BPD free 4H-SiC epilayers for transistors and Schottky diodes

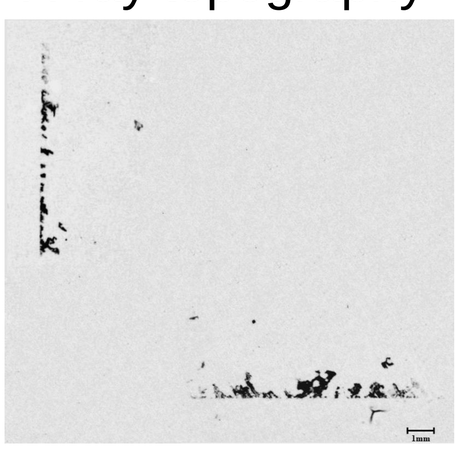
Kinga Kosciewicz[1,a], Pawel Typa[1,b], Mariusz Rudzinski[1,c], Iwona Pasternak [1,d], Wlodek Strupinski[1,e]

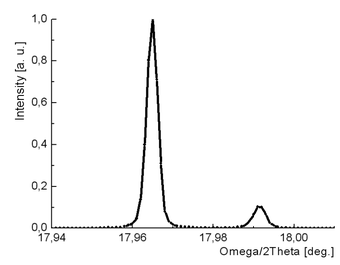
[1]Institute of Electronic Materials Technology, Wolczynska 133, 01-919 Warsaw, Poland

[a]kinga.kosciewicz@itme.edu.pl, [b]pawel.typa@itme.edu.pl, [c]mariusz.rudzinski@itme.edu.pl, [d]iwona.pasternak@itme.edu.pl, [e]wlodek.strupinski@itme.edu.pl

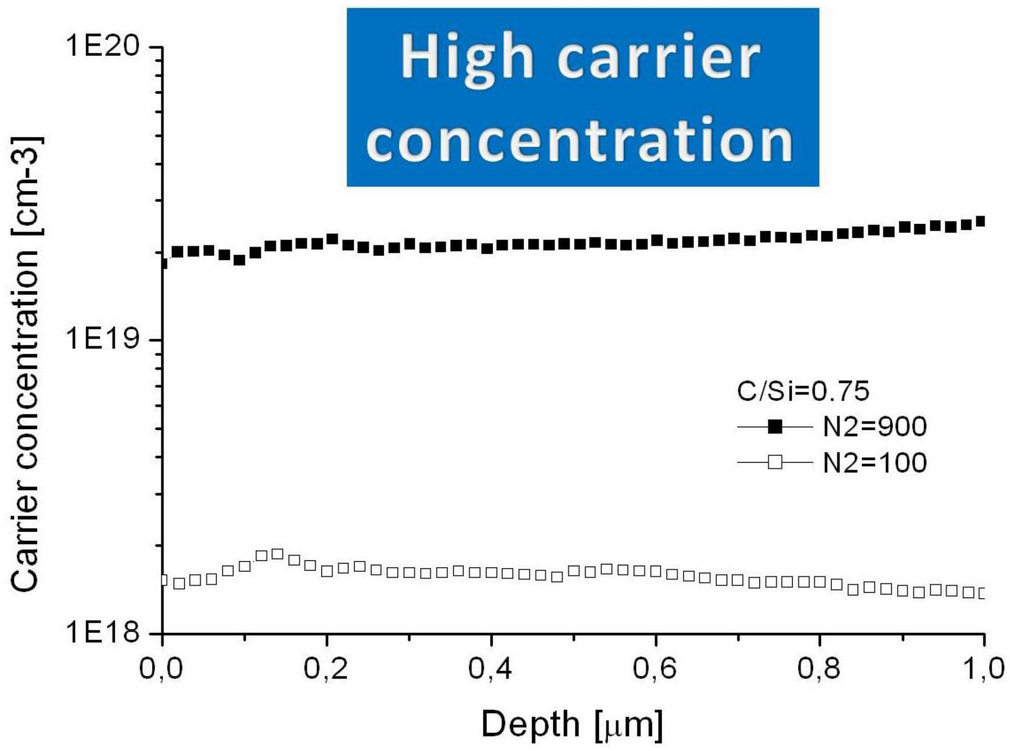
Basal plane dislocations are very common defects in SiC and influence the optical and electrical properties of the materials as well as the electronic devices based on SiC. The complete reduction of such defects is obtained on epitaxial layers grown on on-axis substrates. The growth of 4H-SiC epitaxial layers on on-axis Si-face wafers is now polytypically stable. It is attainable to apply epitaxial layers on on-axis substrates to device structures such as Schottky diodes, pin diodes or high power transistors based on 4H-SiC since they are characterized by an exceptionally high quality.

