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BOOK of ABSTRACTS

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Low-adhesive functionalized silicone rubbers for flexible light-emitting devices

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Abstract. In this work, phenylethyl-functionalized (SSRs) and 2-methyl-3-methoxy-3-oxopropyl-functionalized (MSRs) silicone rubbers with 25% of phenylethyl and 2-methyl-3-methoxy-3-oxopropyl (SSR25 and MSR25, respectively) were developed and employed as materials for nanowires (NWs) array encapsulation. These silicone rubbers are transparent and displays low adhesion to Si substrate. SSR25 exhibits both substantial elongation at break (ε = 45±5%) and tensile strength (σ = 1.5±0.4 MPa, Young's modulus E = 3.4±0.7 MPa). SSR25 was employed as a supporting polymer membrane for encapsulation arrays of NWs. The obtained SSR25-based membranes were used for mastering hybrid light-emitting diodes (LEDs) based on metal-halide perovskite $CsPbBr_3$ and n-doped gallium phosphide (GaP) NWs. Polyethylene oxide (PEO)–perovskite composite layer was spin-coated upon n-GaP NWs partially encapsulated into SSR25 by G-coating method. Single-walled carbon nanotubes (SWCNT) films were employed as transparent flexible electrodes for the fabricated SSR25-based LED membranes. The flexible air-stable $CsPbBr_3$:PEO/GaP/SSR25/SWCNT LED demonstrates electroluminescence in the green spectral region.

1. Introduction

Commercial polydimethylsiloxanes (PDMSs) such as Dow Corning Sylgard 182 or 184 usually being employed as supporting flexible transparent membrane for flexible NWs-based light-emitting devises[1–3] due to the transparency and relatively good elastic properties [4]. However, the commercial PDMS product Sylgard 184 demonstrate a high adhesion to a silicon substrate hampering the membrane release. These factors determine the high demand for development of new durable transparent polymer materials for manufacturing technology of thin membrane NW devices.

Modification of polysiloxanes by their reaction with various vinyl monomers leads to the increased mechanical strength and reduced adhesion [5].

2. Silicone rubbers synthesis and application

Functionalized silicone rubbers were obtained via catalytic hydrosilylation reaction between styrene (SSR) or methylmetacrilate (MSR) and polymethylhydrosiloxane (PMHS) with Karstedt's catalyst and further cross-linking with α,ω-di(dimethylvinylsiloxy)polydimethylsiloxane (v-PDMS).This method helps to avoid formation of supramolecular structures formation and consequently transparency of formed rubbers.

In addition, the presence of phenylethyl and 2-methyl-3-methoxy-3-oxopropyl substituents in the polysiloxane chains led to the reduction of membrane adhesion to the Si substrate (SSR25 – 0.55 and MSR25 – 0.66 of the Sylgard 184 adhesion value). The resulting silicone rubbers were used for encapsulation of NWs arrays to fabricate flexible and transparent membranes for optoelectronic devices. According to swelling data MSR25 poses lower polymer fraction content $\upsilon = 0.30 \pm 0.01$ and number of stiches in comparison to SSR25($\upsilon = 0.50 \pm 0.01$). Thus, MSR has shown sufficient elongation at break ($\varepsilon = 85 \pm 5\%$) along with weak tensile at break $\sigma = 0.6 \pm 0.1$ MPa and Young's modulus $E = 0.6 \pm 0.1$ MPa. SSR25 portray good mechanical properties ($\sigma = 1.5 \pm 0.4$ MPa, $E = 3.4 \pm 0.7$ MPa) and relatively sufficient elongation at break ($\varepsilon = 45 \pm 5\%$).

Due to the mentioned advantages SSR25 was chosen over MSR25 and used as supporting polymer membrane for flexible NWs-thin layer perovskite-based LED operating in the green spectral range [6]. Here, an SSR25 membrane with partially embedded GaP NWs provides both the mechanical support to all structure and excellent electrical contacting to perovskite layer owing to penetration of NW-based electrodes into perovskite; the thickness of perovskite layer can be increased in comparison with the standard perovskites-based LED architecture.

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