THERMAL CONDUCTIVITY OF IRRADIATED, ADDITIVELY-COLORED AND DEFORMED MgO*

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Low temperature thermal conductivity measurements have been made on neutron-irradiated (1) electron-irradiated, additively-colored (2) and deformed MgO. Resonance scattering of phonons is observed in all these crystals at $T = 15-20$ K. Correlation with optical measurements (3) indicate that this resonance is associated with anion vacancies. In addition, a resonance at $T \sim 1$ K in neutron-irradiated crystals is attributed to defect aggregates, which are virtually absent in electron-irradiated (4) and additively-colored samples.

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Figure 1b shows the thermal conductivity of MgO irradiated by 1.5 MeV electrons to a dose of 3×10^{18} e/cm². Although not shown in this figure, measurements were also taken at lower temperatures. There is no phonon scattering at $T \sim 1$ K. The resonance at $T \sim 20$ K is much weaker than that observed in the neutron-irradiated samples, with an anion-vacancy concentration of 2×10^{16} cm⁻³, as compared to 4×10^{17} cm⁻³ for the lowest neutron dose. Following a uv bleach of an electron-irradiated sample at room temperature, a process which has been shown to partially convert (5) F^+ to F centers (anion vacancies with one and two electrons respectively), the thermal conductivity is lower, indicating that the F center is a stronger scatterer than the F^+ center.

*Research sponsored by the U. S. Energy Research and Development Administration.

†Operated by Union Carbide Corporation under contract with the Energy Research and Development Administration.

Whereas anion vacancies in neutron-irradiated crystals are primarily in the F^+ state (6), in additively-colored samples they are normally in the neutral F state (5). Figure 1c shows the thermal-conductivity curve of an additively colored crystal with an anion-vacancy concentration of $2 \times 10^{17} \text{ cm}^{-3}$ entirely in the F state. A strong resonance at 20 K is observed. Following an uv bleach, which induces partial $F \rightarrow F^+$ conversion (5), the resonance becomes weaker. A reversion of $F^+ \rightarrow F$ centers by heating the crystal at 700 K restores the thermal conductivity to its original values. Thus, thermal conductivity measurements on irradiated and additively-colored MgO indicate that anion vacancies scatter phonon at $T = 15\text{-}20 \text{ K}$ and that the neutral F center is a stronger scatterer than the F^+ center.

Figure 1d shows the results of preliminary thermal conductivity measurements on a sample deformed to $\sim 2\%$ along a [100] direction. Again a dip at $T \sim 20 \text{ K}$ is observed. Optical measurement confirmed the presence of the broad deformation band at 5.7 eV, which is probably caused by higher-order point defects. Also, a crystal deformed 2% can be expected to result in $\sim 2 \times 10^{16} F^+$ center/ cm^3 (7). In addition, dislocation dipoles also occur during deformation. Hence, at this time it is not certain whether it is the anion vacancies, other defects, or dislocation dipoles that are responsible for the dip in thermal conductivity. However, a subsequent heat treatment at $\sim 1000 \text{ K}$ partially restores the thermal conductivity to its original curve. At this temperature most of the point defects, including anion vacancies, are annealed out, and some of the dislocation dipoles are converted into dislocation loops (8).

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FIGURE CAPTIONS

Fig. 1. Thermal conductivity vs. temperature for MgO which has been (a) neutron irradiated ($E > 1$ MeV), (b) electron irradiated ($E = 1.5$ MeV), (c) additively colored, and (d) deformed $\sim 2\%$ along a $[100]$ direction.

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Thermal Conductivity (watts $\text{cm}^{-1} \text{K}^{-1}$)

Fig. 1a

MgO
Fig. 1c

THERMAL CONDUCTIVITY, WATTS CM⁻¹ K⁻¹

A: PURE
a: ADDITIVELY
COLORED
b: AFTER UV
BLEACHING