Effect of Surface Doping on The Gas Sensitivity of Si and GaAs P-N Junctions

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Si and GaAs *p-n* junctions are perspective as chemical sensors, having a lower threshold NH_3 concentration for detecting, than porous Si membranes and Si nanowires. The sensitivity of a *p-n* junction as gas sensor was defined as

$$S_I = \Delta I / \Delta P, \qquad (1)$$

where ΔI is the change in the current (at a fixed voltage) due to a change ΔP in the corresponding gas partial pressure. The presence of NH_3, H_2O and C_2H_5OH vapors in the ambient atmosphere strongly increased the direct and reverse currents in studied *p-n* junctions due to forming of *n*-conducting channel, which shorts the depletion region. The gas sensitivity was strongly affected by presence of surface centers. In the homogeneous channel section, the surface free electrons density is defined by

$$N_{ns} = N_i - N_{sf}^- - N_{ss}^- - N_{sA}^- + N_{sD}^+, \qquad (2)$$

where N_i is the surface density of adsorbed donor like ions; N_{sf}^- and N_{ss}^- denote the surface densities of the ionized fast and slow acceptor centers, respectively; N_{sA}^- is the surface density of ionized acceptors in the surface depletion layer; N_{sD}^+ is the surface density of ionized donors. It is seen from (2), that the electrons number N_{ns} in the channel can be increased by N_{sD}^+ growth, i. e. by surface doping with donor like atoms (molecules).

The surface doping of *p-n* junctions was carried out by two methods: a) by a prolonged exposure of the *p-n* junctions in moist ammonia vapors with a partial pressure of 12 kPa; b) by exposure in a Na_2S aqueous solution.

The ammonia-sensitivity of Si and GaAs *p-n* junctions at a reverse bias voltage of -1 V before treatments was of □ 50 nA/kPa and □ 50 µA/kPa, respectively. After the ammonia doping the sensitivity rised by factors of □ 30 and 5, accordingly. The effect of S-doping was analogous.

A durable storage of the treated samples in a neutral atmosphere lowered their gas sensitivity. The characteristic time of this process in GaAs *p-n* junctions was of $5 \cdot 10^5$ s and was of the same order of value in Si *p-n* junctions. The isochronal annealing of the treated Si *p-n* junctions showed that the degradation was due to destruction of centers with a thermal activation energy of □ 0,2 eV. In GaAs *p-n* junctions the degradation rate was constant in the temperature range 290–370 K.