Manipulation, Assembly & Characterization of Optically Functional 1-D Organic Nanostructures.

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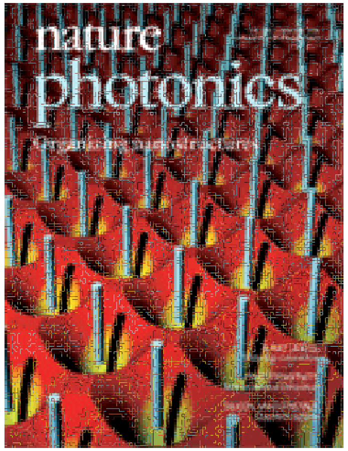
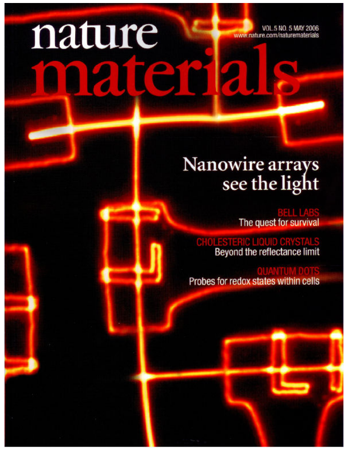
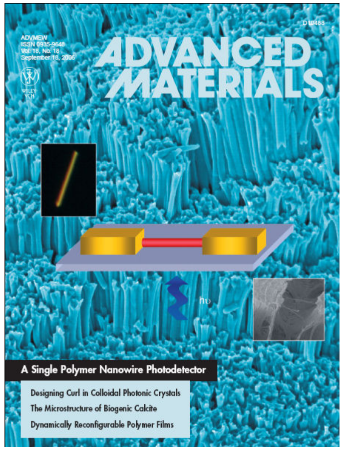
1-D Nanostructures

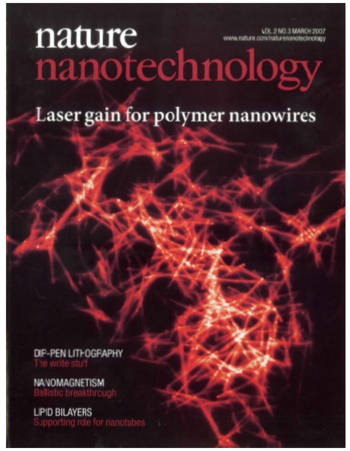
Inorganic 1-D Nanostructures





Organic 1-D Nanostructures



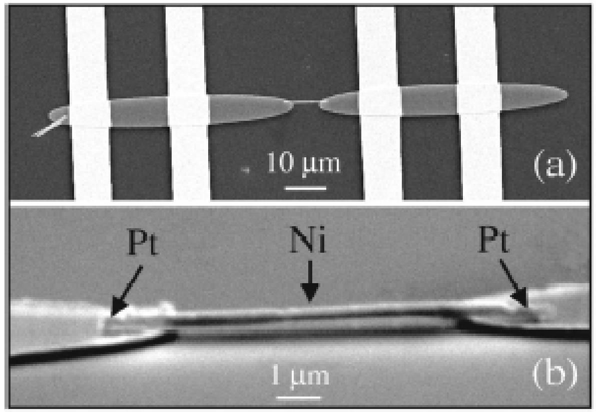


- Inorganic 1-dimensional (1-D) nanostructures have been developed for next generation nanoelectronic and nanophotonics – IBM, Intel, NASA, university labs.

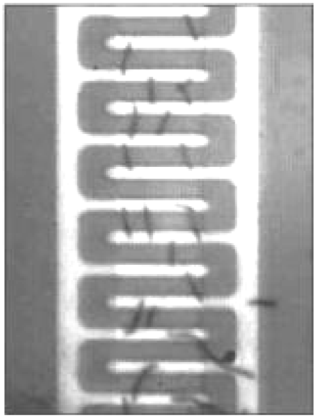
- Recent interest in developing functional organic 1-D nanostructures because of highly tunable electronic and optical properties of organics.

- **Controlled, high-yield assembly routes are required for viable 1-D nanodevices.**

