Hydrodynamics of Electron-Hole Fluid in Mesoscopic GaAs Channels

Yu. A. Pusep[1], M. A. T. Patricio[1], G. M. Jacobsen[2], M. D. Teodoro[2], G. M. Gusev[3], and A. K. Bakarov[4]

[1]São Carlos Institute of Physics, University of São Paulo, PO Box 369,13560-970 São Carlos, SP, Brazil

[2]Physics Department, Federal University of São Carlos, 13565-905, São Carlos, São Paulo, Brazil

[3]Institute of Physics, University of São Paulo, 135960-170 São Paulo, SP, Brazil

[4]Institute of Semiconductor Physics, 630090 Novosibirsk, Russia

pusep@ifsc.usp.br pusep@ifsc.usp.br

A novel spectroscopic method was applied to study the hydrodynamics of electron-hole fluid. Scanning photocurrent microscopy and time-resolved micro-photoluminescence were used to examine strongly correlated electron-hole plasma formed in a high-mobility n-doped mesoscopic GaAs channels. We address our investigation to the diffusion of holes photoinjected into a viscous electron fluid. The obtained results manifest to the formation of a three-component hydrodynamic system formed by background electrons and photo-injected heavy and light holes. The hydrodynamic diffusion regime was found in the temperature window 10 - 30K [1]. Diffusion dynamics were studied using time-resolved micro-photoluminescence in a channel consisting of sections with widths of 4, 10, and 50 µm. As shown in Fig.1(a), the recombination time of photoinjected holes, which is inversely proportional to the rate of their diffusion flow, decreases when holes pass through the expanded sections of the channel. In fact, this is the Venturi effect, which consists in a decrease in the velocity of the fluid in the expanded sections of the pipe. A quantizing magnetic field leads to the disappearance of the Venturi effect. Thus the magnetic field induced breakdown of electron hydrodynamics is observed. Additional evidence of the viscous nature of the studied electron-hole fluid is the observed increase in the recombination rate with increasing temperature, which is similar to the decrease in the electrical resistance of viscous electrons with temperature. Moreover, a nearly uniform and parabolic Hagen-Poiseuille diffusion velocity profiles depicted in Fig.1(b) were observed at 4K (Drude diffusion) and 25K (hydrodynamic diffusion flow), respectively. It is shown that in agreement with a theory, the magnetic field strongly suppresses the viscosity of the electron-hole fluid [2,3]. more, the transformation of Poiseuille diffusion into Drude diffusion with increasing laser pump power was discovered and as a result, an optical analogue of the Gurzhi effect was observed [4].

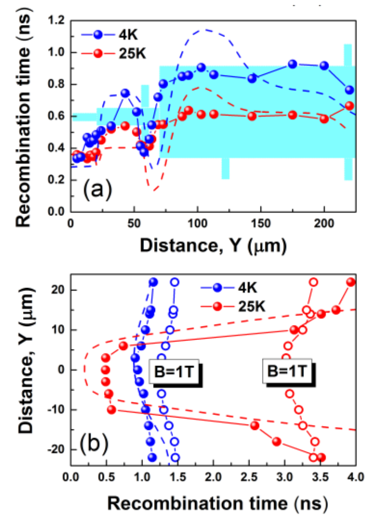

Fig.1. (a) Image of the channel and recombination time measured parallel and (b) perpendicular to the channel at 4 K and 25 K. Open circles show recombination time measured in a 1 T magnetic field. Calculated recombination times are shown by dashed lines.

References

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