THz Detection by Correlated 2D Electron Systems

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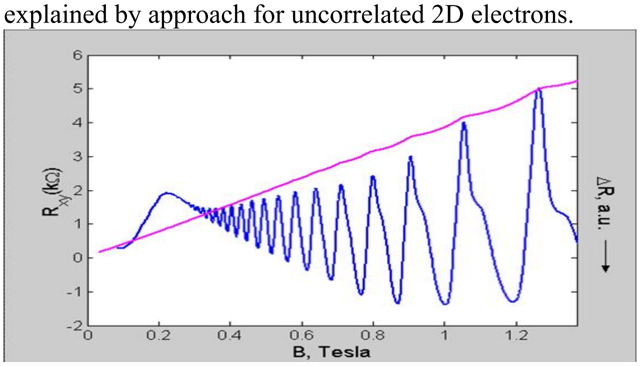
Experimental measurements of transmission and photoresistivity under terahertz (THz) radiation in low magnetic fields at conditions of cyclotron resonance (CR) in two-dimensional electron system (2DES) of GaAs/AlGaAs nanostructures are presented and discussed. We report the experimental discovery of "CR-vanishing effect" (CRV) in structures with high mobility as a well-defined gap on CR-line that is independent on incident THz power. Our analysis shows that the CRV may appear in systems with well correlated state of 2D electrons such as plasma waves and others. Fundamental nature of these correlated states of electrons in 2DES is discussed. Future THz detectors utilizing the new correlated states in 2DES may expand horizons for supersensitive detection in sub-THz and THz frequencies ranges.

I. INTRODUCTION AND BACKGROUND

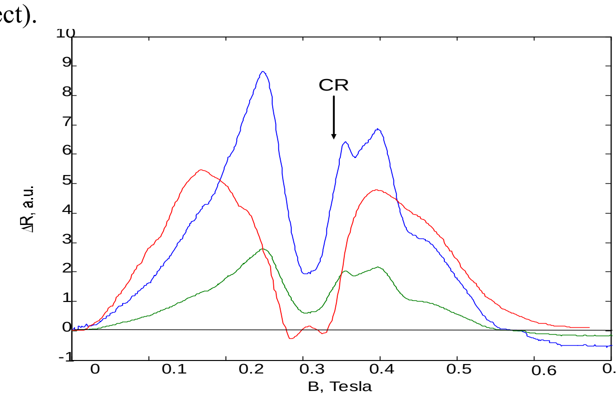
Future of THz electronics is closely connected with development of new nanomaterials based on well explored semiconductors: Si, Ge, GaAs, GaN and others. The emerging nanotechnologies as we believe will allow creating of new nanostructures from these wide-band-gap semiconductors to increase both working frequency and temperature of semiconductor devices at the same time. The more convenient way to demonstrate bright prospective of THz nanoelectronics is to create new THz detectors and sources, because of their simplest design. The direction of new THz supersensitive detectors and lasers is being vigorously developed now[3]. Our specific approach, based on our experimental study of 2DES with the CR technique, allows to find and to separate single-electron-gas state (uncorrelated 2D electrons), from electron plasma waves and other correlated 2D electrons states [1, 2].

II. RESULTS

Complex study of CR, Shubnikov-de Haas oscillations, and Quantum Hall resistance (magenta curve) in GaAs/AlGaAs 2DES with high mobility $10^5 \div 10^6$ $cm^2V^{-1}s^{-1}$ using 0.13÷0.15 THz demonstrate that at low T = 4,2K^0 these effects presented in THz photoresistance magnetospectrum (blue curve) well explained by approach for uncorrelated 2D electrons.



In some conditions we observed that in wide enough area of low magnetic fields (B_{gap}) the photoresistance $\partial R(B_{gap})$ in the center of CR-line jump down to minimum instead going to maximum as in usual CR-lines and creates deep gap - (CRV effect).



We will discuss "CR-vanishing effect" with models for Quantum Hall effect, magneto-plasma waves, non-linear zero-resistance states, and others that have mentioned in literature for the similar experimental conditions. Theoretical analysis indicates on appearance of new fundamental correlated states of electrons at CRV conditions. Searching of current physical models of correlated states in 2DES or creating new one can be suggested at this moment to explain the CRV effect.

Formation of the new states in 2DES is next step for advanced supersensitive THz detectors with tunable spectral selectivity. Comparison with superconductor detectors (that exploits correlated electron's states) predicts that NEP value may be below 10^{-15} W*Hz$^{-1/2}$ at higher working temperature for THz detectors that utilize the new fundamental correlated electron's states of 2DES[1]. Thus, this kind of nanomaterials promises maximal advantages and effectiveness among other approaches to materials for THz electronics. Future THz nanoelectronics may be based on new fundamental correlated electron's states too[3].

REFERENCES

1. A. Chebotarev & G. Chebotareva, Cyclotron Resonance Vanishing Effect and THz Detection, **Invited paper** at *WOFE-07 Cozumel,Mexico,2007; Proceedings of WOFE-07 in Intern. Journal of High Speed Electronics & Systems* (2008) in press.
2. A. Chebotarev & G. Chebotareva, Terahertz Induced Photoconductivity of 2D Electron System in HEMT at Low Magnetic Field in *Proceedings of ICPS-27*, Flagstaff, Arizona, 2004; AIP, 772, 1184-1185 (2004).
3. on-line ***www.opth.us***

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