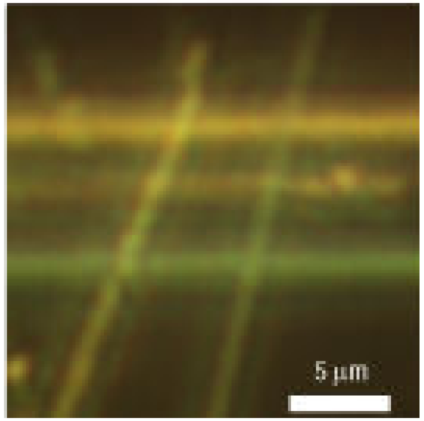
Bottom-up Assemblies: State of the Art



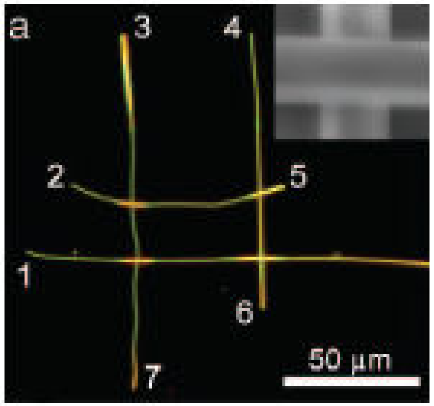
Magnetic



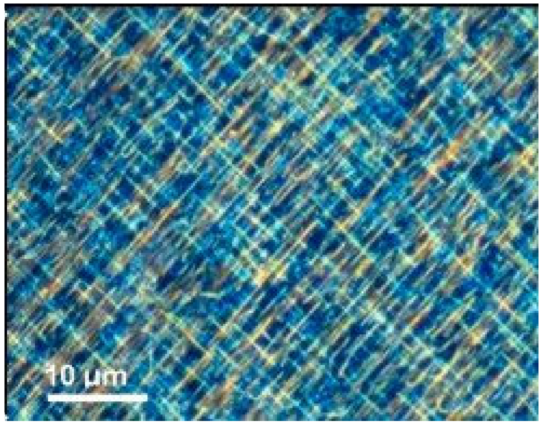
Electric



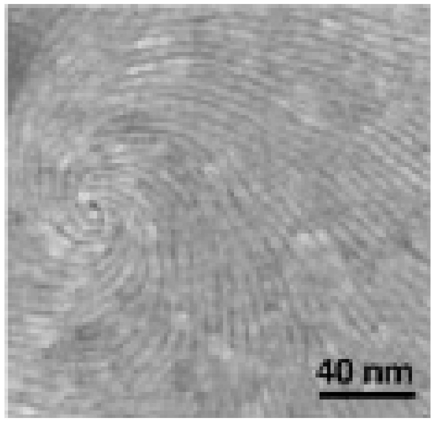
Optical



Probe



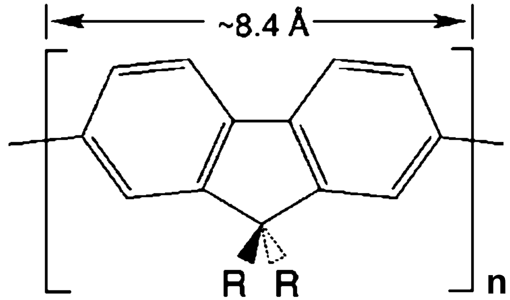
Shear



Langmuir-Blodgett

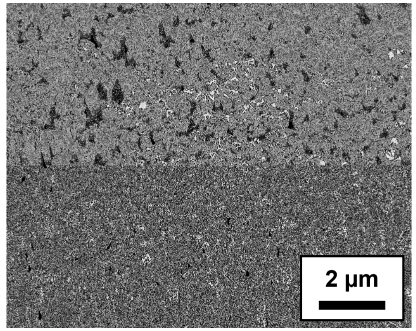
Organic Nanostructure Synthesis

- Poly(9,9-dioctylfluorenyl-2,7-diyl) - a blue emitter
- Thermal & chemical stability.
- High PL quantum efficiencies (50 - 70 %)
- Chemically tunable emission.

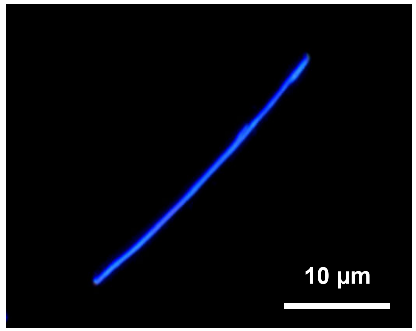


R = C_8H_{17}

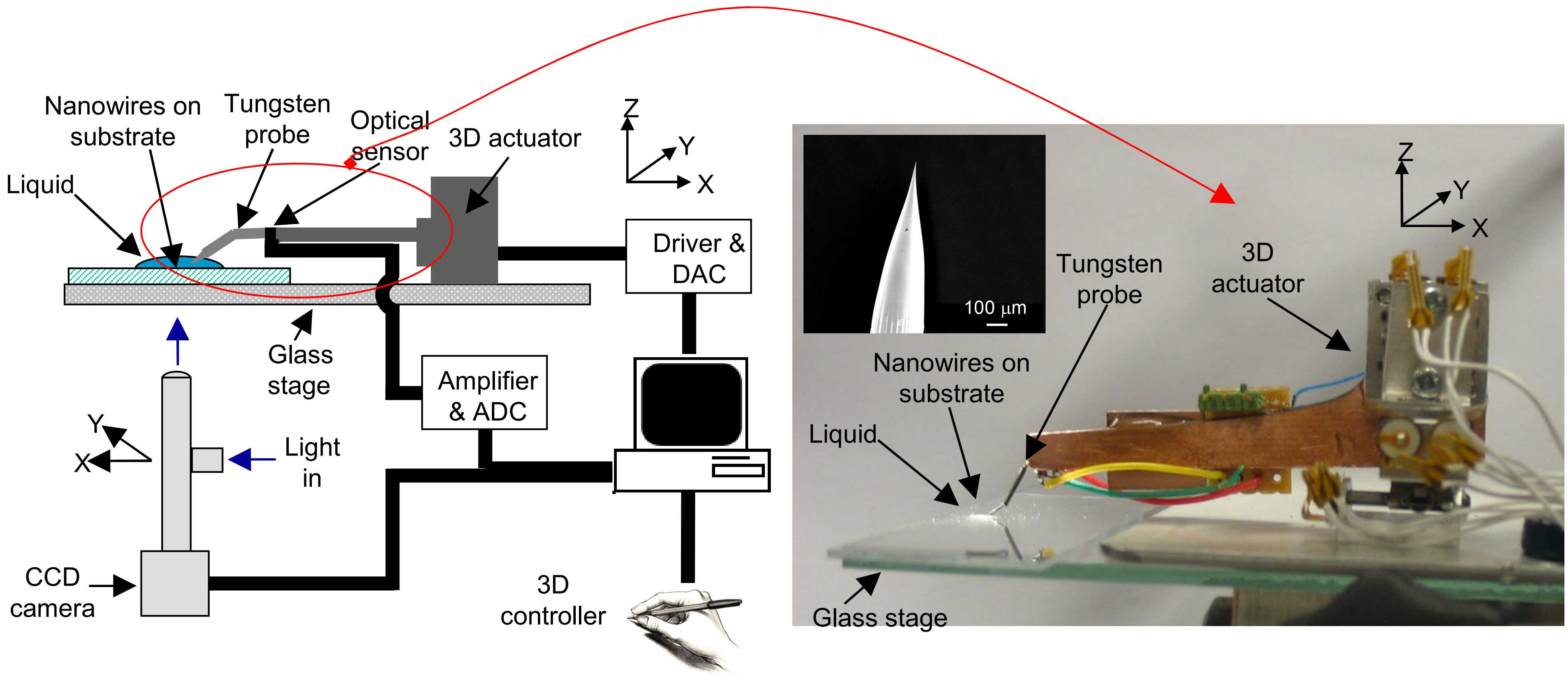
Nanowires synthesized by solution wetting template method.



