RADIATIVE AND MAGNETICALLY STIMULATED EVOLUTION OF NANOSTRUCTURE COMPLEXES IN SILICON SURFACE LAYERS

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Introduction

The problem of longterm operation of semiconductor devices and stability of their parameters in electromagnetic fields is closely related to the issue of the evolution of nanostructure complexes in surface layer of silicon crystals and base components fabricated on their basis.

Materials and methods

P-type Cz-Si with ρ = 10 ohm•cm resistivity was used for the studies. Samples have been cut from a single crystal silicon disk with flat surfaces orientation (111).

The aim of the work was to form a surface-barrier structure (SBS) Bi-Si-Al (Fig.1) and to investigate the change in their electro physical characteristics under the influence of X-radiation.

Irradiation of samples was carried out with X-ray tube (V = 45 kV, I = 8 mA, W-anode).

Magnetic field was applied with different duration and constant induction of 0.17 T.

Electrophysical properties of SBS were studied by measuring and analysing current-voltage characteristic (IVC) and high-frequency capacitance-voltage characteristic (CVC) curves (Fig.2).

From experimental C-V characteristics, the distribution of surface-state density in silicon's bandgap on the boundary of $Si\text{-}SiO_2$ was calculated (Fig.3).

Changes of the defect structure of silicon p-type crystal surface layer under the influence X-radiation were investigated by the methods of deep levels capacitance-modulation spectroscopy (DLCMS) (Fig.4).

Defect formation processes on the surface and subsurface layers of silicon crystals were analysed by IR spectroscopy (Fig.5).

