Transmittance enhancement in 6H-SiC with nanocone structures

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Transmittance enhancement in 6H-SiC with nanocone structures

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***Abstract* — Enhanced transmittance of 6H-SiC with nanocone structures were achieved by using self-assembled Au nanoparticles as etching mask. HF passivation process of nanocone structures was investigated to further improve the transmittance. The max transmittance of structured SiC is significantly improved by 10%.**

Keywords—nanocone; transmittance; HF passivation

I. INTRODUCTION

The light extraction efficiency is one of the most important parameters for high-performance light-emitting diodes, which is usually low due to the refractive index mismatch at the interface of SiC and air[1]. To enhance the extraction efficiency, nanostructures could be implemented at the SiC surface using e-beam lithography[2], nanosphere lithography[3], self-assembled metal nanoparticles[4], or Al thin film[5]. But the surface nanostructures also lead to the enhanced recombination rate due to surface defects and dangling bond, introduced during the fabrication process. To date, hydrogenation, and deposition of SiO_2, SiNx, Al_2O_3 or TiO_2 are effective ways to improve the surface passivation[6]. In this work, nanocone structures on 6H-SiC were achieved by self-assembled Au nanoparticles. We used 5% HF solution to clean and passivate the surface.

II. RESULTS AND DISCUSSIONS

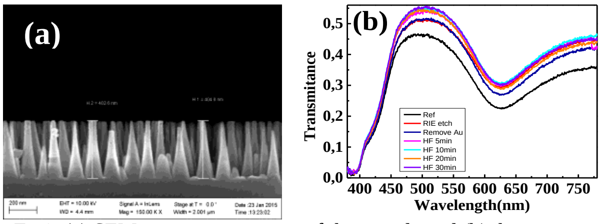

Fig1. (a) SEM cross-section view of the sample and (b) the transmittance curves of the sample after different process.

To improve the uniformity of Au nanoparticles, 20nm SiO_2 layer were deposited on the surface of original 6H-SiC samples. Then, a 6nm Au film layer was deposited on the surface. After treated by rapid thermal annealing at 650 ℃ for 3min, Au nanoparticles were formed. The nanocone structures were fabricated by utilizing RIE etching for 5 min, followed by 15min oxygen plasma cleaning to remove the residual polymer. The residual Au was removed by iodine based solution. The samples were passivated for different time (5min, 10min, 20min and 30min) to improve transmittance. It is found that the nanocone structures are approximately 400nm high and 100nm wide, as shown in Fig.1 (a). Fig1 (b) shows the transmittance curves of the sample after different process, which was measured by a calibrated goniometer system. The transmittance of nanocone structured SiC was enhanced by 6%. After HF passivation for 30min, the transmittance was improved by 10 %.

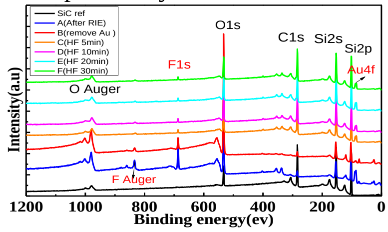

Fig2.XPS survey scans before and after RIE etching, removing Au, HF etching for different time.

The analysis of the surface was carried out with XPS using Al $K\alpha$ radiation with energy resolution of 0.1eV. The corresponding O1s peak was refer to nature oxidation layer of nanocone surface in room temperature as shown in Fig2. It is apparent that RIE processing generated fluoride contamination on the structures, which was practically removed by the oxygen plasma cleaning and HF solution. However, the residual Au couldn't be cleared away after oxygen plasma process, which may suppress the enhancement of transmittance.

III. SUMMARY

In conclusion, we have shown that the nanocone structures created by using Au particles as etching mask, give rise to the enhancement of transmittance. The HF passivation process was introduced to further improve the light extraction.

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