Inkless Printing Multimaterial Electronics – A Laser-Based Additive Nanomanufacturing Approach

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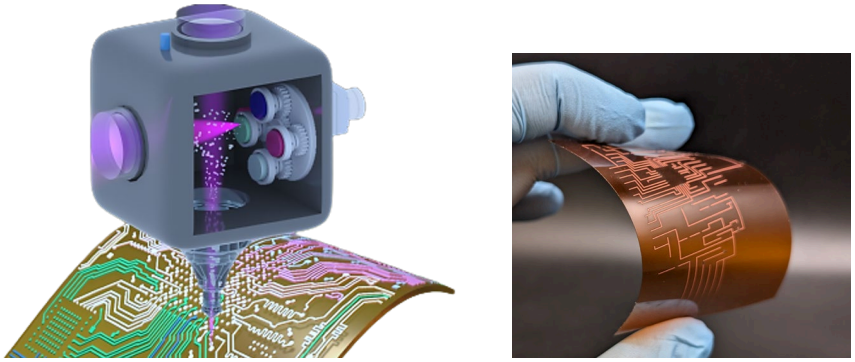
Printed flexible hybrid printed electronics (FHEs) have emerged as a remarkable technology in recent years due to the simple, cost-effective fabrication, reduced e-waste, and development of multifunctional devices. The rising demand for consumer and industrial electronic products that are uniquely fabricated/designed and increasing usage is boosting the demand for this technology. Current techniques rely on ink-based printing technologies such as inkjet and aerosol jet printers, which highly suffer from contamination, expensive formulation procedures, and limited materials sources, making it challenging to print pure and multimaterial devices. In this contribution, I will demonstrate a laser-based additive nanomanufacturing (ANM)[1-3] technique (Figure 1a) that allows dry, pure, solvent-free printing of electronics and functional devices on various substrates (Figure 1b).



(a) (b)

Figure 1. (a) Schematic of dry multimaterial printer. (b) An example of a printed Cu circuit on polyimide substrate.

Pure nanoparticles of various materials, including metals, semiconductors, and insulators, such as silver, copper, zinc oxide, copper, and aluminum oxide are generated in situ and on demand. These nanoparticles are then directed toward the printer nozzle and laser-sintered in real-time to form desired patterns and structures layer by layer. The Key technology advantages include 1) on-demand and in-situ generation of various pure nanoparticles without contaminations, 2) in-situ and real-time laser sintering of nanoparticles on various substrates with no further post-processing, 3) multimaterial printing of hybrid and tunable nanocomposite materials and structures. Several different mechanical and electrical performance tests like bending, cycling, and surface adhesion are performed on the printed devices, which demonstrate their exceptional performance and the considerable impact this technique has on the future of printed sensors and devices.

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[2] Z. Ahmadi, S. Lee, R.R. Unocic, N. Shamsaei, M. Mahjouri-Samani, Additive Nanomanufacturing of Multifunctional Materials and Patterned Structures: A Novel Laser-Based Dry Printing Process, Advanced Materials Technologies 6(5) (2021).
[3] Z. Ahmadi, P. Fathi-Hafshejani, E. Kayali, M. Beidaghi, M. Mahjouri-Samani, Rapid laser nanomanufacturing and direct patterning of 2D materials on flexible substrates—2DFlex, Nanotechnology 32(5) (2020).