- Nanowire shape: Cylindrical.
- Nanowire diameters: 20 – 400 nm.
- Nanowire length: ~ 15 µm
- Nanowire yield: ~ 10^9.



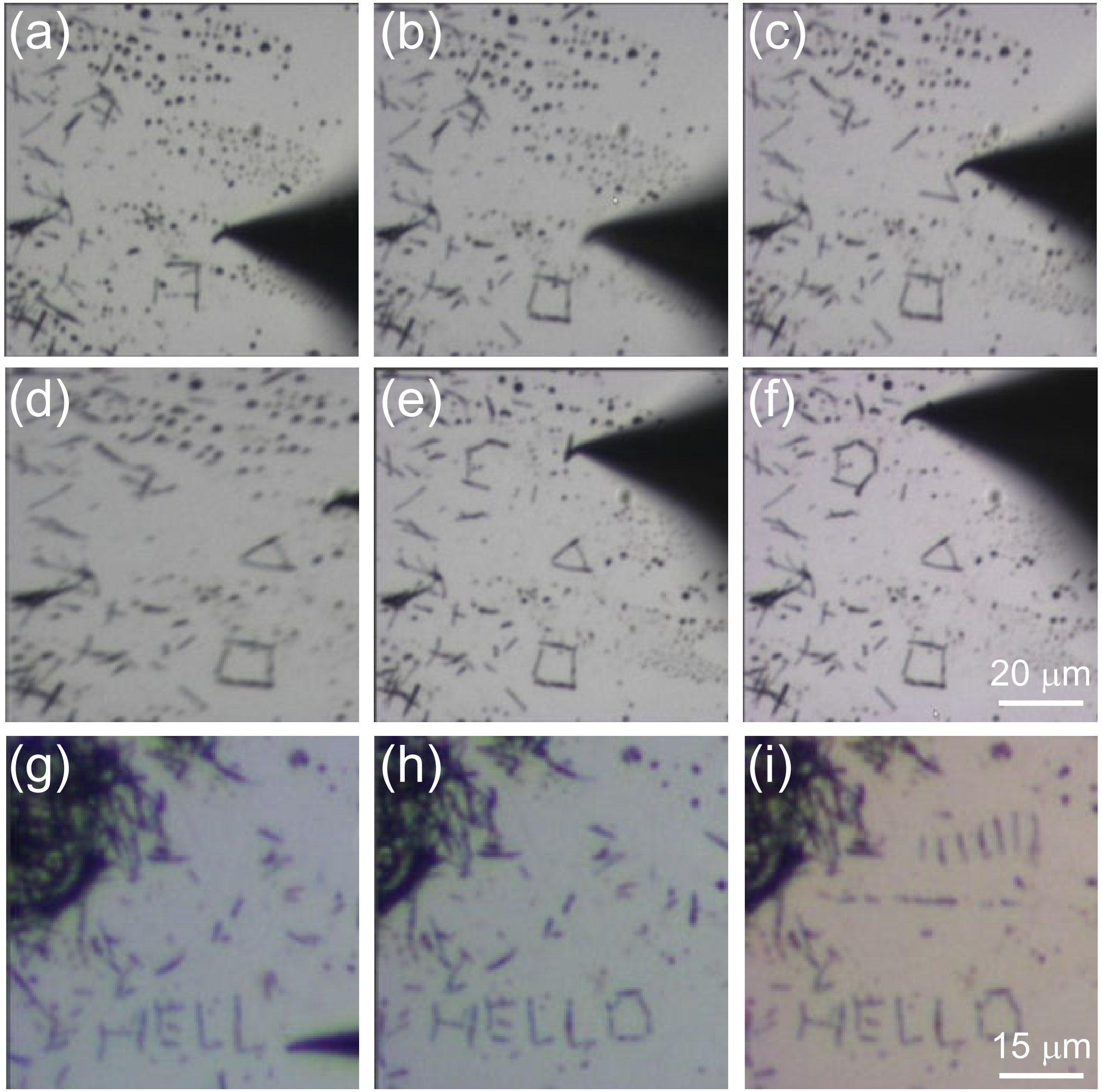
Custom built Probe System



** in collaboration with Dr. Marko Pudas, University of Oulu, Finland & NanoGalex Ltd.*

** Publication arising from this work submitted to Nanotechnology.*

Manipulation of Inorganic Nanowires



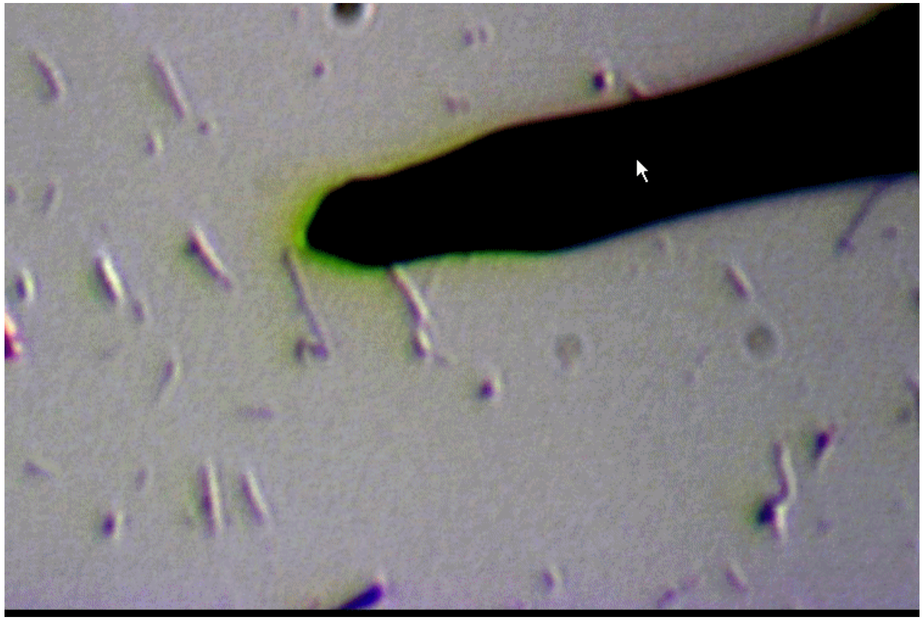
Platinum Nanowires

