the long wavelength it is the dimension of the antenna. The presented detector is well suited for a large number of pulsed laser sources like optical-parametric oscillators and amplifiers or difference-frequency mixers, which makes it a very interesting device for multicolor ultrafast spectroscopy.

Notably, the device presented in this work did not allow gating of the graphene, which leads to a high conductivity without photoexcitation. Gating the Fermi energy to the Dirac point, which would maximize the dark resistivity, should strongly enhance the device performance and lead to a lower NEP [37]. Theoretical studies indicate that even single photon detection in the THz range may be possible with a graphene based bolometer cooled to low temperatures [38]. However, gating of the full structure would deteriorate the fast response. Hence, local gating of just the inner part would be necessary, which would require a much more challenging fabrication procedure.

The continuous coverage of such a wide frequency range enabled by the combination of graphene as a detector material and SiC as a substrate to our knowledge is not reported for any other fast detector. Surprisingly, the response of the detector does not change significantly for wavelengths within or just outside the reststrahlenband. Since in this region the dielectric constant of the substrate varies strongly, also the antenna impedance is expected to vary strongly, resulting in a change of both the impedance matching of the graphene flake to the antenna and the antenna to free space. Note that the matching of the antenna to free-space can be strongly improved in the THz region by applying a hyperhemispherical substrate lens e.g. made of silicon. However, such a lens would restrict the spectral response for the reason just discussed and, even more importantly, because this lens itself would be opaque in the region of lattice vibrations and in the range of interband absorption.

5. Conclusion

In this work we have demonstrated ultrafast detection of laser pulses over an enormous range of wavelengths – spanning from the visible (780 nm) to far-infrared (496 µm). Although the NEP of the device, which is in the 100 $\mu W \cdot Hz^{-1/2}$ range, is rather high, it is still low enough to reliably detect laser pulses in the nJ range; making it a suitable detector for table-top THz sources. The simple structure of the two-terminal device that is based on CVD graphene on SiC makes this device a superior solution for temporal alignment of short laser pulses at various wavelengths.

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