Electronic Supplementary Material

Highly effective transfer of Micro-LED pixels to intermediate and rigid substrate with weak and tunable adhesion by thiol modification

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Section S1. Prevent SWP tape from deforming when spin-coating PS solution

SWP tape will deform when exposed to toluene and therefore we cannot spin-coat PS directly on its surface. Hence, we use an intermediate glass substrate that is made by sticking 3M double-sided tape on the surface of ordinary glass. Then, we stick the SWP tape on it. During spin-coating of PS solution, SWP tape will not deform due to the rigid substrate beneath.

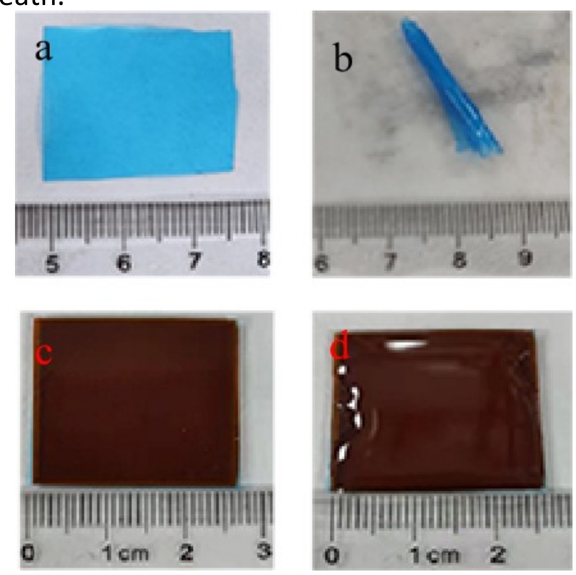

Figure S1. The role of the intermediate glass substrate is to prevent the SWP tape from deforming when it encounters toluene. (a) and (b) are the optical photos before and after the toluene is dripped on the SWP tape; (c) and (d) are optical photos of the SWP tape attached to the 3M double-sided tape.

Section S2. Optical microscope images of the transferred Micro-LED pixels at different positions on IRS

High-magnification optical microscope images showed that the pixels were transferred to IRS with sacrificial layer-assistance without changing the spacing of the pixels and leaving no residue on the pixel surface.

