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Fig. 1

Figure 1: Fig. 1

Abstract

Full Text

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PHYSICS

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ON THE REGULARITIES IN THE CHANGE OF THE RAMAN-SCATTERING SPECTRUM OF α-QUARTZ UPON IRRADIATION WITH FAST NEUTRONS

(Presented by Academician A. V. Shubnikov, 12 VI 1963)

1. In continuation of the work ([1]), with the aim of studying the regularities in the change of the properties of α-quartz under the action of fast neutrons, the Raman-scattering spectra of quartz irradiated with integral neutron fluxes of $4 \cdot 10^{19}$ and $5 \cdot 10^{19}$ n/cm^2 were investigated by the photoelectric method on a DFS-12 spectrometer. On the same instrument, the Raman-scattering spectrum was again recorded for a quartz specimen irradiated with a dose of $7 \cdot 10^{19}$ n/cm^2, studied in ([1]). The results of the measurements are presented in Fig. 1.

Fig. 1. Raman-scattering spectrum of quartz irradiated with integral fluxes of fast neutrons:
1 –$7 \cdot 10^{19}$ n/cm^2; 2 –$5 \cdot 10^{19}$ n/cm^2; 3 –$4 \cdot 10^{19}$ n/cm^2.
On the abscissa axis the positions of the Raman lines in the spectrum of unirradiated α-quartz are marked.

2. It has been established that irradiation produces: a) a gradual decrease in the intensity of the maxima corresponding to the Raman lines of unirradiated quartz, and an increase in the width of these maxima; b) a shift of the maxima toward lower frequencies; c) an increase in the intensity of the continuous spectrum of Raman scattering.

3. The change in the principal parameters of the Raman-scattering spectrum with increasing dose is not monotonic.

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It is seen from Fig. 1 that the Raman spectrum of quartz irradiated with a dose of $7 \cdot 10^{19}$ n/cm^2 (curve 1) differs fundamentally from the spectra of specimens irradiated with doses of $(4 \div 5) \cdot 10^{19}$ n/cm^2 (curves 2 and 3). The Raman spectra of quartz irradiated with doses of $(4 \div 5) \cdot 10^{19}$ n/cm^2 retain the main features of the Raman spectrum of unirradiated α-quartz, whereas the spectrum of quartz irradiated with a dose of $7 \cdot 10^{19}$ n/cm^2, in terms of the number of maxima and their frequencies, especially in the region up to 600 cm^{-1}, is close to the spectrum of β-quartz ([2]).

4. A comparative analysis of the Raman-scattering spectra of irradiated quartz and unirradiated crystalline quartz showed that the changes in the principal parameters of the spectrum caused by the action of fast neutrons are, in many respects, analogous to temperature changes. To each irradiation dose there can be assigned such a temperature at which the principal parameters of the Raman lines of the spectra of heated and irradiated ···

···of quartz agree in the first approximation. Such a comparison for the frequencies of the most intense lines is given in Table 1.

5. A comparison of the spectra of irradiated quartz and unirradiated fused quartz showed that the Raman spectrum of irradiated quartz may be regarded as a superposition of the discrete spectrum of crystalline quartz at the corresponding equivalent temperature and the continuous spectrum of an amorphous phase formed under the action of fast neutrons.

6. On the basis of studies of Raman spectra it has been shown ([3,4]) that the final result of the action of fast neutrons on crystalline quartz is: a) the creation of regions of amorphized quartz whose properties are close to those of fused quartz; b) the transition of the remaining crystalline structure into a new stable state, equivalent to the state of unirradiated quartz at high temperatures; c) an increase in the fraction of amorphized quartz and a rise in the equivalent temperature of the crystalline residue with increasing irradiation dose. At the dose for which the equivalent temperature becomes equal to the temperature of the phase transition, a radiation-induced $\alpha \rightarrow \beta$ transition occurs in the crystalline residue. Under our conditions this dose corresponds approximately to an integral flux of $(6 \div 7) \cdot 10^{19}$ n/cm^2.

Table 1

Frequencies of Raman lines, cm^{-1}

Unirradiated α-quartz, $T = 583$°K	Irradiated α-quartz, $5 \cdot 10^{19}$ n/cm^2	Unirradiated α-quartz, $T = 523$°K	Irradiated α-quartz, $4 \cdot 10^{19}$ n/cm^2	Unirradiated α-quartz, $T = 300$°K
128	118	118	114	113
206	187	184	170	182
267	262	264	260	258

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Unirradiated α-quartz, $T = 583^{\circ}$K	Irradiated α-quartz, $5 \cdot 10^{19}$ n/cm^2	Unirradiated α-quartz, $T = 523^{\circ}$K	Irradiated α-quartz, $4 \cdot 10^{19}$ n/cm^2	Unirradiated α-quartz, $T = 300^{\circ}$K
357	355	354	355	353
466	462	463	460	462
696	695	690	695	690

7. It has been shown that the stability of the high-temperature states of crystalline quartz formed after irradiation is ensured by negative pressures arising within the volume of the crystal as a result of the action of neutrons. It was found that the magnitude of these pressures increases together with the irradiation dose.

8. The proposed model of changes in the state of quartz after neutron irradiation makes it possible to explain satisfactorily all the observed radiation-induced changes in the properties of quartz and may be used to predict the behavior of crystalline materials under irradiation by fast neutrons.

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References Cited

1. V. G. Zubov, L. P. Osipova, *DAN*, **144**, No. 4, 763 (1962).

2. R. K. Nagaupanaswany, Proc. Ind. Acad. Sci., A **26**, 521 (1947); **28**, 417 (1948).

3. L. P. Osipova, Dissertation, Moscow State University named after M. V. Lomonosov, 1962.

4. V. G. Zubov, Doctoral dissertation, Moscow State University named after M. V. Lomonosov, 1963.

Note: Figure translations are in progress. See original paper for figures.

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