X-ray topography

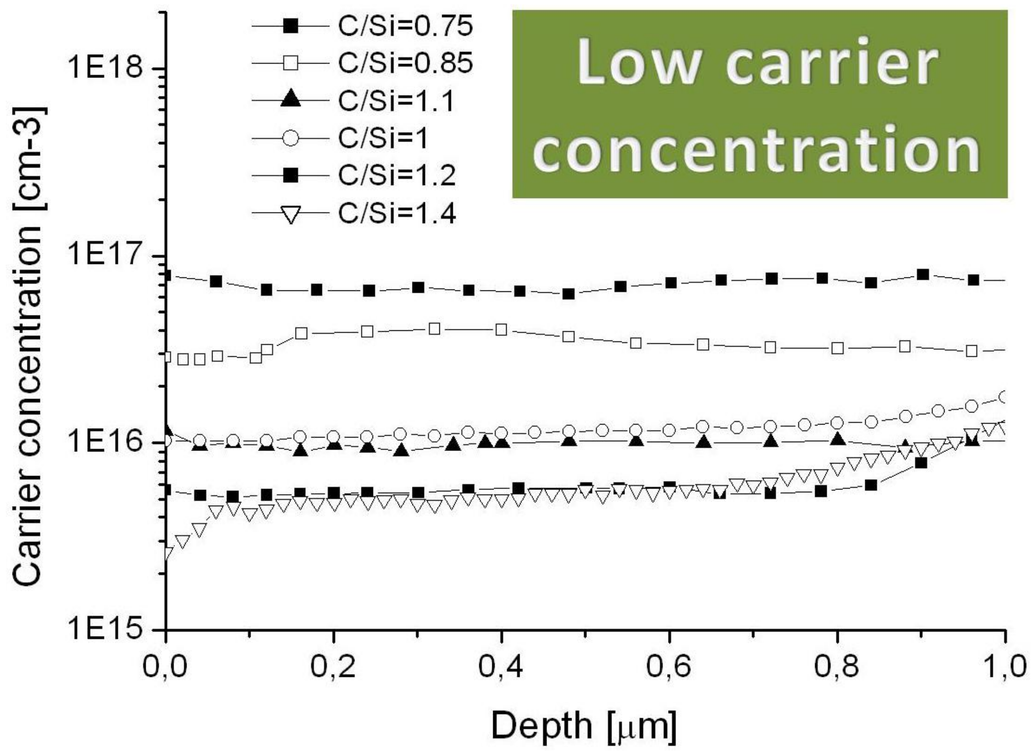




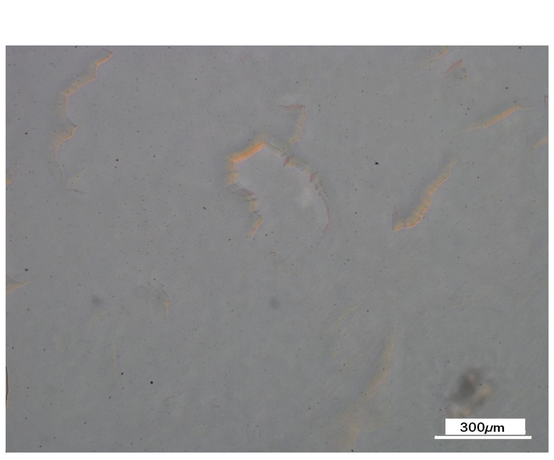
The standard low C/Si ratio (C/Si=0.75) enables obtaining polytypically homogeneous homoepitaxial layers on on-axis 4H-SiC substrates and concurrently causes the generation of a huge number of carbon vacancies, which allows easy incorporation of nitrogen dopands and, in consequence, the carrier concentration is very high → for 900ml/min of N_2 n=2e19/cm^{-3}.

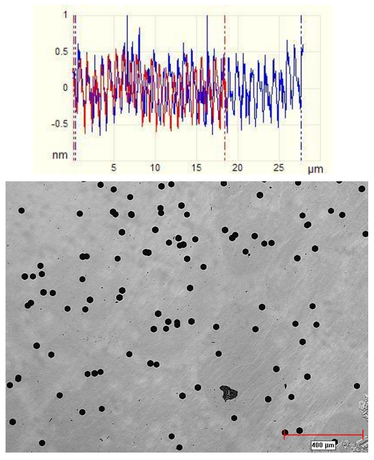


The carrier concentration could be reduced by the C/Si ratio, which would diminish the number of carbon-vacancies and, therefore, enable obtaining a proper carrier concentration in a Schottky diode structure.

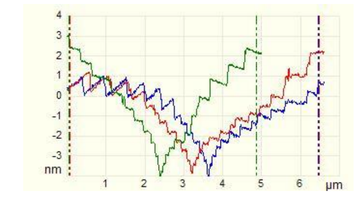


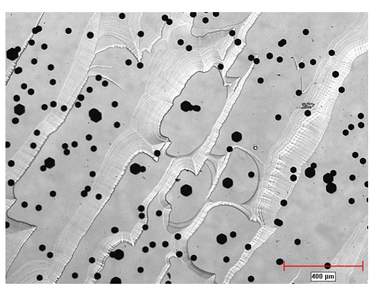
The quality of n-type epitaxial layers on on-axis 4H-SiC substrates is exceptionally high with EPD= 4·10^3/cm^2. Basal plane dislocations are completely eliminated. The surface morphology and screw dislocations density depend on substrate quality. Smooth areas (Ra=0.2nm) and island areas with SD in the center of an island (Ra=1.4nm), which are propagated form the substrate, can be observed on epilayers.