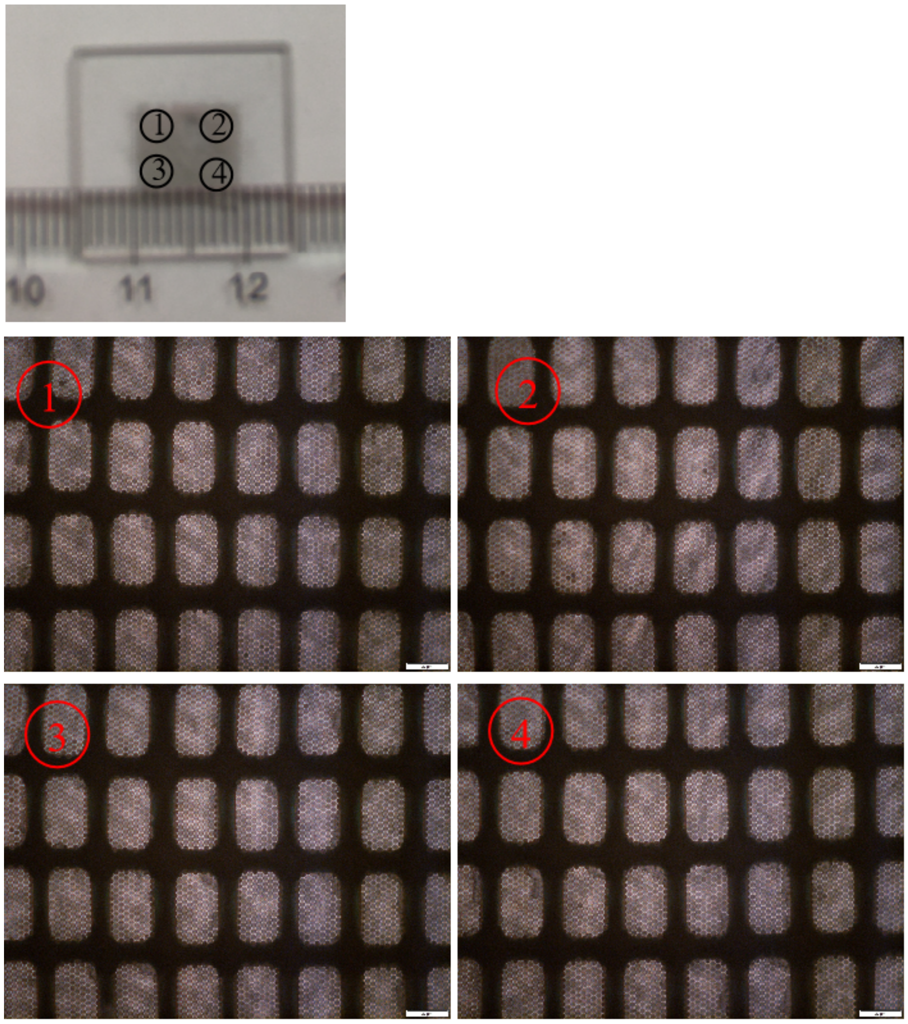

Figure S2. Optical microscope images corresponding to four different positions of the transferred Micro-LED pixels on the IRS (1-4 Scale bar 20 μm)

Section S3. Optical photo of gold-plated silicon wafer adhered to the surface of IRS

Gold-plated silicon wafers were adhered to the IRS surface by the method described in the experimental section, and then the gold-plated silicon wafers remained adhered to the IRS surface after UV light was irradiated from the backside. We can measure the change of the adhesion force before and after UV irradiation through the home-made force measuring instrument.

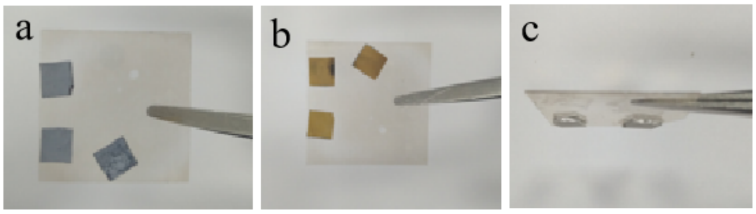

Figure S3. Optical photos (a-c) from different angles show that the gold-plated silicon wafers still adhere to the IRS surface after UV irradiation.

Section S4. Exploring the role of PS film in the process of pixel transfer

We have identified the role of PS in our process as 4-folds. First, the PS material is in between the pixels that are on the SWP tape. It helps keep the pixels as an ensemble when transferring. Second, the PS has to be on the top surfaces of the pixels to prevent them from directly contacting the PI tape that is used to transfer, as otherwise it is very hard to release the pixels from the PI tape. Third, the PS needs to be easily dissolution in order to release the pixels after transfer. Fourth, this dissolution process must be peaceful enough so that the pixel spacings are not affected. We use PI tape to transfer pixels with and without the coated PS film, and in both cases ~100％ of the pixels can be separated from the SWP tape. However, different scenarios occur when removing the sacrificial PS. In order to prepare a toluene containing PDMS pad (20 mm× 20 mm×15 mm), prepolymers and curing agent (Sylgard184, Dow Corning Co. Ltd.) are mixed in weight ratio of 10:1, and the air bubbles in the mixture are removed by vacuuming. The mixture is poured into molds and baked in an oven at 80℃ for 4 h. Afterwards, the PDMS is immersed in toluene for 6 h to swell completely before being blown gently under N2 for a few seconds to eliminate the surface droplets. The PI tape (loaded with pixels) is attached to the PDMS pad and the pixels immediately come off the PI tape for the PS coated sample. For the PS-free sample, nevertheless, basically nothing happens even if it is soaked in toluene for 12 h, meaning that the pixels can not be successfully released if there is no PS. Together with other experimental results described in the main text, the 4-fold role of the PS film can be confirmed, which is vital for our successful transfer.

