PRESSURE INDUCED PHENOMENA IN HEAVILY HYDROGEN-DOPED Cz-Si

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INTRODUCTION

Silicon-on-insulator (SOI) structures are prepared by Si wafers bonding using a hydrogen smart-cut technology. A strain-free top Si layer needs to be created in such structures; its features are dependent, among others, on the implanted hydrogen dose (*D*) and energy (*E*) and annealing temperature of the bonded wafers.

It is known that the treatment of hydrogen-implanted silicon (Si:H) under enhanced hydrostatic pressure (HP) affects its defect structure [1]. Just investigation of the effect of high temperature–pressure (HT-HP) treatment on the defect structure of heavily hydrogen doped Si is the main topic of present work.

EXPERIMENTAL

The 001 oriented Czochalski grown single crystals (Cz-Si) were implanted with H^+ at energy E= 24 keV, $D = 2.7\times10^{17}$ cm^{-2}) using for implantation the ion plasma source [2]. After implantation, the Cz-Si:H samples were HT – HP treated [3] at HT up to 1000^{o}C under HP up to 11 kbar for up to 10 h.

The photoluminescence (PL) spectra of HT-HP treated Cz-Si:H were determined at 6 K (excitation with Ar laser, λ = 488 nm). Structural properties of Cz-Si:H were also investigated by high-resolution X–ray diffraction. Measurements of the rocking curve (RC) shape and reciprocal space mapping (RSM) for the symmetrical 004 reflections were done using Cu$K\alpha_1$ radiation.

RESULTS AND DISCUSSION

The most dramatic changes of the PL spectra as well as of the defect structure were found for the samples subjected to the most prolonged treatment (10 h) at 450^{o}C under 11 kbar (Figs 1 and 2).

The PL spectra and reciprocal space maps of the samples treated at 650^{o}C for 5 h under 1 b and 11 kbar are presented in Figs. 3 and 4. The PL peak at about 1.1 eV is related to the interband transition while the peak at 1.01 eV represents, most probably, the D4 dislocation-related transition. Due to creation of some defects at high pressure, the additional PL line at 0.81 eV (the dislocation related D1 line) was revealed for the sample treated under 11 kbar. Increased treatment temperature (up to 800^{0}C) under the same pressure results in comparatively strong dislocation related D1 line. However, the sample treated at 1000^{0}C indicated much decreased intensity both of the D1 line and of the PL line at about 1.1 eV related to the interband transition. This effect is caused by an increase of the defect concentration, as evidenced by the increased diffuse scattering intensity. It is necessary to admit that this intensity increases with the rise of treatment temperature for the case of same HP.

The pressure-induced defects influence X-ray diffuse scattering; agglomerates of point defects and dislocations are responsible for this enhancement.

The reciprocal space maps of the samples annealed / treated at 650^{o}C are presented in Fig.

4. The increased diffuse scattering intensity was detected for the sample treated under high HP. It follows that increased HP results in the increased defects concentration.

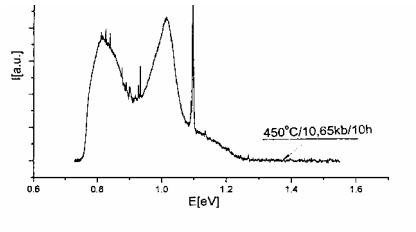

Fig.1. PL spectrum of Si:H sample treated at 450^0C under 11 kbar for 10 h.

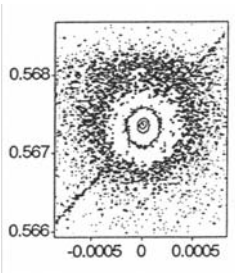

Fig. 2. Reciprocal space maps of Si:H treated at 450^0C under 11 kbar for 10 h.

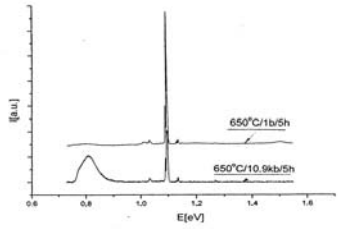

Fig. 3. PL spectra of Si:H sample treated at 650^0 C under 1 bar and 11 kbar for 5 h.

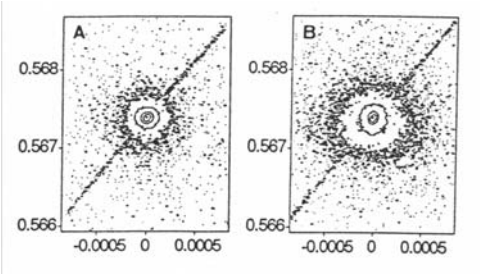

Fig 4. Reciprocal space maps of Si:H treated at 650^0 C under 1 bar (A) and 11 kbar (B) for 5 h.

Enhanced HP at annealing exerts pronounced effect on the structural properties of investigated samples.

The buried hydrogen enriched layer, created in Si:H in effect of implantation, changes markedly its properties after high pressure treatment, especially as it concerns hydrogen storage and its out-diffusion as well as of the kind and concentration of defects.

CONCLUSIONS

Enhanced hydrostatic pressure of ambient gas at annealing of Cz-Si:H prepared by high dose implantation results in defect structure changes dependent on pressure, time and temperature. For the HT-HP treated samples, apparent changes of defect structure were observed through the diffuse scattering intensity as well as the presence and position of defect-related photoluminescence peaks.

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ACKNOWLEDGMENTS

This work was supported in part within European Community program G1MA-CT-2002-4017 (Centre of Excellence CEPHEUS) and by the grant No 4 T08A 034 23 (2002-2004) from the Polish State Committee for Scientific Research.