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Effect of dopants on the morphology of porous SiC

Weifang Lu^{1,*}, Yoshimi Iwasa², Yiyu Ou¹, Satoshi Kamiyama², Paul Michael Petersen¹, and Haiyan Ou¹

¹Department of Photonics Engineering, Technical University of Denmark, DK-2800, Kgs. Lyngby, Denmark

²Department of Materials Science and Engineering, Meijo University, 1-501 Shiogamaguchi, Tenpaku-ku, Nagoya 468-8502, Japan

*E-mail: weilu@fotonik.dtu.dk

Abstract—Porous SiC samples with different doping level were fabricated and investigated by using anodic oxidation method. The morphology of the porous structures was explained by space charge layer width, which was affected by the free carrier-dopants concentration.

Keywords—porous; dopants; space charge layer; morphology

I. INTRODUCTION

Porous SiC is a high-potential sensing material due to its large internal surface area and high activity in surface reactions [1]. The porous SiC structures can accommodate the strain and threading dislocations to obtain high quality epilayers [2]. In addition, the porous SiC yields remarkable luminescence, which may expand their application to the field of light-emitting diodes [3-5]. The optical and electronic properties of porous SiC are mainly determined by the morphological properties of porous structures [6, 7]. In this work, the effect of dopants on the morphology of porous SiC has been investigated and its influence on the luminescence properties was discussed.

II. RESULTS AND DISCUSSIONS

Two porous samples a and b were fabricated by using anodic oxidation method. The anodic oxidation was carried under a pulsed current of 1.25 mA in a HF diluted solution with UV illumination for 960 min. Sample a was prepared on lab-grown pure 4H-SiC, while sample b was fabricated on 4H-SiC substrate highly doped with boron and nitrogen. The thickness of porous layer for samples a and b is 7.9 μm and 16 μm, respectively. Obviously, the etching rate for sample a is lower than that in sample b with high doping level of B and N.

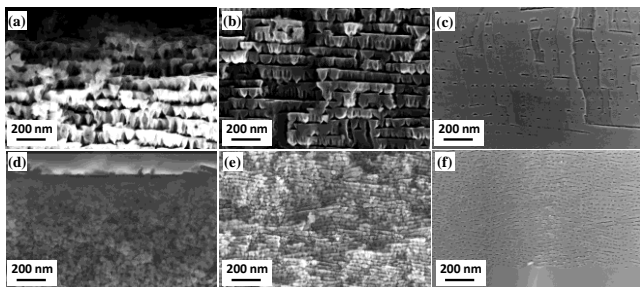


Fig. 1. SEM images of porous samples a and b: taken at the top, middle and bottom area of the porous layer.

The cross-sectional SEM images in Fig. 1(a)-(c) and (d)-(f) show the SEM images of top, middle and bottom layer in porous sample a and b, respectively. One can see that the pore size of the top layer in sample a (50 nm) is larger than that in

sample b (20 nm), while the density of pore is much lower. This phenomenon might be explained by the dependence of space charge layer width on the substrate resistivity (doping level). During anodic oxidation, the charge near the surface of the SiC substrate usually redistribute, resulting in three important regions of the potential drop are distinguished: the space charge region in the SiC bulk due to ionized donors, the immediately adjacent layer of ions in the solution, and the diffuse ionic layer in the electrolyte. Theoretically, the space charge layer can be estimated according to the Poisson equation ($L = \sqrt{\frac{2\epsilon_{sc}\epsilon_0\phi_{sc}}{eN_d}}$, ϕ_{sc} potential of space charge, free carrier-dopants concentration N_d , $\epsilon_{sc} \approx 10$).

Therefore, the higher concentration of dopants in SiC substrates will lead to the formation of smaller pores as well as a smaller spacing between the pores. On the other hand, because the porous layer were formed at the same conditions, i.e, the same total charge was injected into the samples, the etched off material from both samples was same during anodic oxidation process. Thus, smaller pore diameters and thicker porous layer are observed in SiC substrates with B-N dopants.

III. SUMMARY

In conclusion, the dopants in SiC substrate have significant influence on the morphology of porous structures. It is explained that the observed structures were related to the space charge layer (potential distribution) near the SiC/electrolyte interface. The pore diameter decreased with a high doping level, due to decreased width of space charge layer.

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