Terahertz induced optical second harmonic generation from silicon surface

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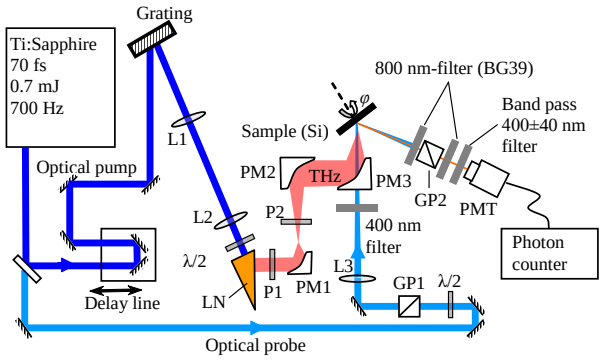
Second harmonic generation (SHG) of optical radiation from surface is one effective technique for surface diagnostics [1]. It is well known, that in bulk media with inversion center the second harmonic generation is prohibited in the dipole approximation. However, the surface breaks the symmetry and allows SHG. In this regard, the second harmonic (SH) signal is extremely sensitive to the state of the surface. The SHG technique allows to measure inhomogeneities of the surface, dynamics of fast processes, such as fast melting under the action of femtosecond laser pulses, contains information about the surface states of the material. An application of the external field on the surface can significantly change the second harmonic signal [2,3].

In this work, we investigated influence of intense THz field on SHG from the silicon surface (111).

A Ti:Sp femtosecond laser system at 795 nm with energy of 0.7 mJ, duration of 70 fs and repetition rate of 700 Hz was used in the experiment. Optical radiation was divided into two beams (see Fig.1). The pump beam was used to generate THz radiation by the tilted intensity front technique in a LiNbO3 crystal



[4,5]. The terahertz radiation was focused on the sample using a system of off-axis parabolas. The maximum THz field in focus reached a value of 300 kV/cm. For the attenuation of THz fields were used two THz polarizer. A probe laser pulse focused on the sample in the spot of about 100 μm (smaller than the size of the THz spot). The second harmonic radiation generated from the surface was detected by the PMT connected to the pulse counting system. The polarization properties of the SH was controlled by polarizer GP2. The special filters was used to block laser radiation.

Fig. 1. Experimental setup (L1, L2, L3- lenses; PM1, PM2, PM3 – parabolic mirrors; LN – LiNbO3; GP1, GP2 – Glan-Taylor prism; P1,P2 – THz polarizer)

In the course of the experiment, the generation of second harmonic at different combinations of polarization of optical and THz radiation was investigated. Under application of THz field, the SH signal was significantly increased when second harmonic and THz electric fields were parallel. In the case when THz, first and second harmonic electric fields have *s* polarization, the SH signal increased by 30 times. The dependences of the SH signal on the energy of optical and THz pulses, on the delay time between them, and the dependence on the azimuthal angle (rotation angle of the sample) were investigated. In Fig. 2 an example of angular dependence is presented, where all fields (THz field, field of the first and second harmonics) have *p* polarization.

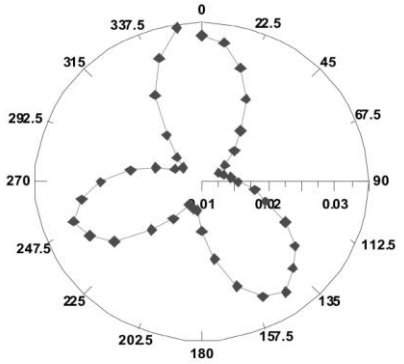


Fig. 2. Angular dependence of SH intensity: optics P-polarization, THz field P-polarization, SH P-polarization

To describe the experimental results, the phenomenological theory of second harmonic generation from (111) silicon surface was developed with account of presents of THz field. By comparison with experimental data, it was found that THz induced source of SH is in phase with the source of SH without THz field.

References

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