Laser Annealing as a platform for manipulating materials' morphology, structure, optical and electronic properties.

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Advanced materials are becoming increasingly important as substitutes for traditional materials and as active elements in new and unique applications. They have had a considerable impact on the development of a wide range of strategic technologies. Structural ceramics, biomaterials, composites, optical materials and advanced semiconductors fall under this particular category. Even though these materials can be fabricated by conventional schemes, material processing with lasers is an expanding field which is drawing considerable attention. In particular laser processing has been employed in many applications to modify materials' properties. As lasers offer several advantages such as spatial and material selectivity, flexibility and automation, the scope for materials' laser processing is further increased.

Recent developments in the use of lasers to probe material properties and importantly the fundamental understanding of the underlying laser-matter interactions are described in this seminar. We borrow examples from three important technological and research sectors, where laser processing can be proven a promising innovation:

- Plasmonic nanostructuring: Nanoconstruction of metals is a significant challenge for the future manufacturing of plasmonic devices. Such a technology requires the development of ultra-fast, high-throughput and low-cost fabrication schemes. Laser processing can be considered as such and can potentially represent an unrivalled tool towards the anticipated arrival of modules based in metallic nanostructures, with an extra advantage: the ease of scalability. Specifically, laser nanostructuring of either thin metal films or ceramic/metal multilayers and composites can result on surface or subsurface plasmonic patterns, respectively, with many potential applications. The photo-thermal processes involved are discussed and processes to develop functional plasmonic nanostructures with pre-determined morphology are demonstrated.

- Rapid photochemical conversion of sol-gel metal oxides for thin film transistor applications: Solution processed metal-oxide fabrication has offered huge promise for the development of high-mobility metal oxide semiconductors and devices that can be manufactured over large areas employing simple fabrication methods. Unfortunately, such methods require a thermal treatment step in order for the condensation and densification of the MO phase to occur. This process presents several disadvantages: the high thermal budget and prolonged exposure times, rendering the process incompatible with plastic substrates. To this end, laser annealing offers fast processing along with rapid, precise and selective energy delivery in area and depth via critical laser energy absorption, demonstrating that laserinduced photochemical conversion of sol–gel metal oxide precursors can be rapid and suitable for the manufacturing of large-area electronics.

- Manipulation of the optical and electronic properties of transparent conductive oxides (TCOs): Functional oxide materials including aluminium doped zinc oxide (AZO), indium tin oxide (ITO) and indium gallium zinc oxide (IGZO) are of interest for numerous electronic applications because of their visible light transparency combined with controllable electrical characteristics. The potential for nanosecond excimer laser annealing (ELA) as an ultra-rapid and localised heating mechanism with a low thermal-budget approach to improve the electrical and optical characteristics of radio frequency (RF) magnetron sputtered at room temperature is demonstrated.