Sound and Light in Graphene Aerogels

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Photo-thermo-acoustic (PTA) loudspeakers [1, 2] transduce light into sound wirelessly and without any bulk electro-mechanically moving parts, as for conventional loudspeakers. Also, they can be integrated with standard silicon complementary metal-oxide semiconductor (CMOS) fabrication techniques. The ability to generate, amplify, mix, and modulate sound in a passive opto-acoustic device would revolutionize the field of acoustics. Recently, we demonstrated that graphene aerogels efficiently generate sound by PTA effect [1].

So far graphene loudspeakers [2] have been realized using PTA transduction. These devices are based on single-layer graphene deposited on a substrate. Despite the major part of heat is dissipated in the substrate, thus reducing the PTA conversion efficiency, those devices are able to operate in a wide frequency range up to tens of kHz.

Here, we show that the ultimate PTA efficiency of graphene aerogels can be experimentally achieved by tuning their mass density. The limiting theoretical efficiency can be obtained owing to the particular morphological, thermal, and optical properties of the aerogels. Furthermore, we illustrate that graphene aerogels can generate sound with wavelength-independent light from the terahertz to the ultraviolet range, behaving as an omni-directional point-source throughout the audible range with low or even no total harmonic distortion. We believe that our research represents a breakthrough for hi-fi audio-visual consumer technologies and it could pave the way to opto-acoustic sensing devices.

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References

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Figures

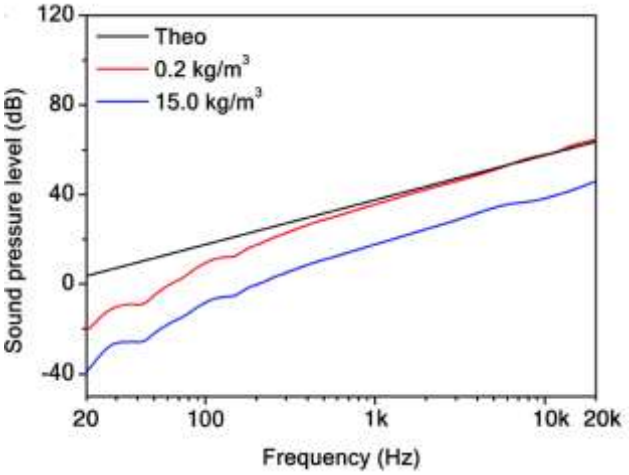

Figure 1: Density-dependent PTA frequency response in carbon aerogels. a, Unweighted SPL frequency response at the input power of 1 W and recorded at 1 m distance from the source for two carbon aerogels with effective mass density 0.2 kg/m^3 (red solid curve) and 15.0 kg/m^3 (blue solid curve). The black solid curve represents the limiting analytical PTA model with no free parameters.