Coherent Acoustic Phonons and Ultrafast Carrier Dynamics in Hetero-Epitaxial $BaTiO_3$-$BiFeO_3$ Films and Nanorods

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Abstract: The improved coupling between electric, magnetic, optical, and structural order parameters found in multiferroic $BaTiO_3$-$BiFeO_3$, generate the desire to explore novel functionalities in these lead-free systems. In order to obtain information to develop high speed multifunctional devices, we performed time-resolved differential reflectivity measurements of (1-x) $BaTiO_3$ -(x) $BiFeO_3$, with x = 0.725 and $BaTiO_3$-$BiFeO_3$ nanorods. We report a quantitative study of ultrafast carrier dynamics in $BaTiO_3$-$BiFeO_3$, by diffusion of the photoexcited carriers away from the surface and that the ambipolar diffusion constant is below 1-2 cm^2/s. We also report the detection of coherent acoustic phonons(CP) in both film and nanorod samples at lower temperatures (100 K). In the film sample, we estimated the CP frequency to be ~ 27 GHz. In the Nanorod sample, we observed a higher frequency oscillation and a lower frequency oscillation with a frequency of ~ 33 GHz and 8 GHz. We attributed Higher frequency oscillations to be coherent acoustic phonons and we explain two probable origins for the lower frequency case. The lower frequency is close to a theoretically predicted magnon frequency in BFO, but the strength of this oscillation only had a very weak magnetic field dependence. Another explanation for this feature could be multiple reflections of the acoustic phonons at the Pt interfaces due to the large acoustic impedance mismatch.