



RAMAN AND FTIR CONSTRAINTS ON RETAINED HETEROGENEITY IN EuO-TREATED KEF-80 SILICON

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Introduction. High-temperature treatment of silicon with a chemically active rare-earth source may preserve the dominant crystalline Si response while generating a smaller reaction-affected population with different optical and bonding signatures. Raman and Fourier-transform infrared (FTIR) spectroscopy are complementary in this situation: Raman constrains a locally weighted lattice response, whereas transmission FTIR integrates bonding-sensitive absorption along the optical path [1–3]. We analyse EuO-treated KEF-80 silicon to determine whether these two spectroscopic projections support retained heterogeneity without implying wholesale transformation of the crystalline matrix.

Experimental basis. Phosphorus-doped n-type Czochralski KEF-80 Si (reference resistivity about $73 \Omega \cdot \text{cm}$; nominal (100) orientation) was treated in sealed quartz ampoules using a finite EuO source spatially separated from the specimens. Heating was approximately $10\text{--}15 \text{ }^\circ\text{C} \cdot \text{min}^{-1}$, followed by a 5 h hold at selected temperatures within $1100\text{--}1300 \text{ }^\circ\text{C}$ and rapid removal from the hot zone [1]. Raman spectra were obtained at three selected surface positions on a Renishaw inVia platform. Complementary room-temperature FTIR transmission covered approximately $4000\text{--}450 \text{ cm}^{-1}$; a locally baseline-corrected residual was examined over $900\text{--}1300 \text{ cm}^{-1}$. Because the FTIR record is path-integrated and a matched



source-free thermal control was unavailable, it is used as a bonding-sensitive constraint rather than a quantitative oxygen or layer-thickness measurement.

Results and discussion. All three Raman spectra are dominated by the first-order Si transverse-optical phonon near 521.0 cm^{-1} . The fitted full widths at half maximum are 6.15 , 6.26 and 6.08 cm^{-1} for Spots 1–3, respectively [1]. No broad amorphous-Si-like contribution replaces the principal mode and no large site-to-site displacement or linewidth difference is resolved. The dominant Raman-visible population therefore remains crystalline and comparatively similar at the sampled positions. Weaker bands near 299.56 – 303.36 cm^{-1} and 955.9 – 976.9 cm^{-1} are compatible with second-order Si scattering and do not identify a Eu-specific phase.

A stronger contrast occurs in the high-shift Raman background. Median values over 2000 – 3000 cm^{-1} are 349.4 , 1670.5 and 92.6 a.u. for Spots 1–3, giving a maximum contrast of about eighteen. Thus a pronounced local optical variation coexists with a nearly unchanged principal Si phonon. This background cannot be converted into Eu concentration or phase abundance because luminescent centres, defect- or oxide-related states, local absorption, interference, surface relief, focusing and collection efficiency can all contribute [2]. The secure conclusion is spatial variability of a subordinate optical response.

FTIR adds a different constraint. In the 900 – 1300 cm^{-1} interval the processed residual reaches an approximate maximum $\Delta A \approx 0.010$ at 1151 cm^{-1} , with a peak-to-peak variation of about 0.013 . No optically dominant broad SiO_2 -like envelope is resolved. The interval is oxygen-sensitive but chemically non-specific: interstitial oxygen in crystalline Si has structure-dependent infrared-active modes [4], while thermally formed silicon oxides exhibit broad bands in approximately the same range whose position depends on oxidation conditions and Si–O–Si network organisation [5]. The 1151 cm^{-1} maximum therefore cannot identify one oxygen reservoir or a unique Eu–O–Si product.

This non-uniqueness is physically expected because oxygen could originate from the Czochralski matrix, the initial surface oxide or the finite EuO source.



Controlled rare-earth oxide/silicon studies show that an oxygen-containing boundary can either suppress secondary reaction or, after oxide transformation, open access to silicon and facilitate rare-earth silicide formation [6,7]. These systems are not direct models of the present ampoule treatment; they demonstrate that boundary chemistry and thermal history govern the accessible pathway.

Conclusions. The combined Raman and FTIR record supports a bounded spectroscopic picture of EuO-treated KEF-80 silicon: a dominant crystalline-Si vibrational response coexists with a strongly position-dependent Raman background and a weak oxygen-sensitive FTIR residual. These observations are compatible with retained heterogeneous material whose spectroscopic weight is subordinate to that of the Si matrix. They do not establish a continuous modified layer, a unique Eu–Si–O topology, or the depth distribution of the contributing populations. Spatially registered Raman mapping, matched untreated and source-free thermal controls, front/back FTIR measurements and chemically selective depth analysis are the principal experiments needed to discriminate among the remaining interpretations.

REFERENCES

- [1] Saidov S. O. et al. Journal of Materials Science: Materials in Electronics. 2026. Vol. 37. Article 1344. DOI: 10.1007/s10854-026-17750-7.
- [2] Nuytten T. et al. Applied Physics Letters. 2024. Vol. 125. Article 053506. DOI: 10.1063/5.0219438.
- [3] Al-Amin K. et al. Nanoscale Advances. 2025. Vol. 7. P. 6677–6702. DOI: 10.1039/D5NA00522A.
- [4] Gentile F. S. et al. The Journal of Chemical Physics. 2020. Vol. 152. Article 054502. DOI: 10.1063/1.5139564.
- [5] Kayed K., Kurd D. B. Silicon. 2022. Vol. 14. P. 10081–10086. DOI: 10.1007/s12633-022-01732-5.
- [6] Held R. et al. Physical Review Materials. 2021. Vol. 5. Article 124419. DOI: 10.1103/PhysRevMaterials.5.124419.



[7] Selegard L. et al. Surface Science. 2021. Vol. 704. Article 121743. DOI: 10.1016/j.susc.2020.121743.