Picosecond VIS-FIR Photoconductive Germanium Detector

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Abstract— **A broad-band fast germanium detector based on unipolar and bipolar photoconductivity has been demonstrated. Typical response times are about 200 ps. Such short times are realized by using heavily doped and highly compensated germanium crystals.**

I. INTRODUCTION

A broad-band, visible to the far-infrared, fast photoconductive detector based on heavily doped and highly compensated germanium (Ge) has been demonstrated. Such detectors are requested for the in-situ diagnostic of power and beam quality of tunable pulsed infrared free electron lasers.

II. RESULTS

A specific gradient doping of germanium crystals by dominating and compensating atoms, namely gallium and antimony, has been performed up to almost the critical concentration of the metal-insulator transition for shallow impurities. Such a material demonstrates optical sensitivity in an ultra-broad, from the visible range, of about 500 nm (band-gap absorption mechanism), to far-infrared (impurity-to-band absorption) wavelengths of about 2 mm. The spectral sensitivity peaks between 2 THz and 2.5 THz and is slowly reduced towards lower as well as higher frequencies. The recovering times of free charge carriers measured in the THz range by a pump-probe technique [1] approach several tenths of picoseconds and remain almost independent on the optical input intensity and on temperature of the detector.

The detector made from such a material operates from liquid helium up to liquid nitrogen temperatures, with reduced sensitivity at higher temperatures. The response time of heavily doped, highly compensated p-Ge:Ga:Sb is shorter than 200 ps (Fig. 1). This is significantly faster than previously reported response times for detectors made from the highly compensated neutron-transmutation doped p-Ge:Ga:As:Se samples [2]. A detector made from uncompensated p-Ge:Sb detector has a significantly longer response time (about 1 ns) when measured under the same conditions (Fig. 1).

The significant shortening of the response time occurs due to a strong increase of the charged impurity centers serving as effective Coulomb traps for the free charge carriers. The realized response times are very close to the fundamental capture time derived from the pump-probe experiments.

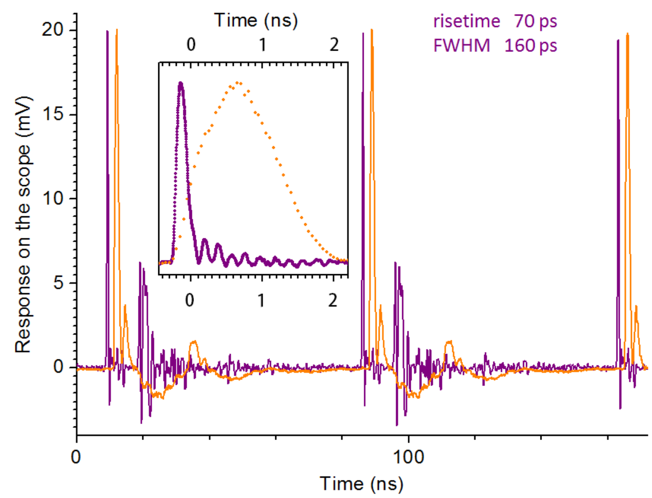

Fig. 1 Typical mid-infrared responses on ~6 ps optical pulses of the free electron laser (FELBE, HZDR) taken with a compensated Ge detector (purple curve) and with an uncompensated Ge detector (orange curve). The relative shift in time between responses on a main graph is introduced for a better view. Afterpulse oscillations occur due to reflections in the cables inside the cryostat.

III. ACKNOWLEDGEMENTS

This research was partly supported by the joint German-Russian program "Research on technological advances of radiation sources of photons and neutrons based on accelerators and neutron sources in cooperation with research organizations and Universities of the Federal Republic of Germany" (InTerFEL Project, BMBF No. 05K2014 and the Russian Ministry for Science and Education, No. RFMEFL 61614X0008). N. Deßmann and A. Pohl gratefully acknowledge support by the Helmholtz Research School on Security Technologies. Authors are grateful to P. Michel and the FELBE team for their dedicated support.

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