X-STIMULATED EVOLUTION OF POINT DEFECTS AND THEIR COMPLEXES IN SILICON STRUCTURES

D.P. Slobodzyan, M.O. Kushlyk, R.M. Lys, B.V. Pavlyk

Ivan Franko National University of Lviv, st. Hen. Tarnavskoho 107, Lviv, 79017, Ukraine
E-mail: slobodzyand@gmail.com

Introduction

The development of modern nanoelectronics in the direction of significant reduction of elements poses increased requirements for the state of the surface layer of silicon structures. The presence of spot and line defects can significantly affect the surface activity. This can be reflected in the efficiency and durability of these elements due to weak electromagnetic fields, in particular.

Materials and methods

P-type Cz-Si with ρ = 24 ohm•cm resistivity was used for the studies. Samples have been cut from a dislocation-free ($N_d \leq 10^2$ cm^{-2}), 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).

Electrophysical properties of SBS were studied by measuring and analysing current-voltage characteristic (IVC) (Fig.2) and high-frequency capacitance-voltage characteristic (CVC) curves (Fig.3,a). From experimental C-V characteristics, the distribution of surface-state density in silicon's bandgap on the boundary of $Si-SiO_2$ was calculated (Fig.3, b).

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)

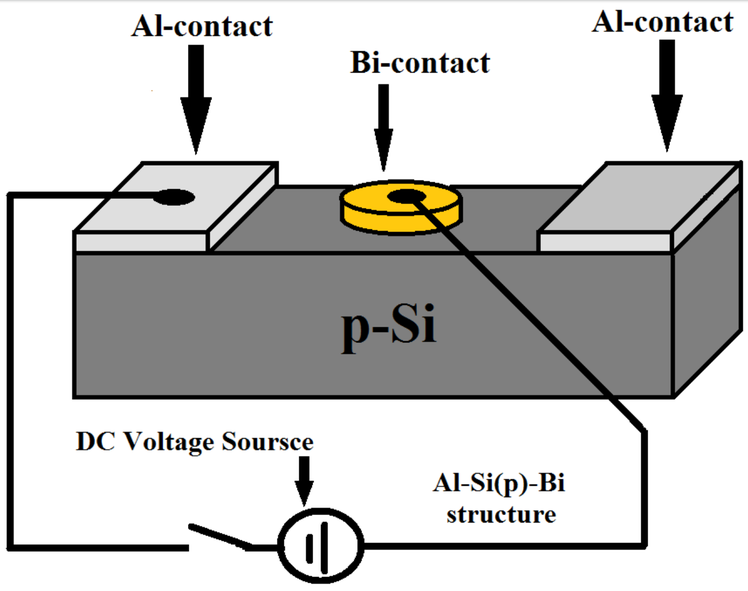

Fig.1. Bi-Si-Al diode structure

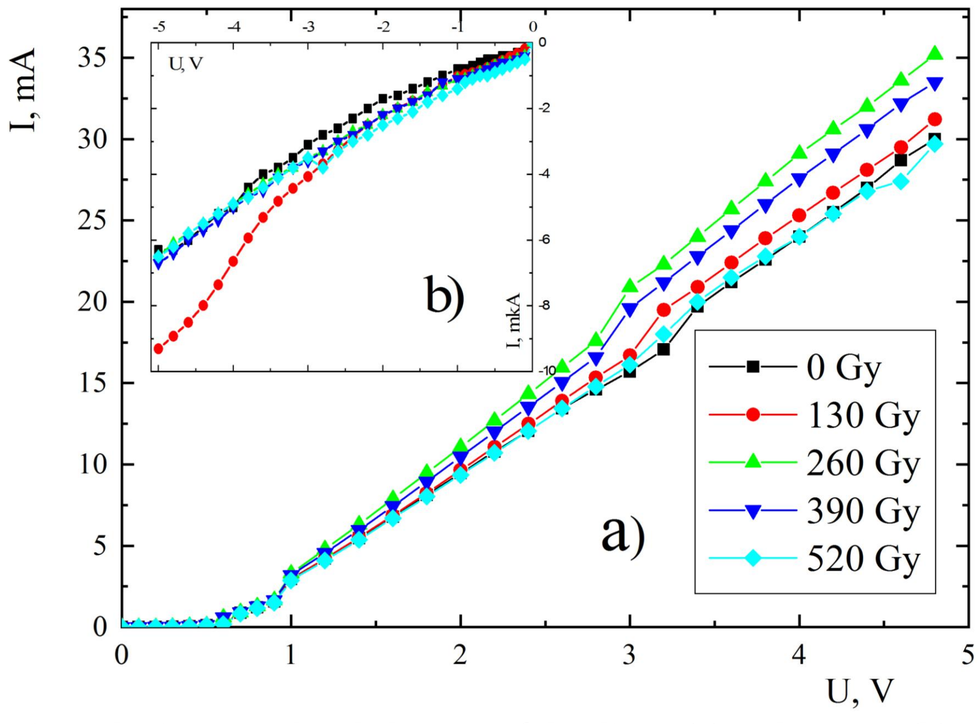

Fig.2. Radiative stimulated changes of the direct (a) and inverse (b) regions of VAC for the SBS

