Supplemental Document

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Anisotropy of DNA molecule detection and enhancement by GaN-based electronic sensor: supplement

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Supplementary material

Anisotropy of DNA Molecule Detection and Enhancement by GaN Based Electronic Sensor

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As the main text mentioned, although the thickness of the intrinsic region and the doping concentration of the PiN structure cannot be changed with great flexibility as the P_{in} and V_B, these parameters are factors that determine the performance of an electronic sensor for characterizing the biomolecule signals. In addition, the effects of these parameters on the behavior of the electrical anisotropy signals still remain unknown. Nevertheless, these two parameters can be considered during the fabrication process. Hence, it is worthy of investigating these subjects.

1. Tuning of the thickness of the intrinsic layer of GaN PiN structure

Figure S1 shows the changes of the electrical anisotropy signals of DNA molecules with different thicknesses of the intrinsic layer of the GaN PiN structure. From Figs. S1 (a1) and (a2), it can be seen that the intensity of photocurrent under *x*-LP and *y*-LP conditions decrease with increasing the thicknesses of the intrinsic layer. However, the *η* decreases slightly with increasing thicknesses of the intrinsic layer, as shown in Fig. S1 (b). Therefore, the thickness of the intrinsic layer is not a key factor in tuning and enhancing electrical anisotropy.

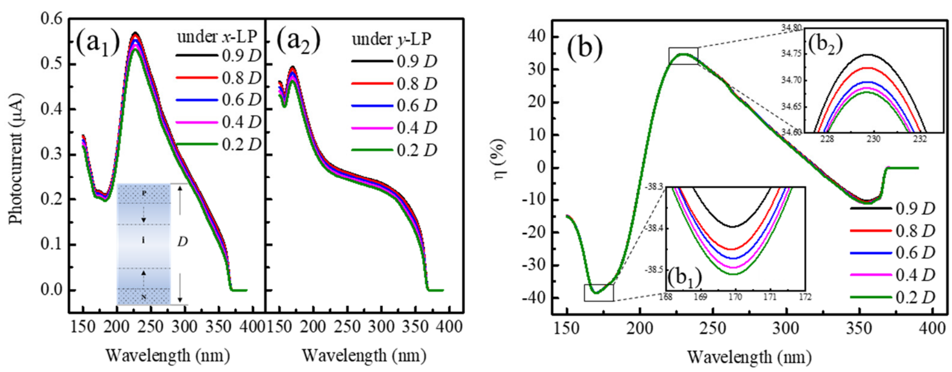

Figure S1: Photocurrent of B/LGPIN with different depths of the intrinsic region of GaN PiN structure under (a1) *x*-LP and (b) *y*-LP. (b) The intensity of *η* changing trend of B/LGPIN with different depths of the intrinsic region of

2. Tuning of the doping concertation of GaN PiN structure

Figure S2 shows the mapping of the *η* intensity of Mode I and Mode II under different doping concentrations for the p- and n-layers of the GaN PiN electronic sensor. Overall, it was found that the *η* intensity is insensitive to the doping concentrations of p- and n-layers. However, from the vertical stripe-pattern distribution, it can be found that the concentration of p-contact (N_a) is relatively more important and sensitive to tune the anisotropy of DNA molecules than the concentration of n-contact (N_d).

