Supplementary Information

Coherent detection of terahertz radiation with graphene

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S1: Direct deposition of ultrathin graphitic material

The direct deposition of ultrathin graphitic material was synthetized on a 0.5 mm thick fused silica substrate. At first a 10 nm thick nickel layer was thermally evaporated on the silica substrate. Followed by the evaporation, the sample was spin coated with 450 nm thick nLOF (AZ 2070) resist layer and baked on a hot plate (1 min/110 C).

Next, the sample was baked in 800 C, hydrogen atmosphere (1 mbar, 15 sccm flow) for 10 minutes. At this temperature, the Ni film melted and receded while simultaneously it was acting as a catalyst in the graphitization process, while resist ribbons were the solid carbon precursor. Thus, the CVD resulted melted Ni particles and inside a graphitic thin film [1]. By a very short oxygen plasma process (15 s/20 sccm/100 W), we removed graphitic film covering Ni particles. Nickel particles were then removed by wet etching in CuSO4-HCl-H2O solution and thereafter the sample was rinsed well in water. The final thickness of graphitic film was 80 nm (measured by stylus profiler).

S2: Characterization of ultrathin graphitic material

To characterize the properties of ultrathin graphitic material synthesized by direct deposition CVD we employed SEM, Raman and optical absorption spectroscopy methods. From SEM and by Raman characterization one can see (presented on Figure S1 (a, b)) the polycrystalline nature of graphitic films deposited by direct CVD technique. More specifically, the SEM image presented on Figure S1 (a) shows holed graphitic film while the strong D peak (at 1355 cm^{-1}) in Raman spectrum (Figure S1 (b)), indicates high disordering. Characteristic "graphite" G peak in the Raman spectrum is located at 1582 cm^{-1} with full-width-half-maximum of 52 cm^{-1}. Furthermore, at around 2700 cm^{-1} one can observe strong second order 2D peak indicating on high structural ordering of the polycrystalline graphene ribbons and similarity of their optoelectronic properties to perfect graphene [S2].

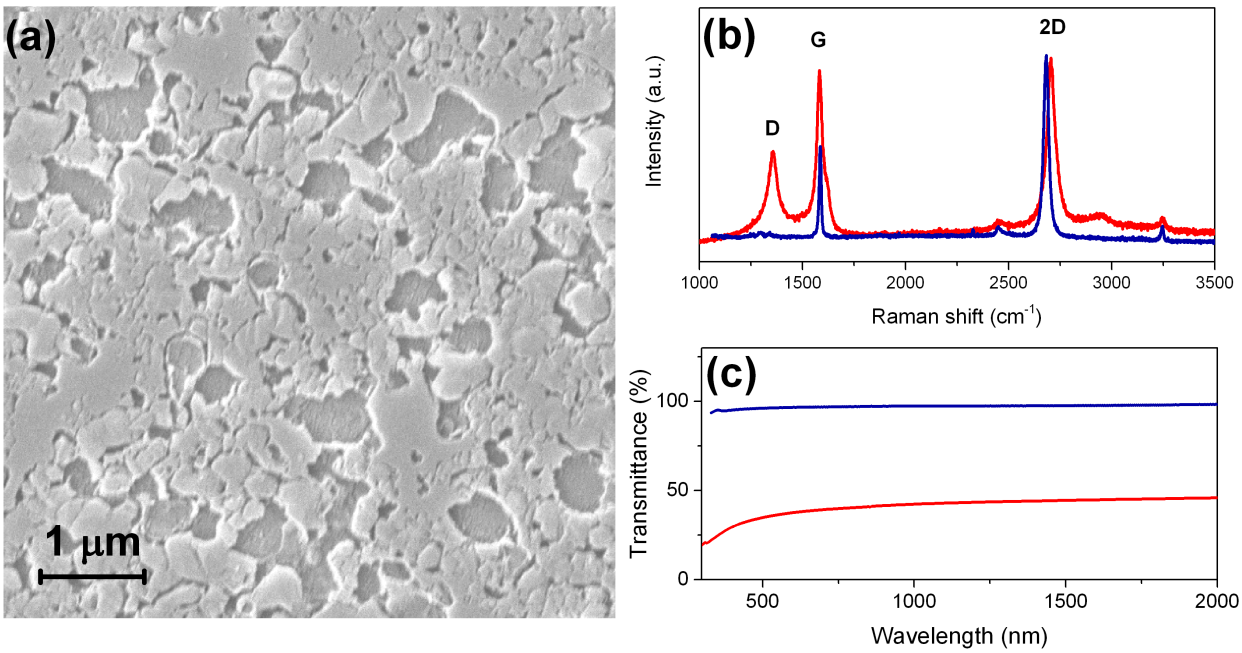

Figure S1:

SEM image of the directly deposited ultrathin graphite film is shown on (a); Raman (b) and optical transmission (c) spectra of directly deposited ultrathin graphite film and single layer graphene are shown with red and blue color correspondingly.

Another experimental evidence of perfect graphite (or graphene) tipe structure of the films, produced by direct CVD, is almost constant values of optical absorption in visual and near infrared spectral regions. Furthermore, the fabricated material shows a clear absorption peak near 260 nm, which is similar to the M-saddle point absorption in graphene (shown on **Figure S1 (c)**). Despite the fact that the directly deposited ultrathin graphite contains a large number of defects, being a grainy, polycrystalline material (**Figure S1 (a)**), its optical properties are similar to multilayer graphene (or thin crystalline graphite).

S3: Fabrication of THz detectors

The THz detectors were fabricated on a half-millimeter thick fused silica (FS) substrate by direct CVD synthesis of graphitic material. To create ribbons, the resist layer was patterned by electron beam (Vistec EBG 5000+), post baked (1 min/110 C) and developed in AZ 347

developer for 90 seconds. After the e-beam lithography and development, the sample was rinsed with water. Now the sample consisted 250 μm wide, 450 nm thick resist ribbons on 10 nm thick Ni film. Electrical contacts for graphitic ribbons were done by sputtering and using a shadow mask.

REFERENCES

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