illustratively and relatively simply discussed [1, 2]. On the other hand, the low-dimensional systems (LDS) play now an important and continuously growing role in the contemporary science and technology [3-6]. Therefore, in order to discuss the physical properties of LDS, i.e. the thin films (TF), quantum wires (QWr) and quantum dots (QD) properties, in the first approach, it is important to have an extension of the free-electron model for the confined structures. In such considerations, the quantum-mechanical approach, and in particular, the concept of quantum wells, plays a crucial role [4, 7].

The aim of the present paper are calculations of the Fermi wavevector in the frame of the free-electron approximation, for the low-dimensional structures (TF, QWr and QD). As the first stage, a comparison of the Fermi surface construction for these systems has been made, showing in the pictures how the confinement of successive dimensions influences the discretization of electronic states. The formulae, suitable for numerical calculations of the Fermi wavevector, k_F, for TF, QWr and QD have been derived. Some numerical calculations of a testing character have been performed for the electron density corresponding to Cu with the surface (100) orientations of LDS. In particular, the Fermi wavevector has been calculated upon the thickness of TF, the thickness and width of QWr, as well as the thickness, width and length of QD. The results have been illustrated in figures. It has also been checked, that by increasing the lateral sizes of the confined structures, for instance, going with the successive sizes to infinity, the results for QD tend first to QWr which, in turn, in the limit of the next infinite size, tend to TF. Some analytical results for TF, and their limiting cases for the bulk material when the thickness of the film tends to infinity, have been discussed elsewhere [8], in detail.

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Name of the presenting author (poster): Tadeusz Balcerzak
e-mail address: t_balcerzak@uni.lodz.pl
url's: http://www.fic.uni.lodz.pl/kfcs/