Laser-fabrication of electrocatalysts from nanoparticles to single atoms

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Precious metal-based *electrocatalysts* have been considered as the best candidates for applications in energy conversion and storage, including electrochemical processes in fuel cells, due to their excellent electrocatalytic performance towards the reactions occurring at both anode and cathode. To minimize the usage of precious metal and enhance its catalytic property, one of the key efforts has been devoted to designing nanoscale materials as the size of metal nanoparticles decreases to nanometer, or down to atomic levels, their catalytic performance can be effectively improved due to increased number of exposed surface atoms and further modification for the ratio of undercoordinated atoms.

At The University of Manchester, we have developed laser-assisted fabrication methods to generate Pt-based electrocatalys, aiming to explore the potential of laser fabrication methods for effective size reduction of nanomaterials from nanoparticles to single atoms. The Pt nanoparticles of ~5nm are achieved through laser ablation and refinement; The Pt-nanoparticles of ~2nm on reduced graphene oxide supporting material are achieved by laser-assisted solution route and the Pt single-atoms on reduced graphene oxide are achieved by laser-assisted solid-phase synthesis via simultaneously photo-reduction of graphene oxide and metal precursors. The electrochemical characterisation demonstrates that the laser-fabricated catalysts exhibit comparable electrochemical activity to the commercial Pt-based catalyst but with ultrahigh precious metal utilization. With the size down to atomic level, the atomically dispersed Pt on graphene support exhibits a small overpotential of -42.3 mV at -10 mA cm^{-2} for hydrogen evolution reaction and a mass activity tenfold higher than that of the commercial Pt/C catalyst.

Such laser synthesis methods can avoid the use of harsh chemicals, are simple, ultrafast and potentially scalable. It can be readily extended to other metals and supporting materials for mass production of functional single atom catalysts (SACs) for various applications.