Ultrasound Action on Radiation Defects at the Silicon Dioxide / Silicon Interface of MOS Structure

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It is widely recognized that ultrasound can serve as an effective tool for influencing defects in semiconductors. Similar effects have been observed in Si/SiO_2 structures [1]. This study presents the results of acoustically induced annealing of radiation defects in γ-irradiated silicon MOS structures.

The experiments revealed that gamma irradiation (^{60}Co source, $5\cdot10^7$ rad) of Au-SiO_2-Si structures alters the current mechanism under low bias conditions (<1 V) (see Fig. 1a). In the pristine structures, thermionic emission (TE) over the potential barrier was the dominant process. However, after irradiation, the *I-V* characteristics align with a power-law behavior. A slope value of ~1.3 suggests the presence of space-charge-limited current with an exponential distribution of trap density. In this context [2]:

$$I = Aq^{l-1}\mu N_C\left(\frac{2l+1}{l+1}\right)^{l+1}\left(\frac{l}{l+1}\frac{\varepsilon\varepsilon_0}{N_t}\right)^{l}\frac{V^{l+1}}{d^{2l+1}} = R_{SCLC}\cdot V^{l+1}, \qquad (1)$$

where N_t is the density of traps, l is the parameter given by $l = E_C / kT$ and E_C is the characteristic energy of traps distribution. The activation energy (0.32 eV), determined from the temperature dependence of the current, suggests that the primary SCLC defects are Pb centers.

Ultrasound treatment (4 MHz, 2 W/cm², room temperature) of the irradiated MOS structures was performed using two consecutive loading-unloading cycles, each lasting 30 minutes. The total treatment time was either 30 minutes (UST30) or 60 minutes (UST60). Under the influence of ultrasound, an increase in l (broadening of the trap energy distribution) and a decrease in R_{SCLC} (reduction in the trap total concentration N_t) were observed. Analysis of the reverse current showed that UST also reduces the concentration of E′ centers, which actively participate in trap-assisted tunneling processes. In our opinion, the observed defect annealing can be attributed to the acoustically stimulated diffusion of interstitial oxygen and hydrogen atoms.

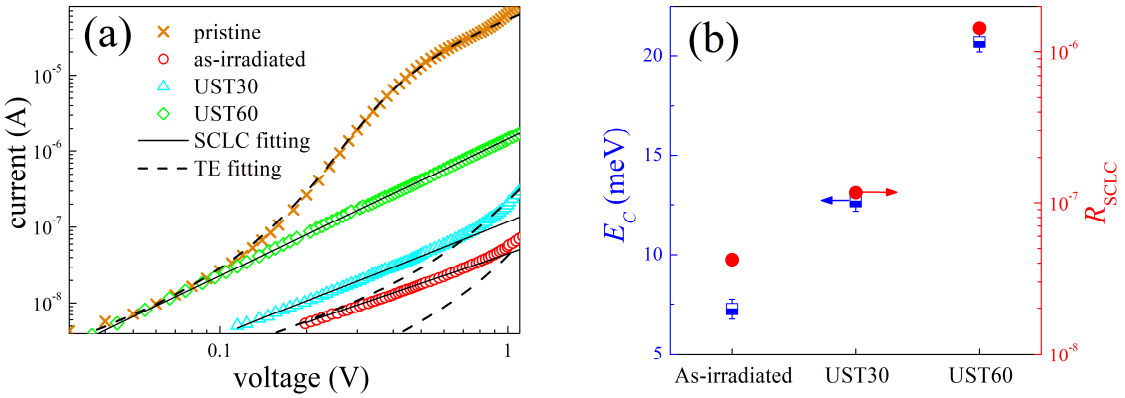

Figure 1: (a) Current versus forward bias voltage for MOS silicon structure. The marks are the experimental results, and the solid and dashed lines are the SCLC and TE fitted curves. (b) UST influence on SCLC characteristics.

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[2] S. Kazmi *et al.*, Physica B 670, 415400 (2023).
[3] P. K. Hurley *et al.*, J. Appl. Phys. 93, 3971 (2003).