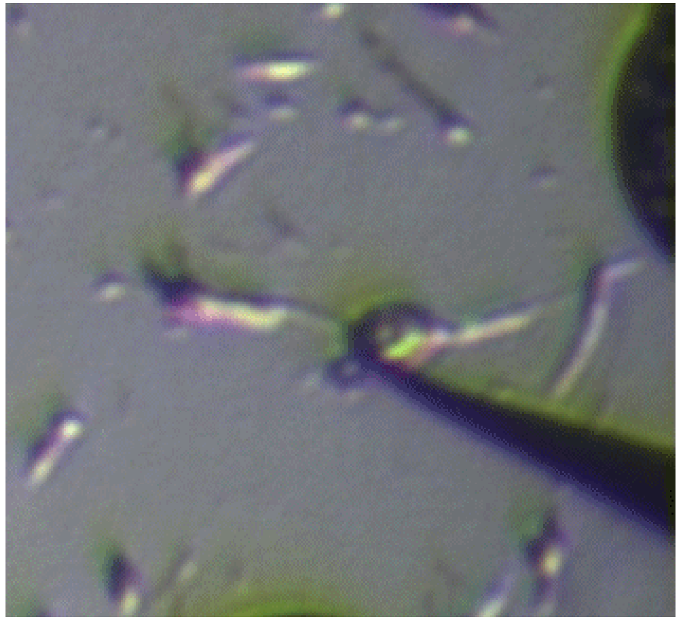
Assembly times

Square:	120s
Triangle:	180s
Hexagon:	300s
Average:	50s

Manipulation of Organic Nanowires

PFO Nanowires





<u>Assembly times</u>

Line 1 (8 wires): 600s

Line 2 (5 wires): 240s

Average: 60s

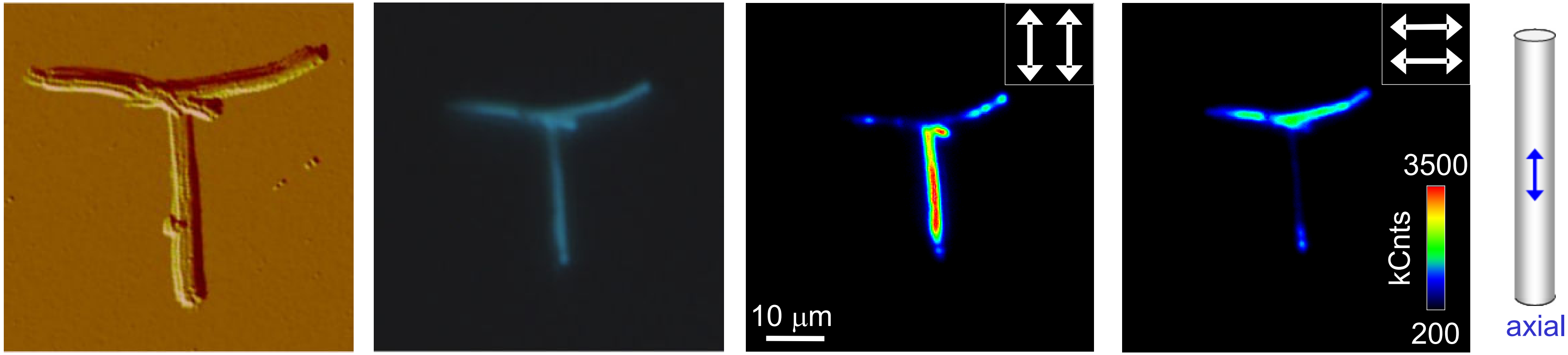
Square 1: 540s

Square 2: 180s

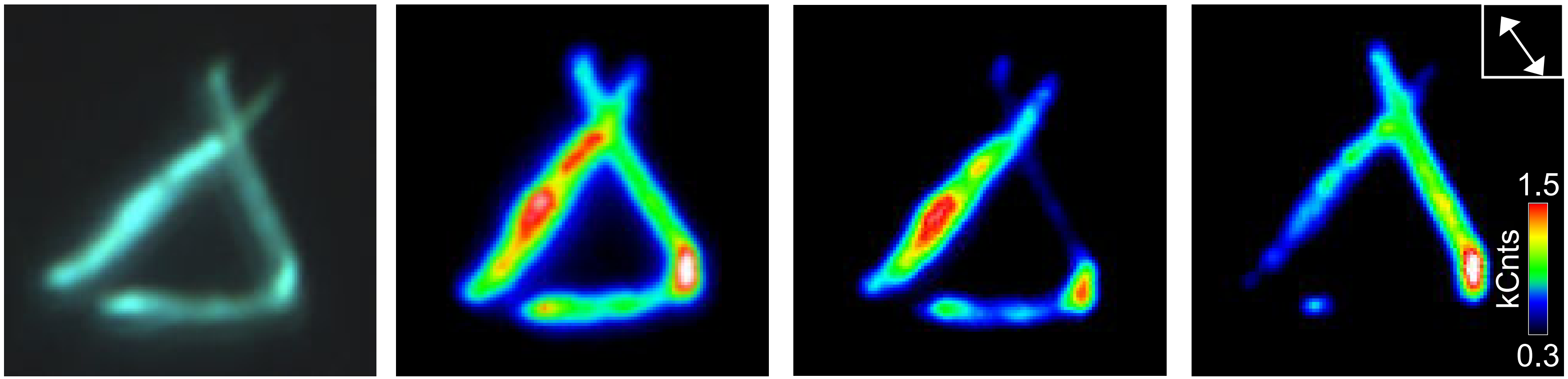
Triangle 1: 180s

Triangle 2: 180s

Mesostructure Characterization