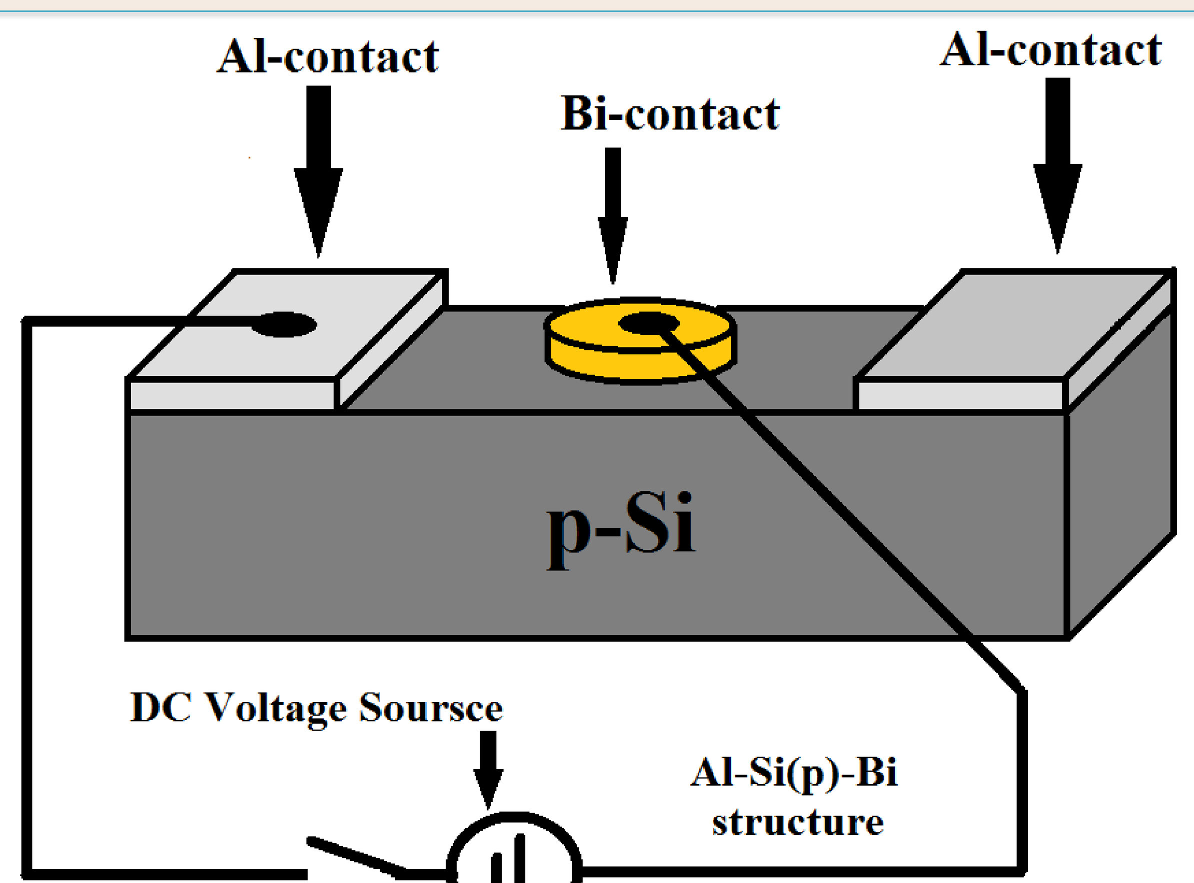

Fig.1. Bi-Si-Al diode structure

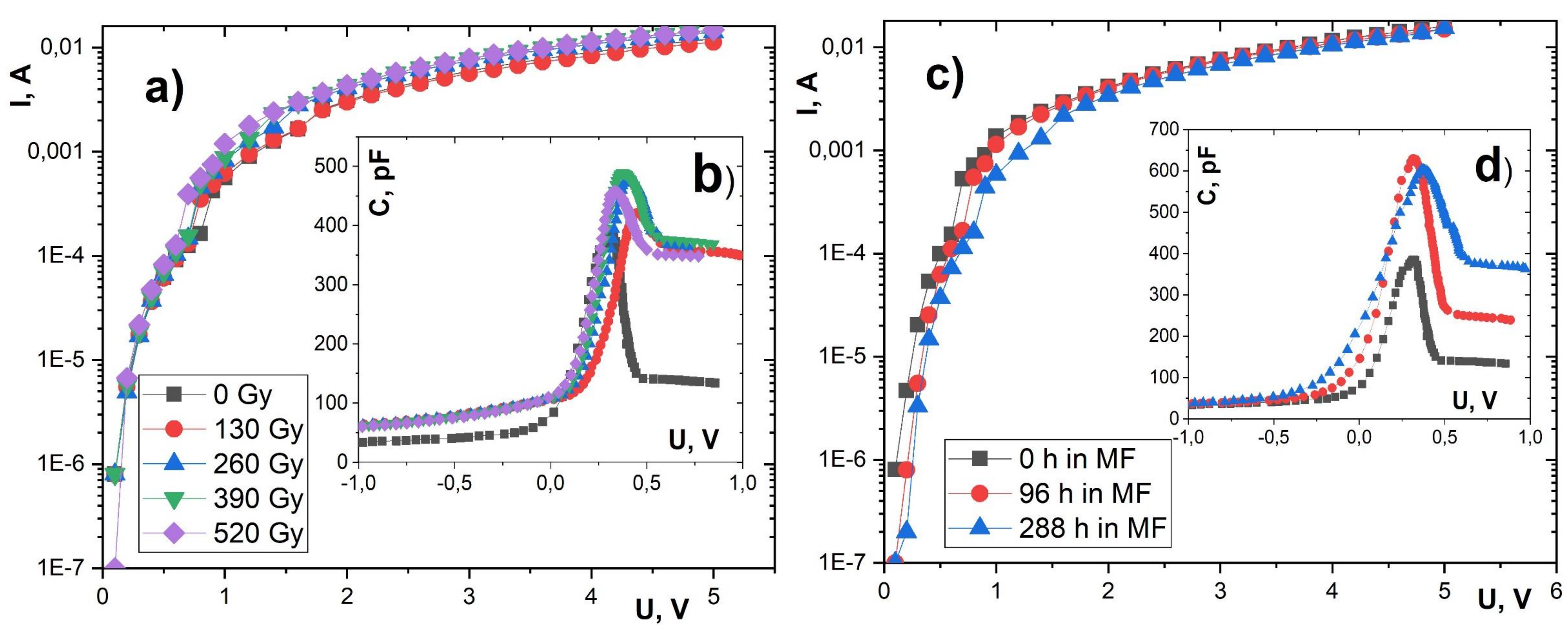

Fig.2. Radiative (a, b) and magnetic (c, d) stimulated changes of IVC (a, c) and CVC (b, d) for the SBS

