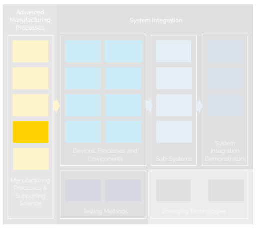

PATHFINDER 2015

ADVANCED MANUFACTURING PROCESSES

Laser annealing for improved flexible electronics (LAFLEXEL)

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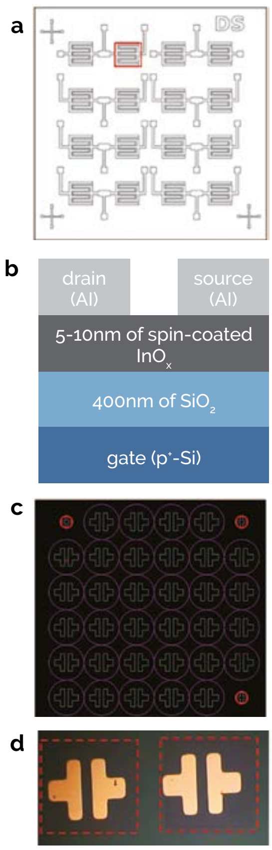
The "Laser Annealing for improved FLEXible Electronics" (LAFLEXEL) project aims to deliver high performance metal-oxide thinfilm transistors (TFTs) by introducing a photonic process, namely laser annealing. LAFLEXEL has focused on metal oxides, which represent an emerging family of semiconductors for application in future generations of TFTs. Most of the recent efforts have been focusing on: (i) improving the carrier mobility, (ii) improving the operating device stability and (iii) development of alternative deposition and post-processing methods with the ultimate aim the lowering of process temperature. Despite the tremendous promise shown in recent reports on optical sintering, the lengthy exposure times needed renders the process unsuitable for roll-to-roll manufacturing. Therefore, alternative methods that can deliver speedy and scalable conversion methods are urgently required.

In LAFLEXEL we are overcoming this limitation through the development of a fully automated excimer laser annealing (ELA) process. The method is demonstrated for room temperature conversion of InO_x and In_4ZnO (sol-gel) and IGZO (sputtered) thin films and their application in high performance TFTs. Our approach allows facile optimisation of the process conditions using a versatile system developed at Nottingham Trent University to meticulously vary parameters including: fluence, number of pulses, wavelength, environmental parameters (pressure, chemical composition) and temperature of the substrate.

In collaboration with Imperial College London, we have successfully fabricated InOx-based TFTs, prepared by spin-coating. Metal oxide conversion was confirmed, with the best InO_x TFTs reaching a mobility of 14 cm^2/Vs (as high as the current state-of-the-art photochemically activated InO_x TFTs) without the requirement to store them in an inert atmosphere. ELA is capable of changing the electrical characteristics of InO_x in specific areas (selective treatment/patterning) of the film, eliminating the need for a photolithographic step to pattern the semiconductor. As a result, the leakage current of the laser annealed TFTs is always very low, in addition to having a good ON-OFF current ratio.

In collaboration with University of Cambridge, we fabricated indium zinc oxide (In_4ZnO) transistors. TFT devices with similar performance, but with highly improved V_{on}, compared to thermally annealed counterparts have been prepared, employing a three step annealing process: two thermal annealing steps (at 120°C) separated by ELA. This mild thermal annealing process has potential for a unique capability for the preparation of oxide TFT devices on polymeric substrates.

In collaboration with PragmatIC Printing, we have fabricated high performance a-IGZO (sputtered) TFTs on flexible substrates. Effort has been focused on the improvement of the stability and reproducibility of devices, which could lead to reduced production costs, through yield improvement and a reduction in performance spread. Additionally, we have improved the performance of TFTs in terms of hysteresis and ON-OFF current ratio.



a) Interdigitated sample contact layout. (b) Schematic representation of TFT devices. (c) Sample contact layout. (d) TFT devices. The highlighted areas show the regions of laser annealing.