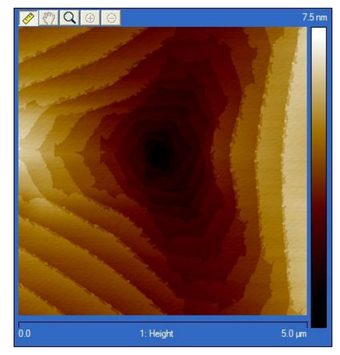




Ra=0.2nm
d_{TED}=4·10^3/cm^2







d_{TED}=6.1·10^3/cm^2
d_{SD}= 6.4·10^2/cm^2

CONCLUSIONS

Donors concentration in epitaxial layers can be controlled by two parameters, namely the partial pressure of nitrogen and the C/Si ratio.

High carrier concentration

-C/Si=0.75

- growth with nitrogen flow N_2=900ml/min is a simple way to reach a high carrier concentration of more than 10^{19}/cm^3 (**transistor structure**)

Low carrier concentration

- even at C/Si=1.1 the carrier concentration is 8e15/cm^3 (**Schottky diode**)

- the lowest concentration of 3e15/cm^3 is obtained at C/Si=1.4

The results completely exploit the potential of epitaxy on on-axis substrates without BPDs to develop device structures in the full range of concentrations in n-type epitaxial layers.

p-type…. to be continued ☺

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