**Microscale deposition of 2D materials via Laser Induced Backwards Transfer**

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**ABSTRACT (100 words for program)**

2D materials such as graphene have great potential as the basis for novel optoelectronic devices. Typically, 2D materials are produced via chemical vapor deposition and therefore form continuous layers. Here Laser Induced Backwards Transfer (LIBT) is used to deposit pixels of 2D materials with precisely controlled size, shape and position. In LIBT, part of the laser energy that is absorbed in the donor substrate becomes kinetic energy imparted to the 2D material, causing localised transfer of 2D material onto the receiver. The capability to deposit high-quality intact 2D materials, in well-defined microscale pixels will eliminate costly and time-consuming lithographic processing.

**ABSTRACT (250 words for technical review)**

Laser Induced Backwards Transfer (LIBT)1 is a candidate for next generation additive manufacturing, especially for materials that are unsuited to more conventional methods. Broadening the range and complexity of materials that can be deposited will enable developments in material functionality e.g. for sensing applications, metamaterials and silicon photonics. Here we demonstrate LIBT as a means of achieving intact transfer of 2D materials (such as graphene and MoS2) onto a receiver substrate (which could be a silicon based electronic or photonic device). Typically, 2D materials are produced via chemical vapor deposition and form featureless, continuous layers. In LIBT, part of the laser pulse energy that is absorbed in the donor substrate becomes kinetic energy imparted to the 2D material, this causes localised detachment and transfer of the 2D material onto the receiver. Here, the transfer region is defined by beam-shaping using a Digital Micromirror Device (DMD)2 allowing precise control over the size, shape and positioning of the 2D material deposition. We use high resolution imaging to observe removal of 2D material from the donor substrate and present Raman analysis of the receiver substrate, verifying both that transfer has occurred and that the 2D materials retain their high quality and viability for end applications.

[1] Feinäugle, M. et al., "Laser-induced backward transfer of nanoimprinted polymer elements," Applied Physics A 122(4), 1-5 (2016).

[2] Heath, D. J. et al., "Dynamic spatial pulse shaping via a digital micromirror device for patterned laser-induced forward transfer of solid polymer films," Optical Materials Express 5(5), 1129-1136 (2015).