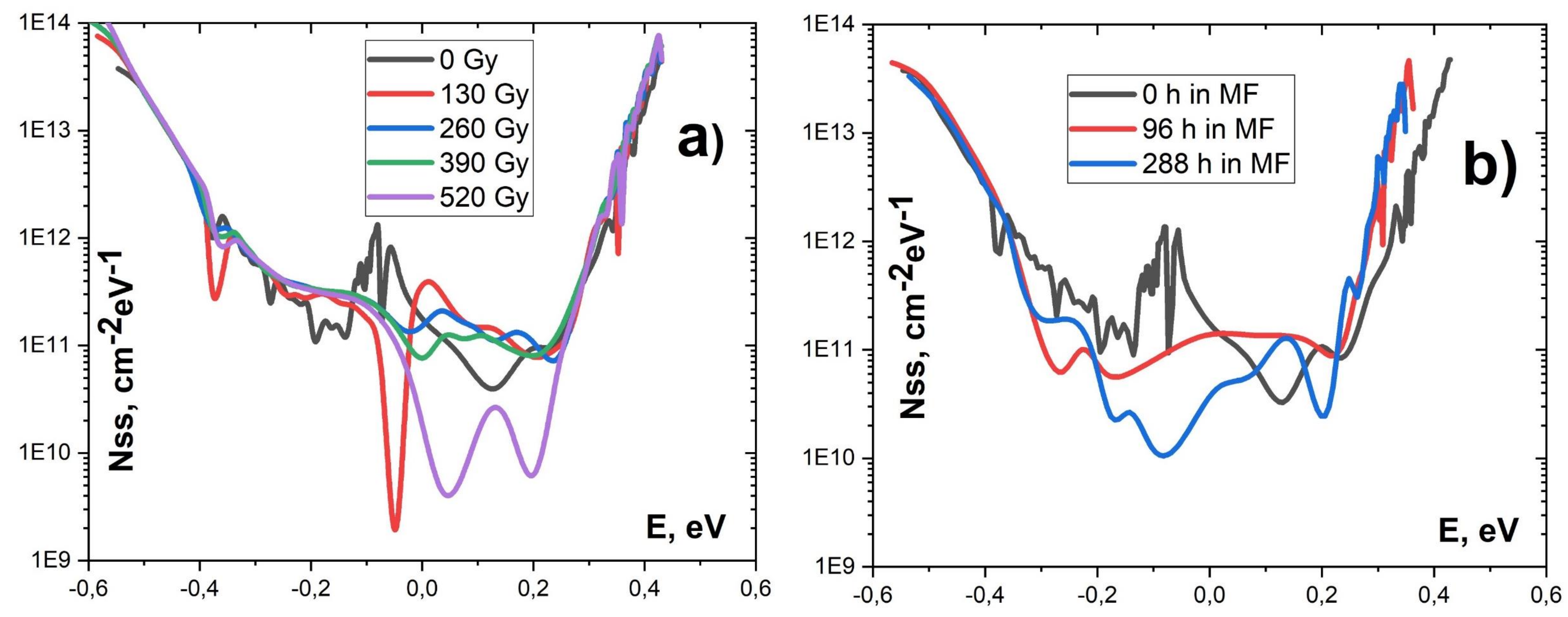

Fig.3. Radiative (a) and magnetically (b) stimulated changes of the charge states of the $Si\text{-}SiO_2$ of the Bi-Si-Al diode structure
(Distribution of the density of fast surface states in the band gap of silicon)

