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Low temperature crystallization of amorphous silicon carbide thin films for p–n junction devices fabrication

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Abstract Metal induced crystallization technique was used to crystallize hydrogenated amorphous silicon carbide (a-SiC:H) thin films at low temperatures. Two types of substrates, silicon and silicon carbide were considered and the substrate effects on the final crystallized film were studied. About 200 nm a-SiC:H films were deposited and crystallized successfully on n-type Si and n-type 6H SiC substrates at a temperature of 600 °C. Fourier Transform Infrared (FTIR) spectroscopy and transmission electron microscopy (TEM) analysis confirmed the crystallization of a-SiC:H film. Current–voltage (*I*–*V*) and capacitance–voltage (*C*–*V*) measurement confirms the formation of p–n junction with rectification over five orders of magnitude from −2 V to 2 V.

1 Introduction

Silicon carbide (SiC) is a promising material for fabricating semiconductor devices because of its capability of functioning at high temperature, high voltage and high frequency without degradation. Different poly-types of SiC such as 3C, 6H of which 6H have been researched the most. There has been a considerable interest in fabricating 3C–SiC/6H–SiC hetero p–n junction devices [1, 2] in recent years. Conventional chemical vapor deposition (CVD) has been used for epitaxial growth of 3C or 6H SiC on different substrates [3]. However doping by thermal diffusion is very difficult for SiC substrates even at high temperature of 1,500 °C [4]. Ion implantation and subsequent annealing over 1,500 °C has been explored to achieve doped SiC layer on SiC substrates. However both the techniques create defects in the prepared layer [5]. A new technology is needed for low temperature doping of SiC to fabricate junction devices for high temperature, high power and high voltage applications.

In this study we present a low temperature alternative to achieve p-type doped micro/nano-crystalline 3C–SiC. The 3C–SiC region is prepared on n-type Si and n-type 6H–SiC substrate by converting hydrogenated amorphous silicon carbide (a-SiC:H) with the help of aluminum. Aluminum induced crystallization is one of the popular techniques to crystallize a-Si [6–8] and a-Ge [9–11] at temperatures lower than respective solid phase crystallization temperatures. Unstable system like amorphous SiC, Si and Ge can be crystallized by thermal annealing and this crystallization temperature can be reduced if a metal like Al is used in contact with the amorphous film. The resultant crystalline film is p-type because of Al doping [7, 10].

2 Experimental procedure

For preparing the samples, n-type Si substrate with a resistivity of 1-10 Ω-cm and n-type 6H–SiC substrate with resistivity of 0.03–0.12 Ω-cm have been used. The substrates were cleaned using modified shiraki [12] procedure prior to placing in the deposition chamber. Hydrogenated amorphous silicon carbide film is deposited using Applied Material's P5000 PECVD tool. In the deposition chamber, 25 sccm SiH_4, 300 sccm H_2 and 300 sccm CH_4 were introduced and plasma was created by 400 W RF power at a chamber pressure of 2 torr. About 200 nm a-SiC:H samples deposited at 400 °C were placed into a sputtering

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