Large area free-standing membrane with embedded GaP NWs for flexible optoelectronic devices

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Flexible optoelectronic structures are the envisioned base for modern wearable and curved surface devices. The application list includes personal computers, biomedical and clinical engineering, paper-like displays, foldable touch screens and antennas, lighting devices, displays for smartphones, desktop monitors, and many others [1, 2]. Currently, the most developed and commercially successful flexible technology is based on organic materials [2]. Fabrication of organic light-emitting diodes (OLEDs) is relatively inexpensive and scalable, while OLEDs have remarkably effective electroluminescence [3]. However, organic devices are inferior to III-V inorganic semiconductor materials in terms of stability and external quantum efficiency of the EL in the optical range, especially in the blue and red regions [4].

The thin film technology dominating in the inorganic optoelectronics faces significant difficulties in flexible full color applications. The alternative to thin films is provided by the nanowire (NW) configuration, i. e. III-V crystals with a high aspect ratio of height to diameter [5]. An array of vertical NW LEDs grown on Si substrate can operate independently from the growth substrates, while the small footprint of the NWs allows easy detachment them from the substrate. NW LED arrays encapsulated in a flexible matrix (e. g. silicone elastomer, most commonly polydimethylsiloxane (PDMS)) have demonstrated a remarkable device flexibility. PDMS/NW device fabrication scalability is provided by the possibility to use Si substrates, which is further enhanced by the substrate re-use.

In our work we focus on fabrication scalability, applying the previously developed approach [6] to 3 square inch size samples. This scalability was achieved by the implementation of modified PDMS with improved strength and reduced adhesion to Si substrate, and adaptation of the G-coating method to heavy-load centrifuge. The presented work is not also motivated by LED devices development, but by large scale second-harmonic generation PDMS/GaP structures. This work focuses on the development of flexible free standing large area (exceeding several square inches) *graft*-copolymers of PDMS and polystyrene (PDMS-St) / NW membrane fabrication technique suitable for implementation in commercial applications, e.g. inorganic LED, bright screens or infra-red (IR) viewers.

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