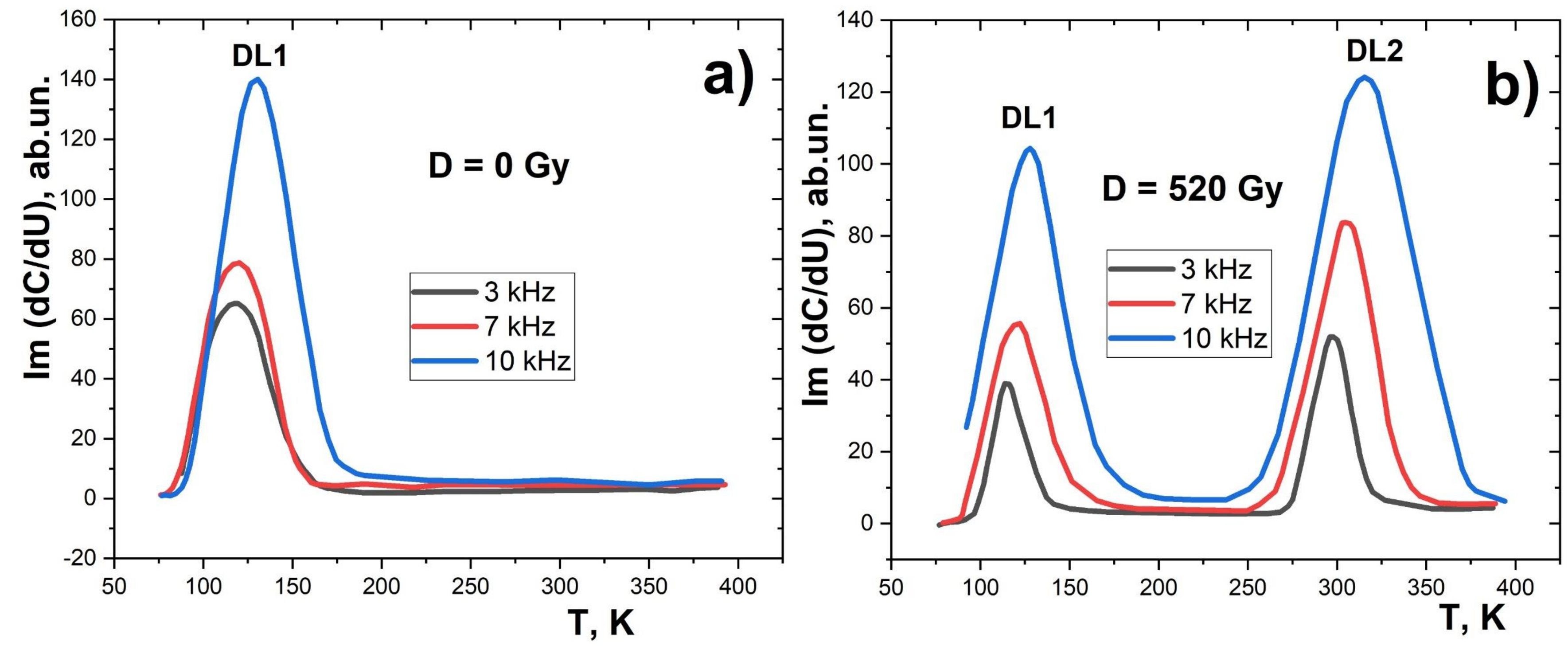

Fig.4. Capacitive-modulation spectrum of deep levels in the bandgap of silicon of SBS: a) - not irradiated, b) – D = 520 Gy

	DL1	DL2
E, eV	Ev+0.38	Ev+0.45
σ, cm^{-2}	$3\cdot10^{-14}$	$1\cdot10^{-15}$
	Si_I+Si_I	B_I

