HYDROGEN CONTAMINATION AND DEFECT GENERATION IN P-TYPE SILICON AND SILICON-GERMANIUM SCHOTTKY BARRIER TEST STRUCTURES

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In this paper, we show that the introduction of hydrogen into silicon during normal cleaning procedures together with defect generation during the deposition of the Schottky barrier can result in very serious misinterpretations of CV and DLTS data. We hypothesize that such effects have been unknowingly present in some previously published work and have been erroneously attributed to issues associated with epitaxial growth.

Hydrogen is a common contaminant in silicon. The introduction of hydrogen during preparation of test samples is in general unavoidable. In p-type material H^+ is the predominant species of hydrogen and is attracted to the negatively charged boron acceptor, resulting in passivation. However, this bonding is rather weak so that if the sample is warmed to a temperature >80°C, the hydrogen can move within the lattice. This movement is facilitated by the presence of the depletion field.

A typical result is shown in Fig. 1. Prior to Schottky barrier deposition, an RCA clean has been used and this has resulted in a high concentration of hydrogen at the surface of the silicon. However, under reverse bias, the hydrogen migrates from the surface into the bulk. In the as-processed structure ("Initial profile"), the CV measurement records a reduction in the carrier density due to the passivation of the boron by hydrogen. However, in our samples, the boron concentration is constant throughout the whole of the epitaxial layer.

In Fig. 2 we make a comparison of the DLTS spectra from an MBE layer between sputtered Schottky barriers and those produced by thermal evaporation on a separate piece of the same slice. During sputtering, damage is produced in the surface region of the semiconductor by low-energy ions. However, a confusing issue in the interpretation of these data is that there are significant differences between epitaxial layers and CZ silicon. This is in part due to the differences in oxygen and carbon concentrations, but another very significant factor is the proximity of interfaces. The defect reactions which ensue around room temperature are quite complex and can also involve reactions with the inadvertent hydrogen and with boron. An example of this is shown in Fig 3.

In the paper, we propose a methodology for distinguishing between defects introduced during processing and those which truly characterize the as-grown material.

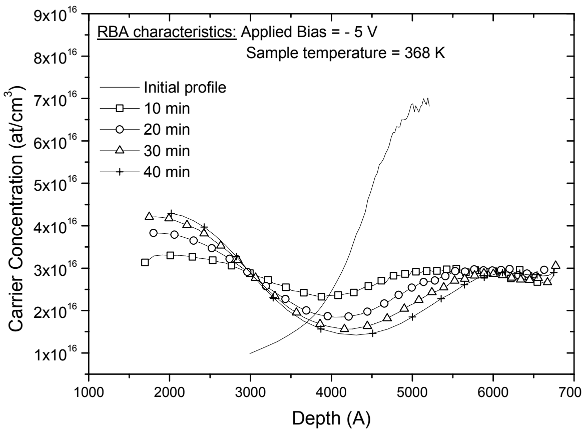

Fig. 1: Free carrier concentration profiles derived from CV measurements on a thin MBE silicon layer. The apparent profile changes after low temperature anneals under reverse bias. The effect is due to inadvertent hydrogen contamination during cleaning.

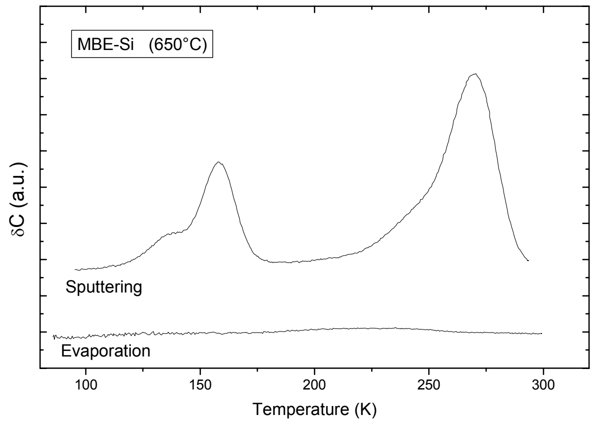

Fig. 2: Comparison of DLTS spectra taken from the near surface region of MBE grown silicon on which titanium Schottky barriers have been deposited by sputtering (top) and by thermal evaporation (bottom).

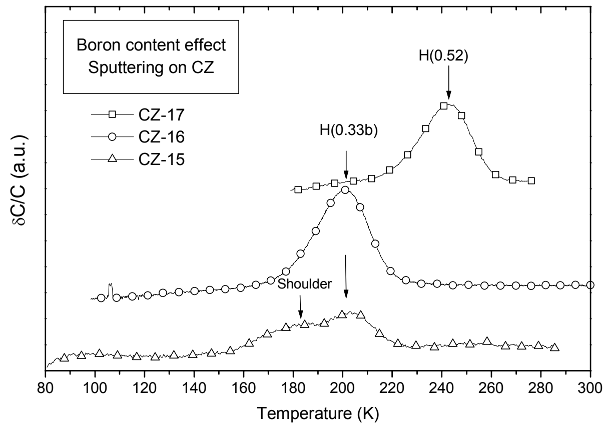

Fig.3: The defects created by sputtering result from reactions of intrinsic defects with impurities hence the DLTS signatures depend on the material type, hydrogen contamination etc. Here we show the DLTS spectra from sputter damaged CZ silicon of different boron concentrations $5x10^{17}$ (top), $6x10^{16}$ and $5x10^{15}$ cm^{-3} (bottom)