NANOCRYSTALLINE SILICON SURFACE FOR SENSOR APPLICATIONS

D. Milovzorov*, D.S. Eremin+ and A.G.Kazansky+

* The Institute of Physics & Technology of Russian Academy of Science, Nakhimovsky Pr., 36, Moscow, Russia
+ Moscow State University, Vorobyevi gori, Moscow, Russia

The plasma-enhanced chemical vapor deposition (PECVD) was used for deposition of nanocrystalline silicon (nc-Si) films with mean value of grains' sizes around 10-15 nm and crystalline volume fraction varied in the range of 65-80%.

We studied the electrophysical properties of films: dark conductivity and photoconductivity. The structural properties was studied by using X-ray diffraction (XRD) and Raman spectroscopy measurements. The chemical properties was investigated by means of Fourier-Transformed infrared (FT-IR of Bruker company) spectrometer. The oxygen and hydrogen contents were estimated according to the calculation procedure from the previous work [1].

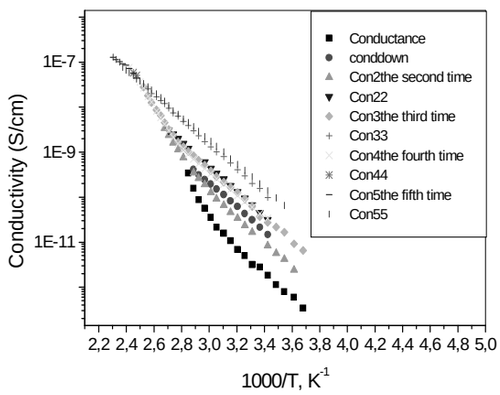
The defect concentration was evaluated by using electron-spin resonance data. It was clear, that the paramagnetic P_b centers and E' centers were appeared during the oxygen incorporation by film deposition. The defect diffusion was negligible by the room temperature of substrate. However, the hydrogen termination of dangling bonds in nc-Si causes the silanol bonding Si-OH in grain boundary region. By the annealing the nc-Si films to the value of temperature 150^{o}C the silanol bonds transform into siloxane bonds Si-O-Si with water removing [2].

The dark conductivity measurements data was shown on the Fig. It is seen that there are great difference in the values of conductivity by the annealing the film. The measurements was in vacuum conditions. By the second measurement of conductivity for each sample during the film annealing the value of conductivity was slightly increase up to the saturation value. We assume that the dark conductivity as a function of temperature depends on concentrations of oxygen and hydrogen. The water removing from the surface and absorption from the air causes the changing in electronic structure of nc-Si films.

To our mind, the temperature control of film by the air conditions is a powerful tool for determination of water concentration and, therefore, the characteristic of temperature dependence of dark conductivity.

We suppose that the oxygen donor doping of nc-Si films produces the shift in the Fermi level's position inside band gap of silicon.

The nature of conductivity was intensively studied by using spectroscopical and electrical measurements. Figure shows the five times of repeating the annealing procedure. The dark conductivity value by the fixed temperature increased up to the saturation value. We suppose that at this value all the water was removed and all silanol bonding transformed into siloxane bonding Si-O-Si. Because, the contents of hydrogen in the interface area between silicon nanocrystals decreases by the sample annealing of several times. The desorption of hydrogen from the surface layer of film causes the gradient of concentration and, therefore, the increase in hydrogen diffusion. The hydrogen diffusion results in the increase



in dangling bonds concentration, and subsequently, increase in the value of dark conductivity [3].

References

1. 1. D. Milovzorov, T. Inokuma, Y. Kurata, and S. Hasegawa, Journal of the Electrochemical Society, **145**, N 10, 3615-3620 (1998).
2. Q.-Y.Tong, U.Gosele, Semiconductor Wafer Bonding:Science and Technology, John Wiley & Sons Inc., NY, 1999.
3. F.Finger, J.Muller, C.Malten, H.Wagner, Philos. Mag.,**77**, 816 (1998).