Laser-printing of carbon-based materials for sensor fabrication

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Over the past few years, there has been an increasing interest in utilizing carbon-based materials in the electronic and optoelectronic industries. Although these materials boast numerous advantages, their practical application in devices is hindered by the requirement of specific growth, synthesis, and handling conditions. In the realm of sensors, most of the research is focused on reducing sensor size, detecting various species, and achieving fast response times, minimal hardware requirements, excellent reversibility, sensitivity, and selectivity. The primary challenge in creating the next generation of miniature sensors lies in the complexity of integrating numerous functions into a single device through a singular manufacturing process.

To address these issues, our work has focused on optimizing the laser-induced forward transfer (LIFT) process of carbon-based materials using the shadowgraphy. The LIFT process involves depositing a thin film of the desired material, known as the donor material, onto a substrate that is transparent to laser light. A pulsed laser beam is then focused on the interface between the donor material and the transparent substrate, causing a rapid increase in pressure that ejects and propels a portion of the donor material onto a parallel substrate located in close proximity to the donor material. With the current configuration of LIFT, only insensitive materials like metals or ceramics can be successfully transferred as the laser beam interacts directly with the material to be transferred. However, if the material to be transferred is susceptible to damage from the laser beam, such as proteins or polymers, an intermediate layer is necessary to protect it. This layer, which consists of a triazene polymer layer, is placed between the donor substrate and the material to be transferred and shields it from the laser light and heat generated during the LIFT process. Therefore, to modify the deceleration rate and reduce material stress during LIFT, we investigate both experimentally and via hydrodynamic simulations the role of an intermediate polymer layer.

Furthermore, we have achieved high spatial resolution in the transfer of carbon-based materials, allowing for the development of sensors capable of detecting low concentrations of gases such as ammonia.