Exciton Mediated Superconductivity

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The concept of superconductivity mediated by Bose-Einstein condensates of excitons or exciton-polaritons has been first outlined in 2007. Initially, we were considering a strong coupling regime, where Coulomb attraction of two electrons to one exciton leads to formation of charged bosonic quasipartices: quatrons [1]. Next, we have considered the weak coupling regime, similar to the Bardeen-Cooper-Schriefer (BCS) superconductivity [2]. The excitations of an exciton condensate (one can call them bogolons) play role of phonons mediating attraction of free electrons in a layer of metal or in a doped semiconductor layer. The strength of electron-electron attraction can be tuned by changing the occupation number of the condensate. In turn, the occupation number of the condensate can by controlled by optical pumping. This leads to the optically controlled superconductivity. Our estimations showed that at sufficiently high condensate occupation numbers, the critical temperature of superconductivity may exceed the room temperature in two model systems we have considered: the microcavities with embedded neutral and n-doped quantum wells (QWs) and biased coupled QWs covered by a thin layer of metal or put in the vicinity of an *n*-doped QW. For experimental realization of the proposed effect, one needs to optimize the geometry of a structure containing excitons and the density of a two-dimensional electron gas (2DEG) which is to be put in contact with excitons. From [3] it is clear that excitons with significant normal-to-plane stationary dipole moments are preferential and the higher their density is the better, in general. It has been unclear till recently what 2DEG density would be the best. Clearly, the Fermi energy in the electronic system must exceed the superconducting gap, on the other hand, the increase of the Fermi wave-vector leads to the decrease of momentum-averaged electron-electron attraction potential. We shall overview the recent progresses in this field and address specifically the crucial issue of the optimum 2DEG density.

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