Tab. 1. Energy of deep levels and type of defect

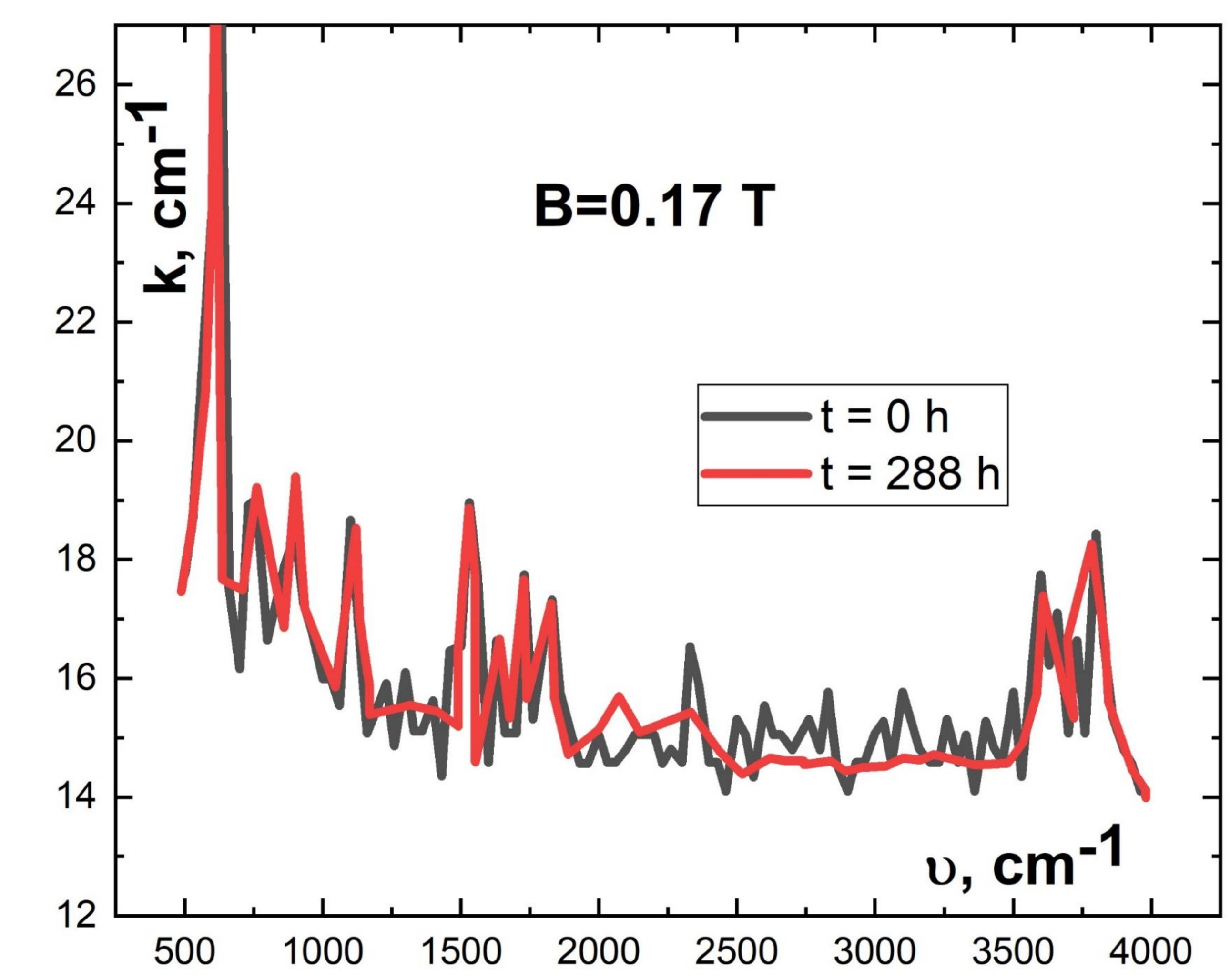

Fig.5. Infrared absorption spectra of the initial p-Si samples

Conclusions

- Analysis of the DLCMS spectra showed radiative stimulated evolution of clusters of interstitial silicon atoms (Si_I + Si_I) and formation of new point defects (B_I).
- 288 hours exposure of single-crystal silicon samples in a magnetic field stimulates the decay of hydrogen-containing surface complexes ($C\text{-}H_X$,) and the formation of $Si\text{-}H_3$ centers.