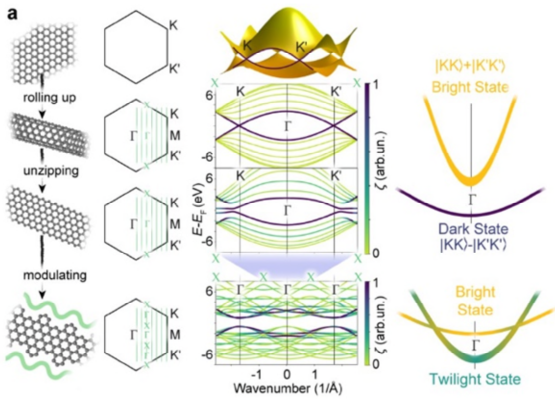
Magneto-optical spectroscopy of new exciton states in Cove edged individual graphene nanoribbons with magnetic fields

RJ Nicholas[1], BK Sturdza[1], RA Taylor[1], MK Riede[1], F Kong[1], X Yao[1] and L Bogani[1], Physics Dept., Materials Dept., Oxford University,

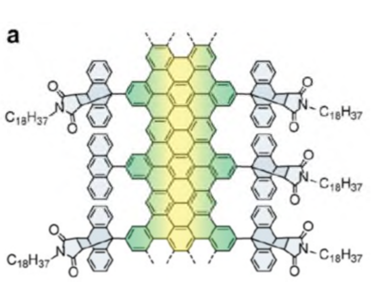
Wenhui Niu[2], Ji Ma[2], XinLiang Feng[2], TU Dresden, Dresden Germany, MPI Microstructure Physics, Halle, Germany, and

C. Faugeras[3], EMFL, Grenoble, France



We have recently demonstrated a dramatic improvement in the optical properties of graphene nanoribbons by the use of chemically synthesized ribbons which have a well-defined structure and width. Adding a regular side chain to the ribbon creates a one dimensional superlattice and strongly inhibits aggregation. As a result, we see narrow excitonic ZPL (Zero Phonon Line) emission from thin films as described in our latest work (Sturdza et al, Nat. Comms. https://doi.org/10.1038/s41467-024-47139-1) and most recently in ribbons deposited on silicon where the ribbons lie flat to the surface. The cove-edge superlattice structure strongly brightens the emission by folding and mixing the nanoribbon dispersion (figure above) creating newly emissive 'Twilight States'. Applying a magnetic field introduces the equivalent of a Rashba shift to the two opposite edge-states which generates a spin polarization across the ribbon, and shifts and splits the dispersion relations of the superlattice significantly (Do et al, PRB 103.115408, 2021). The superlattice unit cell is approximately 0.8 x 1.2 nm in size giving the potential for magnetic commensurability (Hofstatter type) oscillations, and is almost the same area with which we have seen large Aharonov-Bohm type effects in carbon nanotubes. We are about to look for these effects in very high magnetic fields (experiment planned June 2024) using imaging spectroscopy which can detect individual nanoribbons which have linewidths approximately 30 times smaller and which couple to specific nanoribbon RBLM (Radial Breathing Like Mode) phonons.

As shown below we have recently succeeded in observing PL from individual ribbons where the linewidths are less than 0.5 meV. These individual ribbons should enable us to see the development of the spin polarization and follow the development of the magnetic states at high precision.



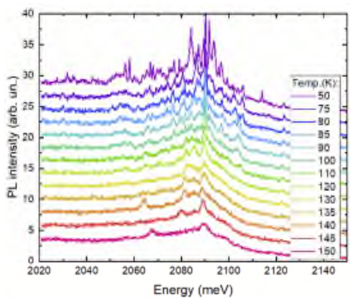


Figure shows the nanoribbon structure (left), and the temperature dependence of Micro-PL from 1 micron spots of a high density (right) film of GNR deposited onto silicon substrates