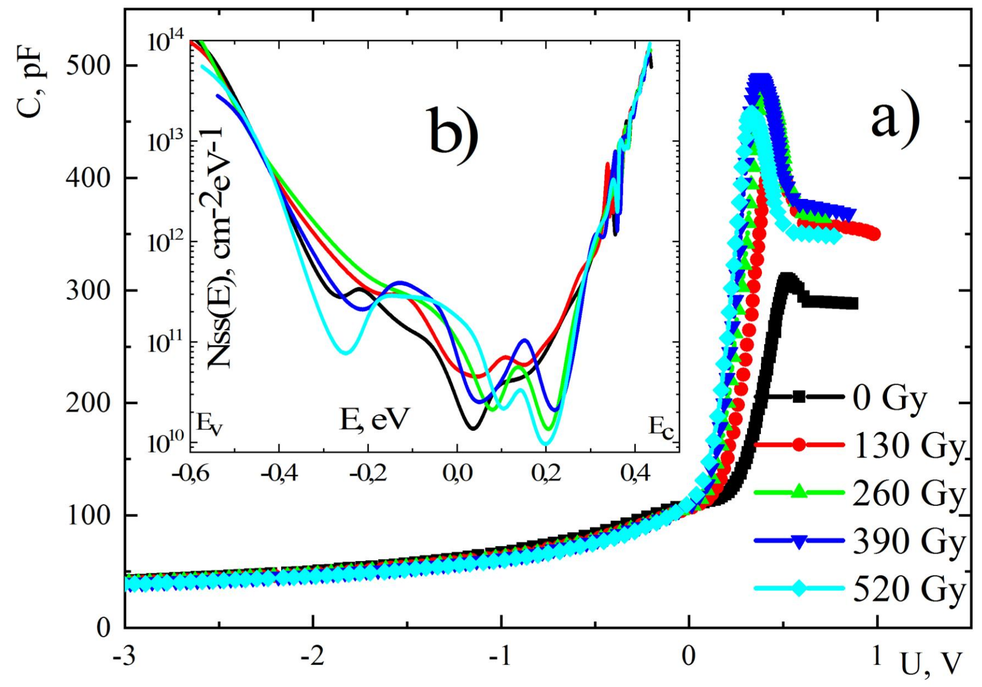

Fig.3. Radiative stimulated changes of the CVC (a) and charge states of the $Si-SiO_2$ of the Bi-Si-Al diode structure (b)
(Distribution of the density of fast surface states in the band gap of silicon)

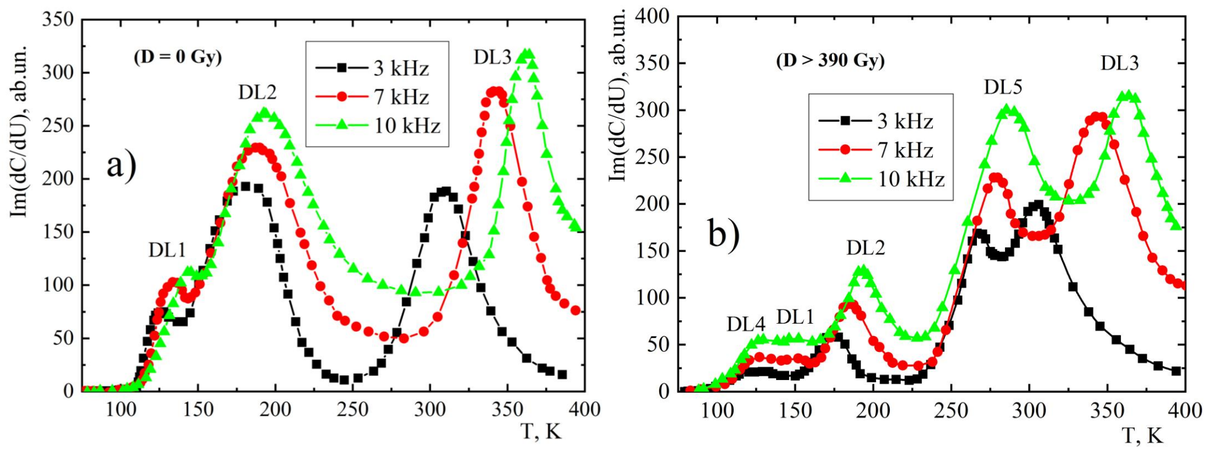

Fig.4. Capacitive-modulation spectrum of deep levels in the bandgap of silicon of SBS: a) - not irradiated, b) – D > 390 Gy

Tabel 1. Energy of deep levels and type of defect

	DL1	DL2	DL3	DL4	DL5
E, eV	Ev+0.13	Ev+0.30	Ev+0.18	Ev+0.38	Ev+0.36
σ, cm^{-2}	$5 \cdot 10^{-17}$	$1 \cdot 10^{-16}$	$1 \cdot 10^{-17}$	$3 \cdot 10^{-14}$	$1 \cdot 10^{-15}$
	V+	C_I	C_S-O_I	Si_I	C_I-O_I

Conclusions

- The analysis of electrophysical properties irradiated SBS confirmed the existence of two competing radiation processes: the radiation-stimulated ordering of the defect structure of the near-surface layer (D < 390 Gy) and the generation of defects (D > 390 Gy).
- Analysis of the DLCMS spectra showed evolution of oxygen and carbon centers and formation of complexes C_I-O_I by Watkins mechanism in surface layer of silicon.