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Background-Free Ultrafast Pump-Probe Transmission Spectroscopy of Graphene JOSEPH R. MURPHY, Department of Physics, University at Buffalo, State University of New York, TIANMU ZHANG, TIM THOMAY, ALEXANDER N. CARTWRIGHT, Department of Electrical Engineering, University at Buffalo, State University of New York, SAIMA HUSAINI, ROBERT G. BEDFORD, Sensors Directorate, Air Force Research Laboratory, Wright-Patterson Air Force Base — Graphene and graphene-related materials exhibit properties of interest for optical applications. Time-resolved pump-probe spectroscopy has been proven an effective tool to measure the time scales of carrier dynamics of materials with adequate absorption. Ultrafast measurements are challenging to conduct due to graphene's low absorption of 2.3% per layer and time scales of the carrier dynamics in the sub-picosecond range. To perform these experiments, laser pulses with a duration of 200 fs from the 800 nm beam from an amplified Ti:sapphire laser system with a repetition rate of 250 kHz were used with energy densities as low as 4 $\mu J/cm^2$. The difficulty of the detection of the low absorption in this single-color experiment is further exacerbated by the need to distinguish the signal in the probe beam from the noise present in the two beams used. We present the results from a background-free technique used in our ultrafast pump-probe measurements; these results reveal the presence of electronic processes with time scales on the order of 500 to 700 fs in multilayer graphene. This background-free technique uses optical chopping to modulate the pump and probe beams at different frequencies and we have found that this method significantly improves the signal to noise ratio.

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