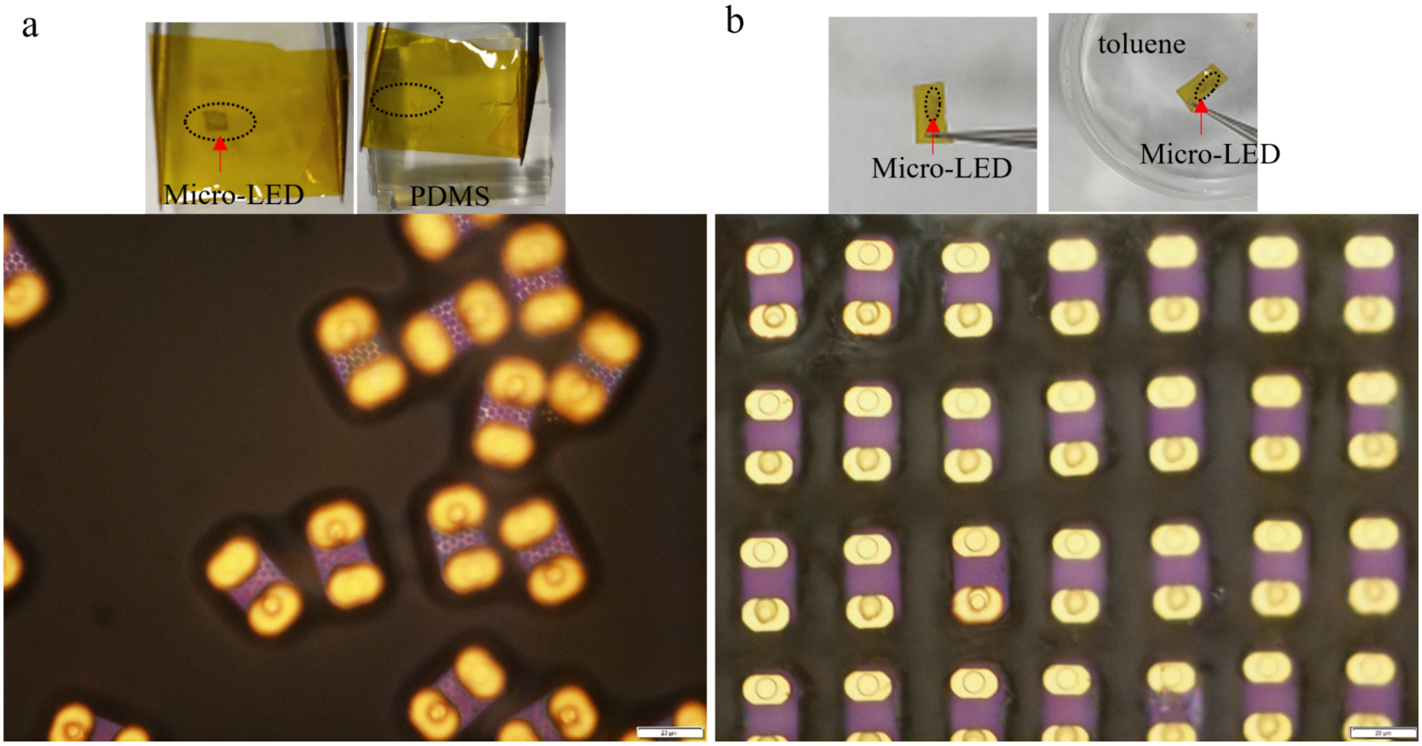

Figure S4. Optical and microscope photographs demonstrate the role of PS film. (a) Transfer the pixels coated with sacrificial PS film onto the PI tape, which was then placed on the swollen PDMS surface, and the pixels were all released from the PI tape in merely a few minutes. The microscope images show that the pixels were disorderly scattered on the PDMS; (b) Transfer the PS-free pixels onto the PI tape, which was put in toluene for 12 h. The pixels were still on the PI tape and none of them came off. The results demonstrate the key role played by the PS in the transfer, which guarantees easy picking up from the SWP tape a smooth releasing from the PI tape.