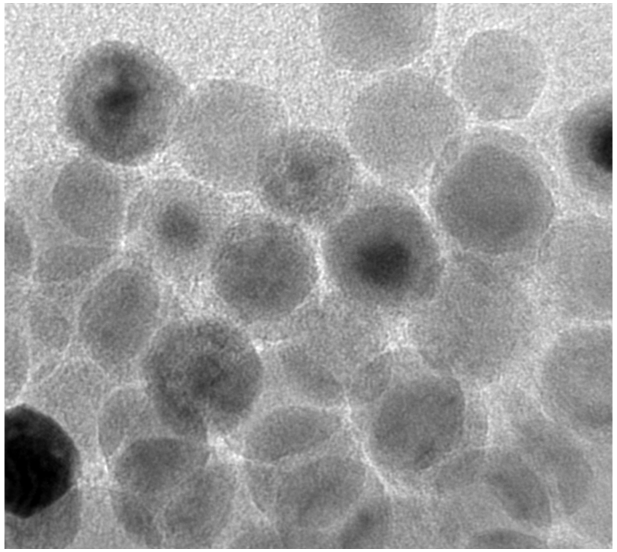
- Minimal damage to polymer nanowires.
- Net alignment of the polymer chains parallel to the long axis of each wire.



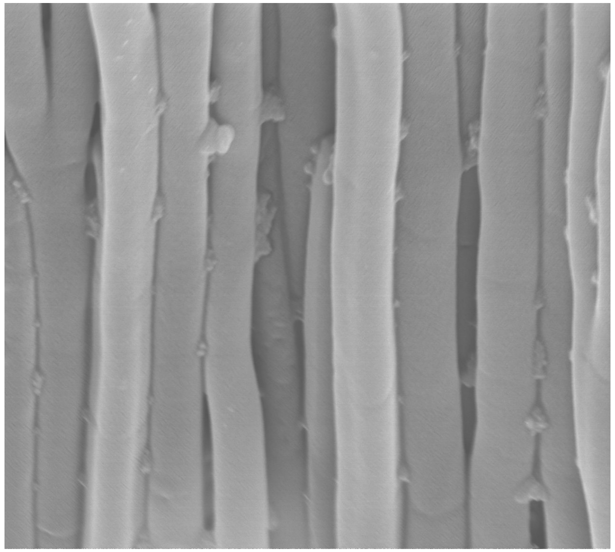
- 2 NW mesostructure – longer wire bent to form 2 sides of a triangle.

Magnetically doped Organic Nanowires

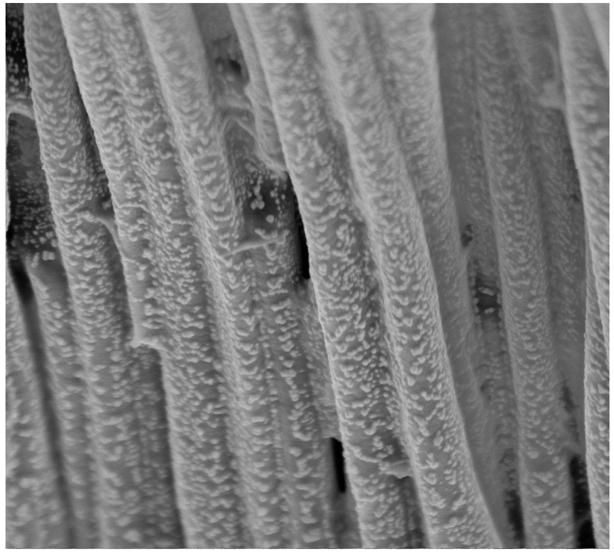
Nanocrystals	+	PFO nanowires	=	**Nanocrystal doped PFO nanowires**



20 nm Fe_3O_4 nanocrystals.



