ACCURATE & REPRODUCIBLE METHOD FOR SINGLE NANOPARTICLE POSITIONING ON NANOSTRUCTURES

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Controlled integration of metallic nanoparticles (NPs) onto photonic nanostructures enables realization of complex devices for extreme light confinement and enhanced light-matter interaction [1,2]. However, metallic NPs are usually deposited via drop-casting, which prevents their accurate positioning. In our work, I will present a reproducible, single-step, and cost-effective method for the controlled nanopositioning of single metallic NPs [3]. This methodology can be used for both the parallel printing as well as the single positioning of individual NPs onto lithographically fabricated nanostructures with sub-micron accuracy in one single step. It is based on soft lithography printing that employs elastomeric stamp-assisted transfer. Taking advantage of the capillary forces in the elastomeric stamps and a custom-built µ-positioning system, we achieve a single-step single NP transfer yield of up to 28% in a matrix of more than 2300 photonic resonators (Figure 1).

This large-scale approach opens the path towards deterministic Nanoparticle-on-a-mirror (NPoM) fabricated cavities on nanophotonic structures for advanced spectroscopic architectures on-a-chip, showing the potential of building complex photonic nanodevices for applications ranging from enhanced sensing and spectroscopy to signal processing.

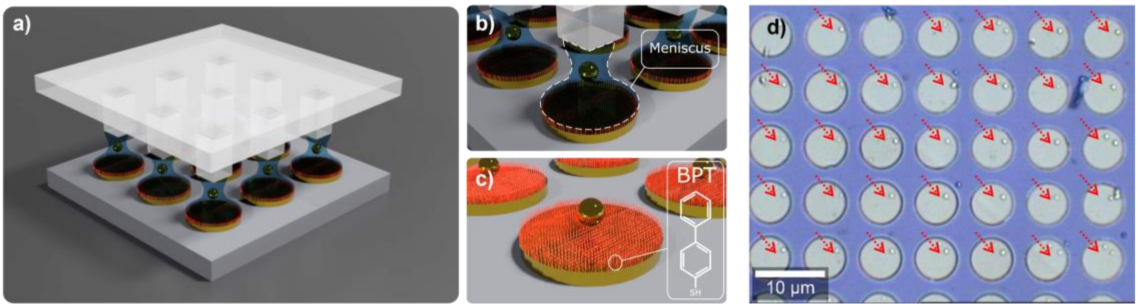

Figure 1. a) Schematic parallel stamp-assisted printing method. b) Meniscus formation between the stamp protrusion and sample. c) BPT Functionalized lithographed Au sample with NP attached. d) Optical image of a Au/BPT disk array after single-step NP transfer. Red arrows show NP positioning.

[1] Ciracì, C.; Hill, R. T.; Mock, J. J.; Urzhumov, Y.; Fernández-Domínguez, A. I.; Maier, S. A.; Pendry, J. B.; Chilkoti, A.; Smith, D. R. Probing the Ultimate Limits of Plasmonic Enhancement. *Science* **2012**, (80-.). 337 (6098), 1072–1074.

[2] Baumberg, J. J.; Aizpurua, J.; Mikkelsen, M. H.; Smith, D. R. Extreme Nanophotonics from Ultrathin Metallic Gaps. *Nat. Mater.* **2019**, 18 (7), 668–678.

[3] J. Redolat, M. Camarena-Pérez, A. Griol, M. Kovylina, A. Xomalis, J. J. Baumberg, A. Martínez, E. Pinilla-Cienfuegos*. Accurate Transfer of Individual Nanoparticles onto Single Photonic Nanostructures *ACS Appl. Mater. Interfaces* **2023**, 15, 2, 3558–3565 https://doi.org/10.1021/acsami.2c13633