Extremely Fast Electron Capture in Moderately Doped Germanium

S. G. Pavlov [1], N. Deßmann [2], M. Mittendorff [3], S. Winnerl [3], R. Kh. Zhukavin [4], V. V. Tsyplenkov [4], D. V. Shengurov [4], V. N. Shastin [4], N. V. Abrosimov [5], H. Riemann [5] and H.-W. Hübers [1,2]

[1] *Institute of Planetary Research, German Aerospace Center, Berlin, Germany,*

[2] *Institut für Optik und Atomare Physik, Technische Universität Berlin, Berlin, Germany*

[3] *Helmholtz-Zentrum Dresden-Rossendorf, Dresden, Germany*

[4] *Institute for Physics of Microstructures, Russian Academy of Sciences, Nizhny Novgorod, Russia*

[5] *Leibniz Institute for Crystal Growth, Berlin, Germany*

sergeij.pavlov@dlr.de

Deeply cooled germanium based photoconductive detectors characterized by low infrared losses and low background current have been serving for decades as one of the most sensitive far-infrared detectors in solid state spectroscopy and astronomy [1]. The sensitivity of extrinsic photoconductivity of germanium doped by hydrogen-like impurity centers, such as gallium (*p*-Ge:Ga) and antimony (*n*-Ge:Sb), peaks at far-infrared wavelengths around 100 μm (3 THz) and extends towards the infrared. Achieving high sensitivity requires low doped (~10^{14}/cm^3) and weakly compensated germanium [2]. This broad band low-noise and high sensitivity operation features dominated the research on Ge photodetectors. So far the shortest response times are in the nanosecond scale [3].

We report the observation of ultrafast capture of free electrons (*n*-Ge:Sb:Ga) and holes (*p*-Ge:Ga:Sb) in moderately doped (net concentration > 2×10^{15}/cm^3) Ge with high compensation, up to 50%. The typical range of the relaxation times for photoinduced (far-infrared photo-ionization) transmittance is in the range of 20-300 ps dependent on the sample characteristics and the far-infrared light intensity (Fig. 1). Measurements of the photoinduced decay have been carried out by a contactless pump-probe technique at the infrared free electron laser facility at HZDR, Dresden [4]. The observed relaxation times of free charge carriers are up to two orders of magnitude shorter than the ~ 2 ns response time observed in the photoconductive response of neutron transmutation doped isotope-fixed compensated *p*-Ge:Ga:Se:As in Ref [3]. This indicates the potential for very fast broad band detection of infrared pulses by extrinsic photoconductive germanium detectors with optimized doping, compensation, geometry and an appropriate electrical readout circuit.

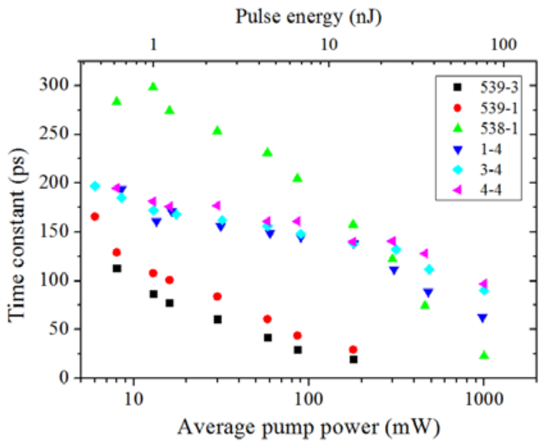

Fig.1. Typical dependences of free electron decay times on the energy of the pump pulse (wavelength is 105 μm) for the photoinduced far-infrared transmittance in *n*-Ge:Sb:Ga and *p*-Ge:Ga:Sb samples as measured by the pump-probe technique.

This work was partly supported by BMBF (grant #05K10KTD), RFBR (grants #12-02-01231, 11-02-00957, 12-02-31291 mol) and Russian Ministry of Education and Science (grant #8622).

References

[1] E. E. Haller, Infrared Phys. **25**, 257–266 (1985).

[2] N. Hiromoto, M. Saito and H. Okuda, Jpn. J. Appl. Phys. **29**, 1739-1744 (1990).

[3] F. A. Hegmann, J. Williams, B. Cole, M. Sherwin, J. W. Beeman, and E. E. Haller, Appl. Phys. Lett. **76**, 262–264 (2000) and references therein.

[4] N. Deßmann, S. G. Pavlov, V. N. Shastin, R. Kh. Zhukavin, S. Winnerl, M. Mittendorff and H.-W. Hübers, *Proc. 37th Int. Conf. Infrared, MM and THz Waves*, 23-28.09.2012; Wollongong, Australia. Paper # 2569425.