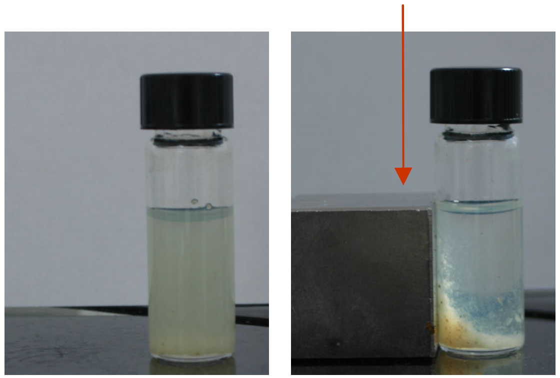
Nanowire diameter ≈ 230 nm



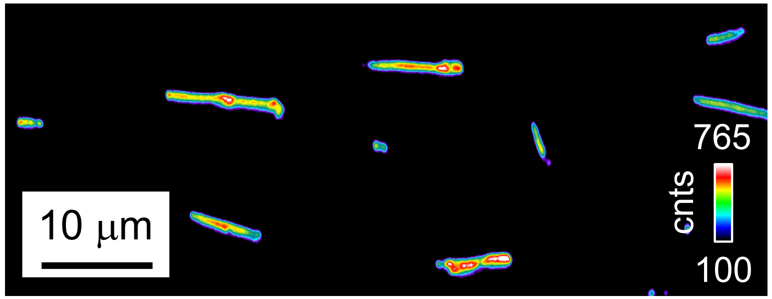
Hybrid inorganic/organic nanostructures

Doping had minimal effect on NW's internal molecular structure & optical properties.

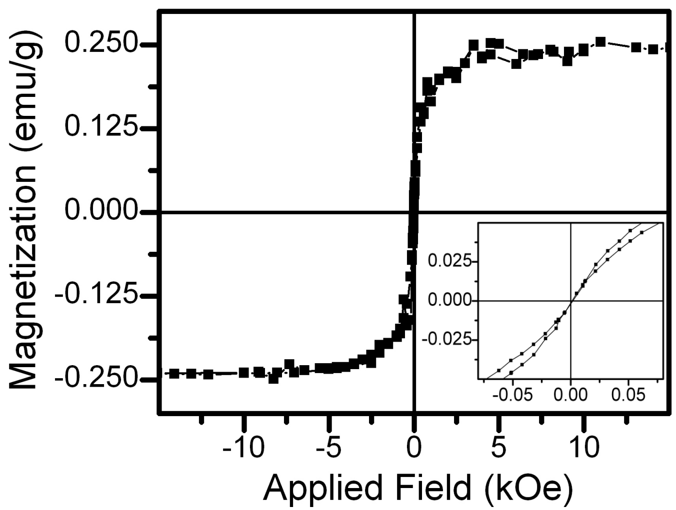
Magnetic Manipulation of Organic Nanowires