Section S5. The contact angle of H2O on PI tape, IRS and GaN surfaces

PVA needs to be dissolved by H2O. The wettability of H2O on the surface of PI tape, IRS and GaN is relatively poor. When PVA is used as a sacrificial layer in the dissolution process, it is not conducive to the lateral wetting of the solvent, and the dissolution process is very slow.

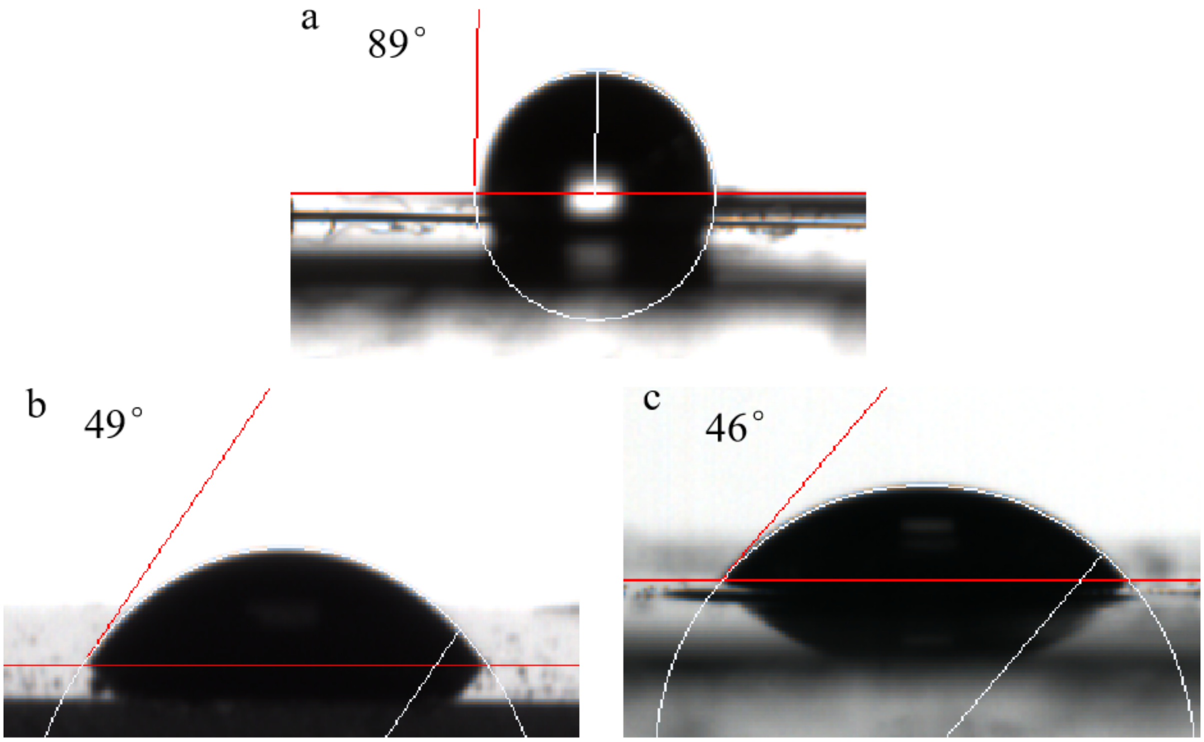

Figure S5. Measurements of the contact angles of H_2O on (a) PI tape;(b) IRS; (c) GaN surfaces.

Section S6. Schematic diagram of the device structure and fabrication process of Micro-LED

Details of Micro-LED fabrication are presented in the experimental section of the main text. The following figure mainly shows the schematic diagram of the device structure and fabrication process.