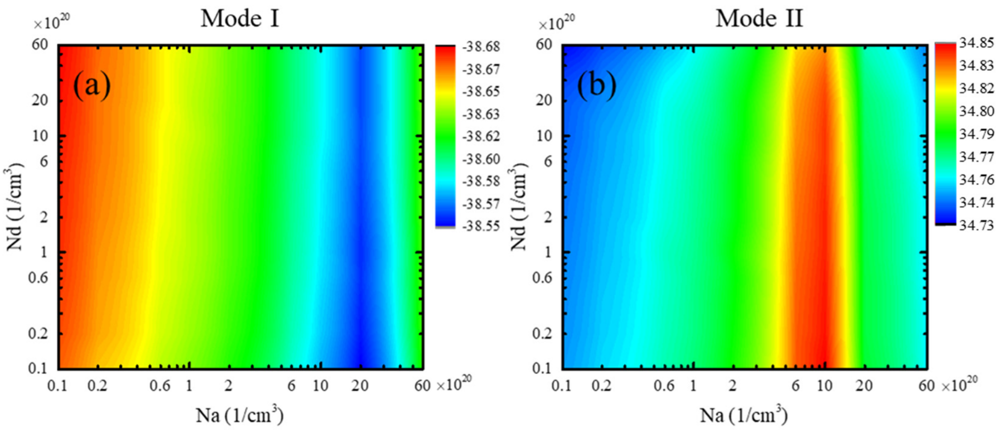

Figure S2: The mapping of the η intensity of (a) Mode I and (b) Mode II with different doping concentrations of p- and n-layers.

3. A brief guideline of fabrication of L-shaped Al nanograting and DNA film and the limit of detection

In this section, possible methods to obtain the L-shaped nano grating and to coat the DNA film were given. The GaN PiN structure can be grown by Metal-organic Chemical Vapor Deposition on GaN or Al2O3 substrates. Then, a layer of PMMA can be coated on the PiN structure, as shown in Fig. S3 (a). Electron beam lithography is used to deposit the template, as shown in Fig. S3 (b). Al can be deposited using two different deposition angles approach, as shown in Figs. S3 (c) and (d). After the lift-off process, the L-shaped nanograting can be obtained on the surface of PiN structure. Then, the spin coating method is used to coat the biomolecules film on the L-shaped nanograting. Since the chain structure of DNA molecules and the orientation limitation of the grating grave-shaped path on the PiN structure, under a high spin speed, the orientation of the DNA chain can be deposited relatively uniform. For more details about the nanostructure fabrication, please refer to the previous study about a similar three-dimensional nanostructure by Bai et al. [3].

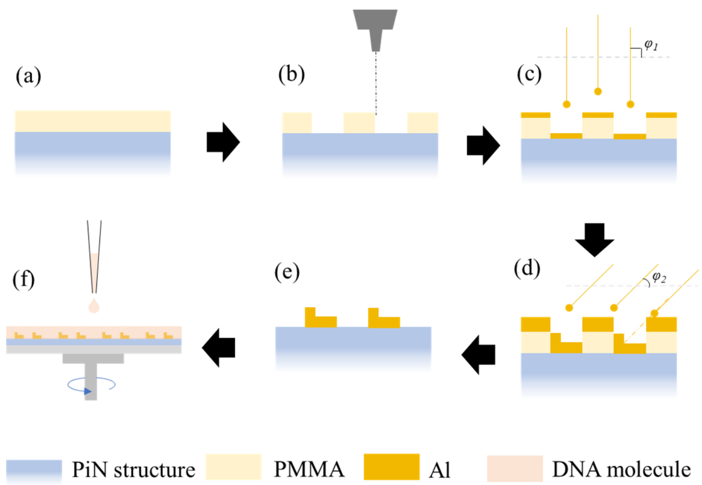

Figure S3: The possible fabrication method of L-shaped nano grating and DNA film.

In actual experiments, there are some factors that will influence the detected signal. Firstly, for the doping profile, the simulation work is based on a uniform system, i.e., the doping profile with Gaussian distribution. However, it is hard to get such a perfect doping profile experimentally, which will affect the generated photocurrent. Secondly, for the L-shaped nanostructure, in the simulation work, all the corners of the grating are right angles. But in the experiment, most of these angles are fillets, which will influence both the resonance wavelength and intensity. Finally, the GaN material is sensitive to the selected wavelength range. Those electric anisotropy modes are not in this wavelength range (maybe caused by the ununiform of the real device, such as the grating's size and thickness of DNA film), GaN-based detection system cannot be used to detect them.

Reference

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