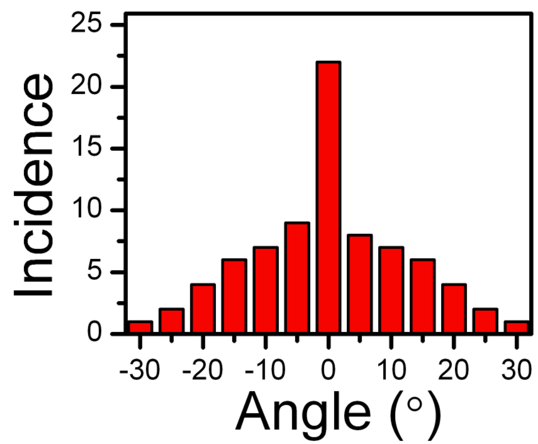
Magnetic extraction



Static magnetic alignment

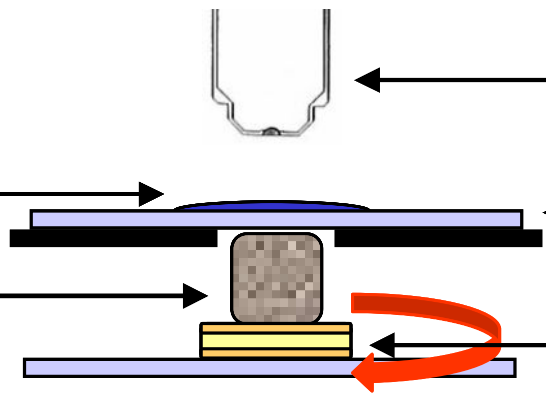


Superparamagnetic response



Alignment characterization

Magnetic Manipulation of an Organic Nanowire

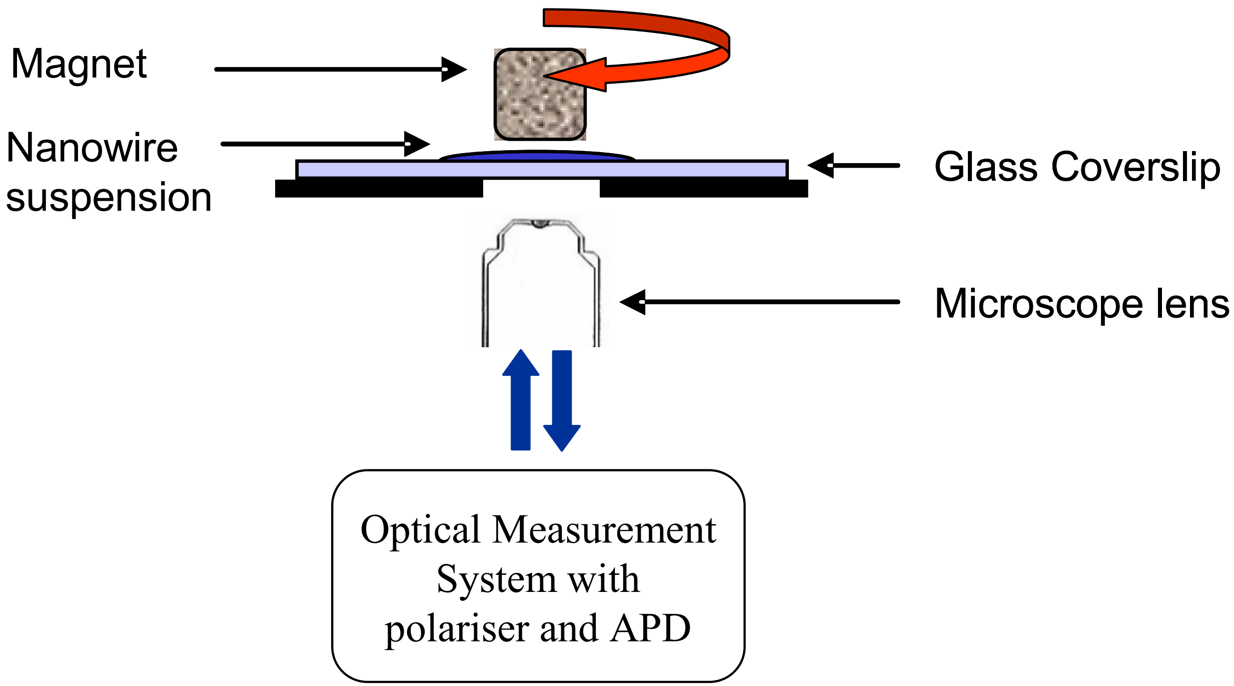


Dynamic Magnetic Manipulation

Nanowire length: 12μm

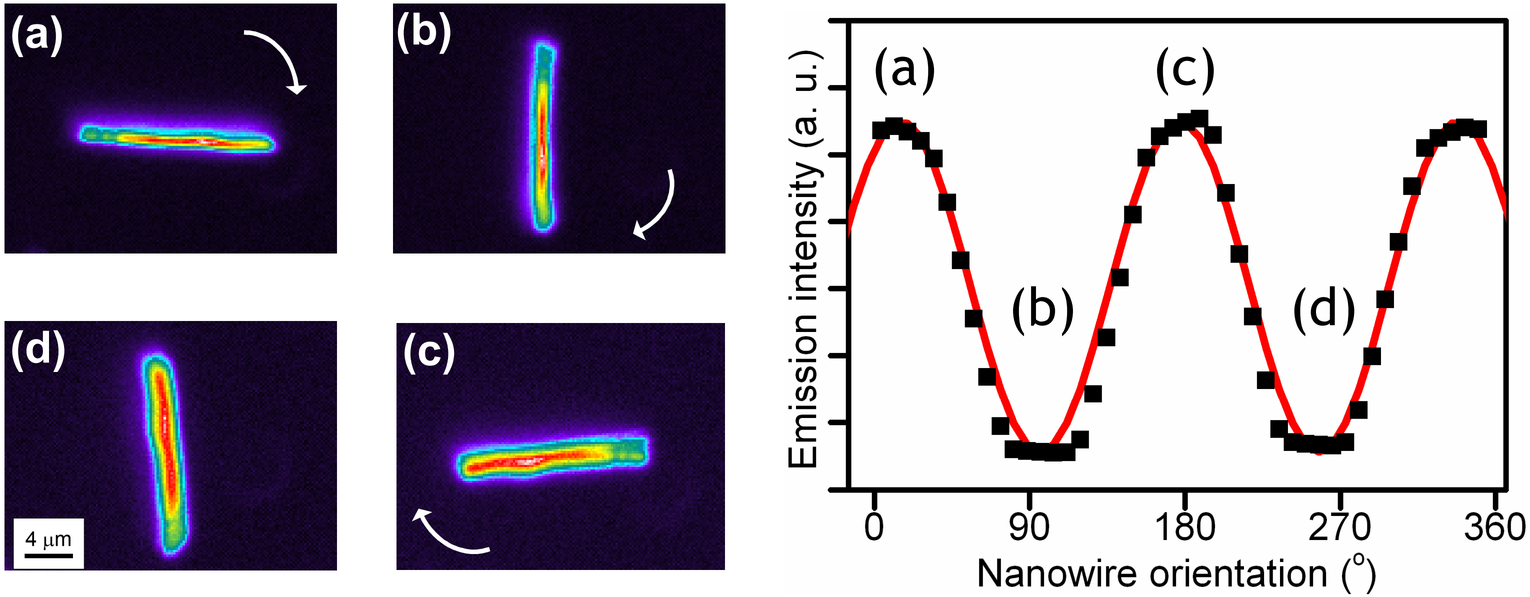
Polymer nanowire based nanorotor

Clocking an organic nanorotor by monitoring its intrinsic emission anisotropy



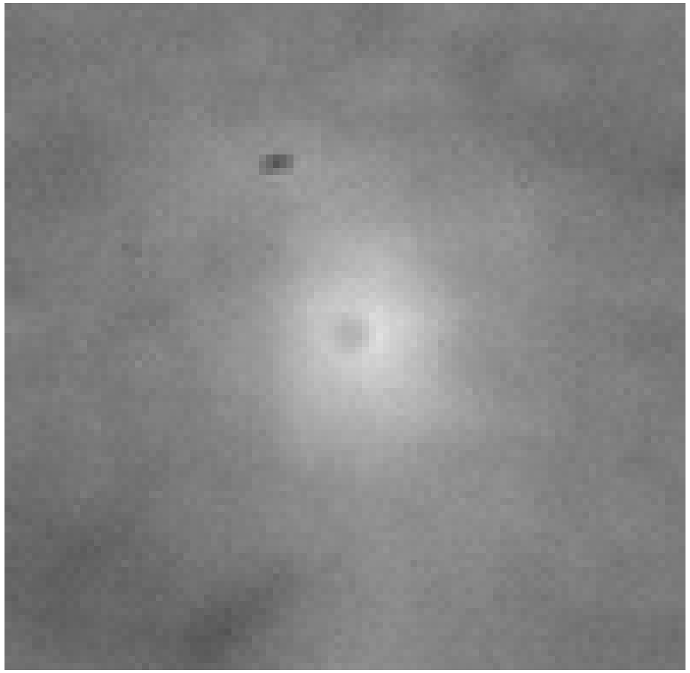
Single nanowire rotated by a magnet and its photoemission measured by an APD having passed through a longitudinal polariser

Clocking an organic nanorotor by monitoring its intrinsic emission anisotropy



Monitoring the wires intrinsic emission anisotropy results in a $\pi/2$ sinusoidal modulation of fluorescence intensity recorded at an APD.