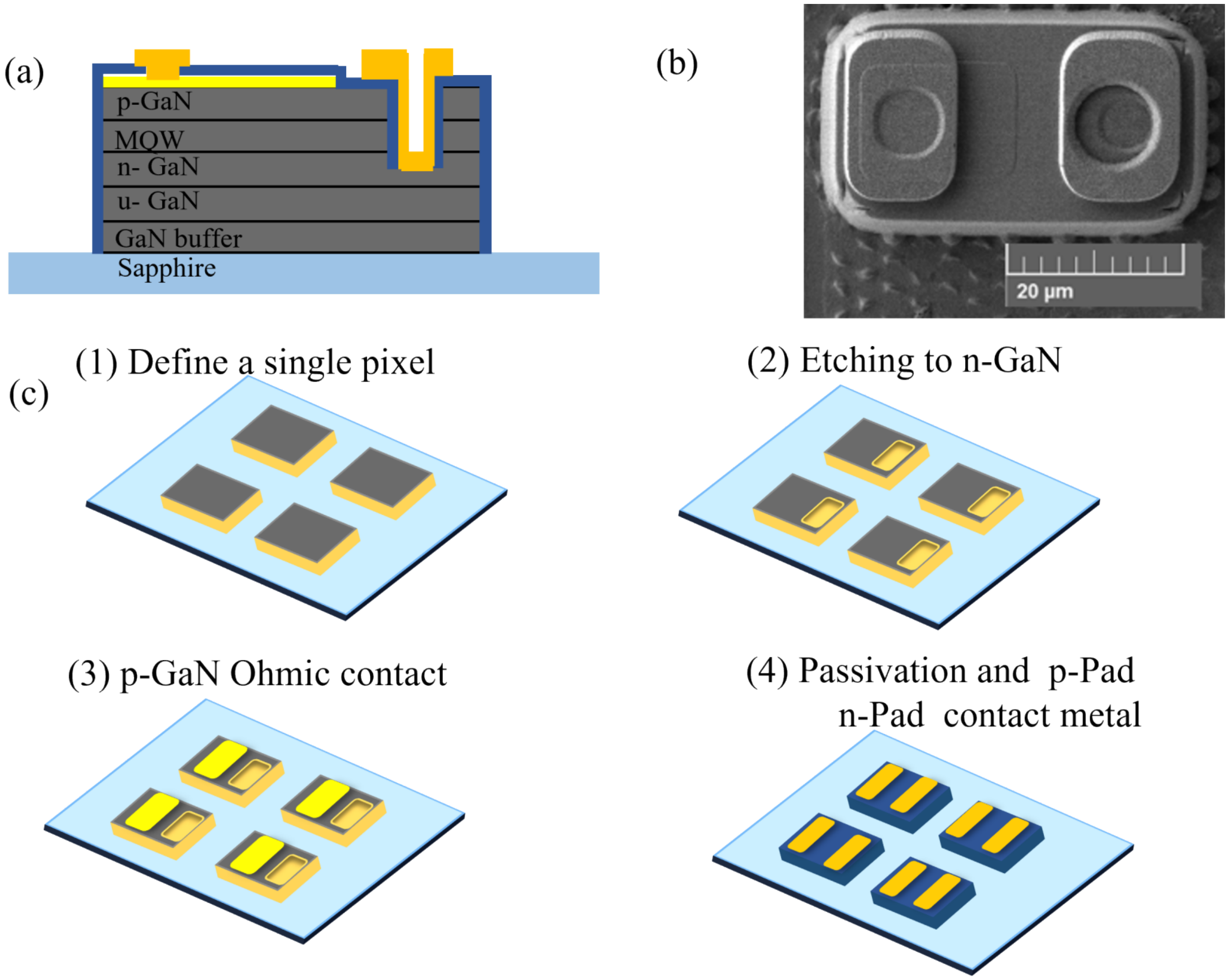

Figure S6. Fabrication procedures of the Micro-LED device. (a) Cross-section diagram of the Micro-LED; (b) SEM image of the fabricated Micro-LED; (c) Processing flow of the Micro-LED devices.