Coherent exciton dynamics in InP nanowire clusters

M. T. Larson[1], S. Alyami[1,4], C. A. Ulrich[2], N. Wang[3], W. W. Wong[3], H. H. Tan[3], C. Jagadish[3], H. P. Wagner[1]

[1]Department of Physics, University of Cincinnati, Cincinnati, OH 45221, USA
[2]Department of Physics and Astronomy, University of Missouri, Columbia, MO 65211
[3]ARC Centre of Excellence for Transformative Meta-Optical Systems, Department of Electronic Materials Engineering, Research School of Physics, The Australian National University, Canberra, ACT 2600
[4] Department of Physics, Najran University, Najran 11001, KSA

We investigated the coherent exciton dynamics in uncoated and Al_2O_3 coated wurtzite InP nanowires to explore their potential as media for studying strong coupling and quantum entanglement effects. This was accomplished by performing power and excitation wavelength dependent three-beam heterodyne four-wave mixing (HFWM) measurements using a photon echo configuration. For these experiments, the nanowires were removed from their substrate and transferred onto a sapphire slide. The measurements were performed at 14 K to mitigate coherence loss due to phonon scattering. A tunable 150 fs Ti:sapphire laser was used as an excitation source.

Through these studies we have noted several effects which depend on the length and coating of individual nanowires. First, the HFWM amplitude is strongly polarization sensitive, showing a stronger amplitude for nanowires with their long axes orientated perpendicular to the exciting source polarization. This can be explained by the weak momentum matrix element along the long axis of wurtzite phase nanowires. Second, generally all measured nanowires possess significantly shorter coherence times than bulk material which is attributed to a weak thermal contact between the nanowires and the sapphire slide leading to higher equilibrium temperatures. Third, the exciton dephasing time in uncoated nanowires is shorter than in coated nanowires, the latter possessing a slight inhomogeneous broadening. Finally, long nanowires display a longer exciton dephasing time along the τ_{3ref} delay axis than in the τ_{12} delay scan and an apparent beating structure (see Figure 1) both of which are absent in the short wires. We tentatively attribute this behavior to a cavity effect leading to a modification of the HFWM signal.

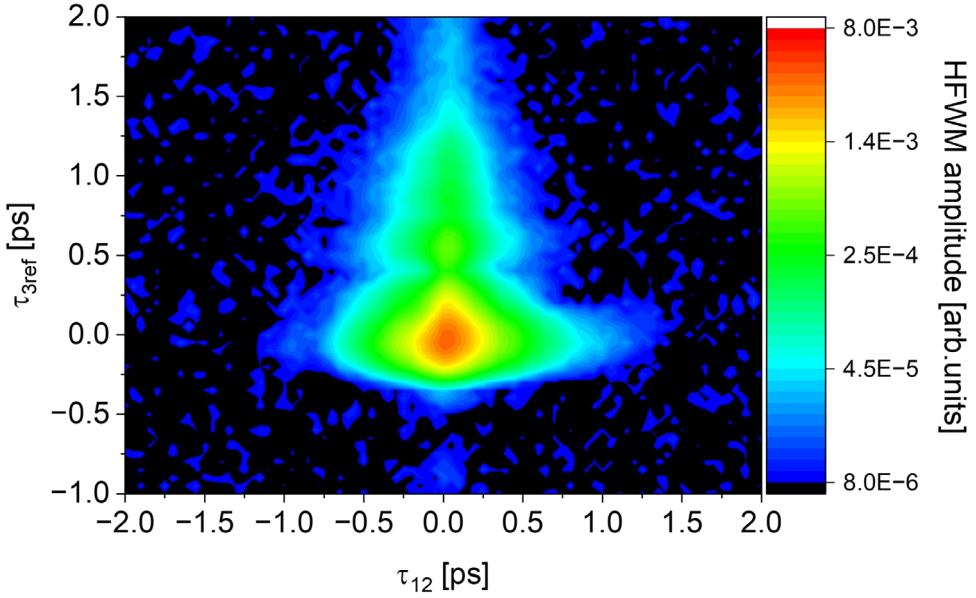

Figure 1: 2D contour plot of the HFWM amplitude on a logarithmic scale varying delays τ_{12} and τ_{3ref} for a cluster of uncoated InP nanowires at 14 K. The measurements were performed with collinear polarized electric fields. The excitation power for pulses in direction $\mathbf{k}_1$, $\mathbf{k}_2$ and $\mathbf{k}_3$ were 1, 1 and 1 mW, correspondingly.

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*Email: wagnerhp@uc.edu