Optical Trapping of Organic Nanostructures



- For a PFO NW of $L = 3\ \mu m$, $\phi = 250\ nm$, spring constant k: $1.1325\ pN/\mu m$.
- Future work

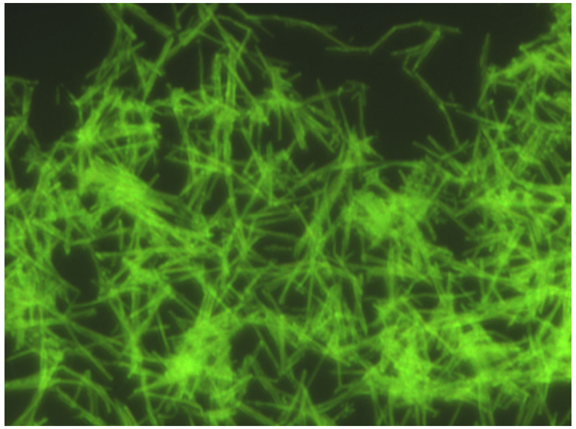
  (1) nanowires/tubes interactions

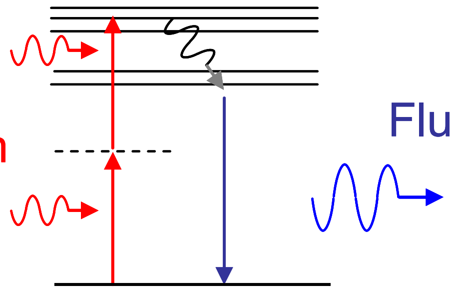
  (2) k-based sorting of various nanowires values.

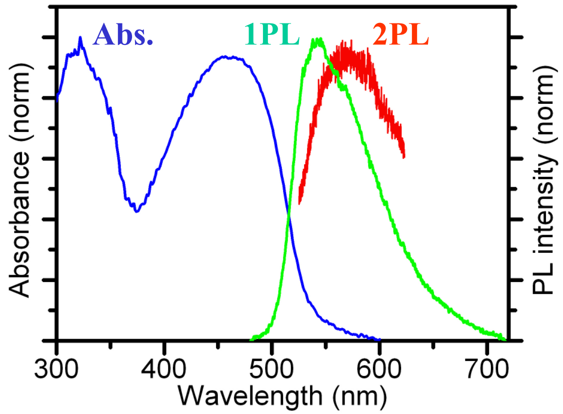
  (3) Large scale assembly using holographic optical trapping.

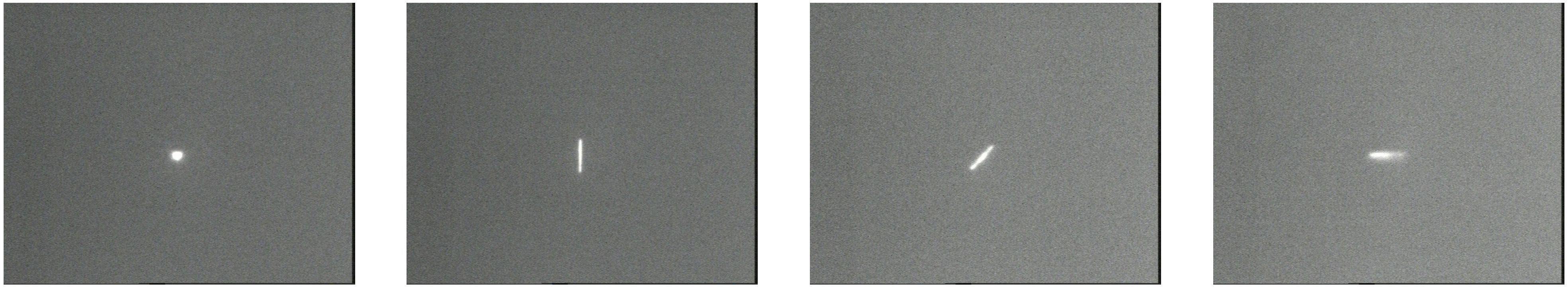
** in collaboration with Dr. Phil Jones, University College London, UK.*
& Prof. John Ketterson, Northwestern University, USA.

Optical Trapping of Organic Nanostructures









- F8BT nanotube is trapped vertically in a static trap then pulled into the horizontal and shown in three different orientations.
- While in trap laser induces 2-photon emission in nanotube. Not seen in PFO.
- Possible application: Nanotube based scanning probe.

Summary

- Developed a range of synthesis and assembly methodologies for organic nanostructures.
- Probe-based system for rapid prototyping of 1-D naostrucutre based devices/systems.
- Developed hybrid organic/inorganic nanostructures.
- Demonstration of a doped polymer nanowire as a nanoroter undergoing 360° rotation under the influence of a rotating NbFeB magnet while clocking its polarized fluorescence.
- First demonstration of polymer nanowires and nanotubes manipulated using an optical trap.