Multifunctional polymer lens for optical enhancement of GaN photodetectors

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1. Abstract

This work presents the fabrications of polymer lenses to enhance a sensitivity of gallium nitride (GaN) based ultraviolet (UV) photodetector by focusing incident lights on the sensing region. In this study, a novel method for polymer lens fabrication were suggested (*in-situ* curing) to realize the photocurrent increasement and their optimizations are studied as well. Furthermore, by utilizing low thermal conductivity of the polymer and in-situ curing technology on the GaN surface, much better performance of the optical device for an application in various harsh environments is expected.

2. Introduction

Wide bandgap materials such as gallium nitride (GaN), silicon carbide (SiC), and zinc oxide (ZnO) have many reliable applications owing to its stability in the harsh environments (e.g., corrosive media and high temperature). Among them, the GaN semiconductor is widely studied as an ultraviolet (UV) photodetector because its bandgap of 3.4 eV matches with the 365 nm. Due to the advantages of the GaN material, a myriad of efforts to enhance the photosensitivity are suggested nowadays [1]. At low temperature with humid air, for example, frost formation on the sensing area of the photodetector deteriorates the absorbance of the incident UV lights because the ice layer acts as a reflective surface [2]. Therefore, novel methods to help the photodetector are required to absorb the target lights successfully at low temperature. Herein, we fabricated polymer lens by a novel method (i.e., *in-situ* curing) to enhance the optical sensitivity of GaN photodetectors. Computational analysis was also conducted to optimize the function of the polymer. This study supports the reliability and feasibility of the applying polymer lens to the GaN-based UV photodetectors for various harsh environments.

3. Results

As seen in the Fig. 1, the polymer lens applied photodetectors showed more enhanced photocurrent (sensitivity). Polydimethylsiloxane (PDMS) was selected for the lens material because of its flexible, cost-effective and other useful properties [3].

In addition, figure 1 represents in-situ cured 3D

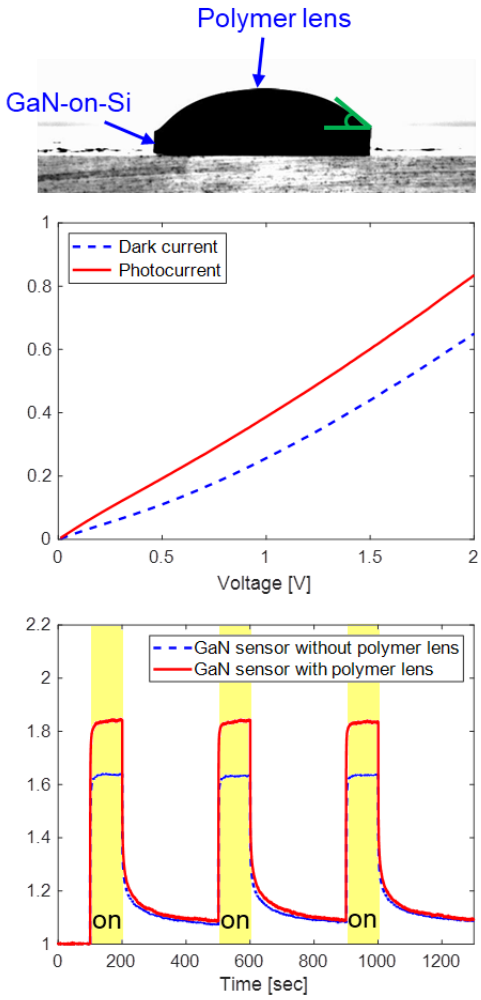

Fig.1. Photocurrent measurement results with in-situ cured lens

polymer lens on the photodetectors can easily enhance the photocurrent by focusing UV lights onto the sensitive region.

4. Conclusion

In summary, the optical performance enhancement of GaN-based UV photodetector was realized by utilizing PDMS lens (in-situ curing). The fabricated polymer lenses successfully focus UV lights onto the main sensing area, thereby photocurrents were enhanced well. These results demonstrated the feasibility of the polymer lens to obtain simple and facile enhancement of optical sensitivity at various harsh environments.

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References

[1] H. So, J. Lim, A.J. Suria, D.G. Senesky, Highly antireflective AlGaN/GaN ultraviolet photodetectors using ZnO nanorod arrays on inverted pyramidal surfaces, Appl. Surf. Sci. 409 (2017) 91–96.

[2] H. So, D.G. Senesky, Effect of Frost Formation on Operation of GaN Ultraviolet Photodetectors at Low Temperatures, IEEE Sens. J. 17 (2017) 4752–4756.

[3] S. Hemmilä, J. V. Cauich-Rodríguez, J. Kreutzer, P. Kallio, Rapid, simple, and cost-effective treatments to achieve long-term hydrophilic PDMS surfaces, Appl. Surf. Sci. 258 (2012) 9864–9875.