# Terahertz lights up the nanoscale: Paving the way for nanotechnology via terahertz spectroscopy

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As our reliance on technology continues to increase, the demand for smaller, faster devices with increased functionality is constantly growing. Just think how much thinner and smaller your phone has become in the past few years! Nanomaterials are rapidly finding their way into our everyday lives with a range of applications, from electronics and solar cells to biomedical, such as drug delivery and sterilisation. However, if we really want to harness the advantages of these nanomaterials, we need to understand their fundamental optoelectronic properties. How fast are electrons moving in the material? How efficient are they at converting light to an electric current? This is where terahertz spectroscopy comes in.

The terahertz frequency range (1011 to 1013Hz) provides the perfect probe for investigating electronic processes within these nanomaterials. The energy range of terahertz radiation extends over the energies of several typical quasiparticles, such as free electrons and holes, plasmons, magnons and polarons. Scattering rates between these mobile charge carriers also occur on a timescale of 10-14 to 10-12 seconds, placing them firmly in the terahertz frequency range. In this talk, I will show how terahertz spectroscopy can examine the ultrafast carrier dynamics of an ensemble of semiconductor nanowires, allowing characterisation of photoconductivity lifetimes, mobility and doping levels. Finally, I will discuss how terahertz spectroscopy can be combined with atomic force microscopy to probe individual nanostructures on nanometre length scales with surface sensitivity, presenting the first terahertz microscopy study of topological insulator thin films. This novel microscopy technique will provide a huge amount of ‘untapped’ material information that will be vital for future device development.