REACTOR RADIATION DOSIMETRY USING
FUSED QUARTZ

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The characteristics of quartz glass for separate dosimetry of γ radiation from a VVR-SM reactor in the presence and absence of neutron fluxes are investigated. Comparing the absorption and photoluminescence spectra of samples irradiated with γ rays from a stopped reactor and mixed with neutron and γ radiation from an operating reactor shows that in both cases oxygen defects are produced and the dose dependences are linear. The dosimetric bands are stable with respect to light and temperatures up to 400°C. The stationary γ-ray flux from the reactor, after the reactor is stopped, is calibrated according to a known source of γ-ray source 60Co and is ~15 Gy/sec.

Radiation-induced formation of defects in oxides is a serious problem for disposal of radioactive wastes by methods of vitrification and cementation. The combined effect of neutron and γ radiation on oxides has been investigated in detail, and it has been believed that neutrons with energy >100 keV are capable of displacing atoms and the γ component gives rise only to ionization heating of materials and electron transfer between atoms. However, even back in 1973, it was shown [1] that average Compton-electron energy $E_{av} = 5E_g = 40–45$ eV is sufficient to produce one electron-hole pair in a SiO₂ lattice with gap width $E_g = 8–9$ eV. Then the concentration of optical centers produced by γ radiation is related to dose by the empirical relation $N(\text{cm}^{-3}) = 10^{10} D_\gamma (\text{Gy})$. It has been proved experimentally that 60Co γ rays with $E \sim 1.25$ MeV can shift light anions (O, F) in crystals and glasses by an inelastic mechanism.

In a certain interval, the concentration of radiation-induced optical centers in an oxygen sublattice is proportional to the absorbed energy. Consequently, the intensity of the corresponding optical absorption band or photoluminescence can be used as a dosimetric parameter if the optical sensors are stable with respect to the effect of light and temperature (up to 400°C) and also do not overlap in spectra with other centers and do not convert into other centers. For such requirements, the material must be either free of impurities down to $10^{-4}$% or contain only one optically active impurity, the change of whose valence can be used to determine the absorbed dose of ionizing radiation. In addition, it is desirable that high-temperature annealing of irradiated samples would restore the initial optical spectra and the material can be fused repeatedly. Such a material turned out to be germanium-doped SiO₂ glass, which is applicable as a solid dosimeter for determining the absorbed dose of neutron and γ radiation [2].

Investigations [3] have shown that most quartz glasses acquire color under the action of 60Co γ radiation. This can be used in dosimetry. The intensity of the optical absorption at wavelength $\lambda = 550$ nm increases almost linearly with increasing absorbed dose of γ radiation up to dose $10^5$ Gy, which attests to the possibility of using KI quartz glass for γ-radiation dosimetry. However, KGS and KSIII glasses acquire almost no color and remain transparent. Consequently, the band at 215 nm may be better as the working band because it is related with the formation of oxygen vacancies (structural defects designated in the literature as $E_g'$-centers) and has a wider dose range [4–7]. The absorbed dose of the γ component of reactor radiation can be determined by the increase of the concentration of oxygen vacancies and the flux of fast neutrons – according to the increase...
in the content of silicon vacancies in ultrapure quartz glasses. The separate dosimetry of reactor-radiation components is a topical problem in connection with the switching the research VVR-SM reactor to low-enrichment fuel.

The purpose of the present work is to investigate the dosimetric characteristics of pure fused quartz to determine the intensity of \( \gamma \) radiation in the presence of fluxes of fast neutrons with energy above 0.1 MeV in the core and after the reactor is stopped.

**Experimental Part.** Dosimetric investigations of ultrapure quartz glass were performed using spectrometric optical absorption and photoluminescence. The SiO\(_2\) absorption spectra were measured in the range 200–900 nm with a