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HYDROGENATION STUDIES OF DEFORMED n-Si

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Résumé - Nous présentons de nouveaux résultats sur l'hydrogénation du silicium de type n déformé. Nous montrons que la profondeur de passivation par l'hydrogène est plus grande que 10 µm.

Abstract - New results on hydrogenation of dislocated n-Si are presented. Hydrogen passivation depth was found to be more than 10 µm.

Hydrogen bonded chemically in both crystalline and amorphous Si produces significant changes in electrical properties of these materials. This fact caused the upsurge in interest in hydrogenation studies of Si. In the previous paper (1) the effective hydrogen-passivation of defects associated with dislocations in n-Si was reported.

The samples studied in this work were of 1.15 Ω cm P-doped FZ silicon. Dislocations were introduced at 650°C by uniaxial compression (final strain $\varepsilon = 3.4\%$), parallel to the $<211>$ direction. The samples underwent hydrogenation at 350°C in 3 Torr, 3 MHz hydrogen plasma. The hydrogenation process was optimized to the point where all measurable by DLTS technique defects, except for one with ionisation energy 0.45 eV, were removed to the depth of 10 µm.

The hydrogen penetration depth was investigated by subsequent polishing of the sample surface initially subjected to H-plasma. The relation $\frac{S-S_h}{S} = 100\%$ ($S$ - initial DLTS signal amplitude, $S_h$ - amplitude after hydrogenation). Results are shown in Fig. 1.
The notation $E_3$, $E_4$ and $E_5$ corresponds with the one used in Fig. 2. The $S$ and $S_0$ are the amplitudes of DLTS spectrum in the temperature points denoted by the respective arrows. As it is seen from Fig. 1 as deep as 40 $\mu$m beneath the surface which underwent hydrogenation 45% of initially detectable defects is still passivated. This result shows that hydrogenation can have a practical application in conventional device processing. There is also another information concerning the defect configuration in dislocated Si available from the studies of H penetration depth. The similar passivation depth for the defects $E_3$, $E_4$ and $E_5$ indicates the common diffusion path which is followed by H before it is trapped on these defects. The simplest interpretation assumes the H diffusion along the dislocation cores and the location of the defects seen in DLTS spectrum (or at least 3 of them) in the vicinity of dislocation lines (in agreement with [2]).

Fig. 2 shows: the initial DLTS spectrum of investigated sample, the spectrum after hydrogenation, and spectra obtained after a series of isochromatic ($1h$) heat treatments at indicated temperatures. Another spectrum seen in Fig. 2a belongs to a reference-sample which underwent the same heat treatments but was not hydrogenated. It is seen in Fig. 2b that hydrogen diffuses into Si under exposure to the H-plasma removing electron traps. The concentration of the only defect detectable after hydrogenation (0.45 eV), decreased over 2 orders of magnitude in comparison with its initial value. After anneal at 350°C the reconstruction of 0.42 eV defect is most pronounced.

The most striking feature of the DLTS-spectrum measured with the sample annealed at 450°C is the appearance of 0.53 eV peak at relatively high temperature indicating unusually small capture cross-section of the defect concerned. This indicates that the addition of H creates new structural configurations in deformed Si.

The results of annealing at 550°C and 650°C do not differ very much. After anneal at 650°C the re-appearance of most of the spectral features of the deformed sample is complete except for $E_4$ and perhaps $E_5$ defect. The difference between the spectra shown in Fig. 2a and 2f reveal also the inhomogenity of the sample. It results from the fact that before subsequent heat treatments the layer of about 2 $\mu$m thick was taken off to remove Au contact. Nevertheless in all investigated samples (as also reported in [1]) the re-appearance of $E_4$ defect was incomplete.

Spectrum of the reference sample did not change until anneal at 750°C. The DLTS spectra after anneal at 750°C for both reference and hydrogenated samples are shown in Fig. 2g. Clear difference between these spectra indicates that in spite of such a high temperature in disordered samples a part of H is retained in the crystal lattice. Much of this hydrogen does not merely passivate dangling Si bonds. Once trapped, the H inhibits the annealing of certain defects ($E_6$) and enhances the annealing of others (e.g. $E_3$, $E_4$).

After anneal at 850°C only one distinct peak $E_4$ remains in the spectrum of non-hydrogenated sample (as in [3]), whereas in the spectrum of hydrogenated sample the amplitude of $E_6$ peak still exceeds the one of $E_4$ peak. Further anneal at 900°C brings very little change in non-hydrogenated sample spectrum but further decreases $E_4$ peak in hydrogenated sample spectrum.
Fig. 2. - DLTS spectra at different investigation stages
It is not possible on the base of the above results to attribute explicitly the peaks of DLTS spectra to the definite defects in deformed n-Si. More research is also required to understand the structure of Si-H bonds and the interrelation between the structure and the electrical properties of this material. The EPR and spin dependent photoconductivity (SDP) measurements are under-way in order to correlate their results with DLTS results.

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References

1. PCHORYLES, B., phys.stat.sol a 67 1981 K75
2. SZKIELKO, W., BREITSTEIN, O., PICKENHEIN, R., Crystal Res. Technol. 16 1981 197