

INTERACTION OF INTRINSIC DEFECTS WITH OXYGEN IN NEUTRON-IRRADIATED MCZ-SI: AN INFRARED ABSORPTION STUDY

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OUTLINE

- Experimental
- IR spectra of n-irradiated MCz-Si samples
- Annealing at 80 C
- Annealing at 150-250 C
- I₂ and I₂O defects: what we know
- Conclusions

Experimental

- **Samples:**

- MCz-Si crystals ($[O_i] = 5 \times 10^{17} \text{ cm}^{-3}$, $[C_s] < 5 \times 10^{15} \text{ cm}^{-3}$)
- Dimensions were 10 × 6 × 2.8 mm

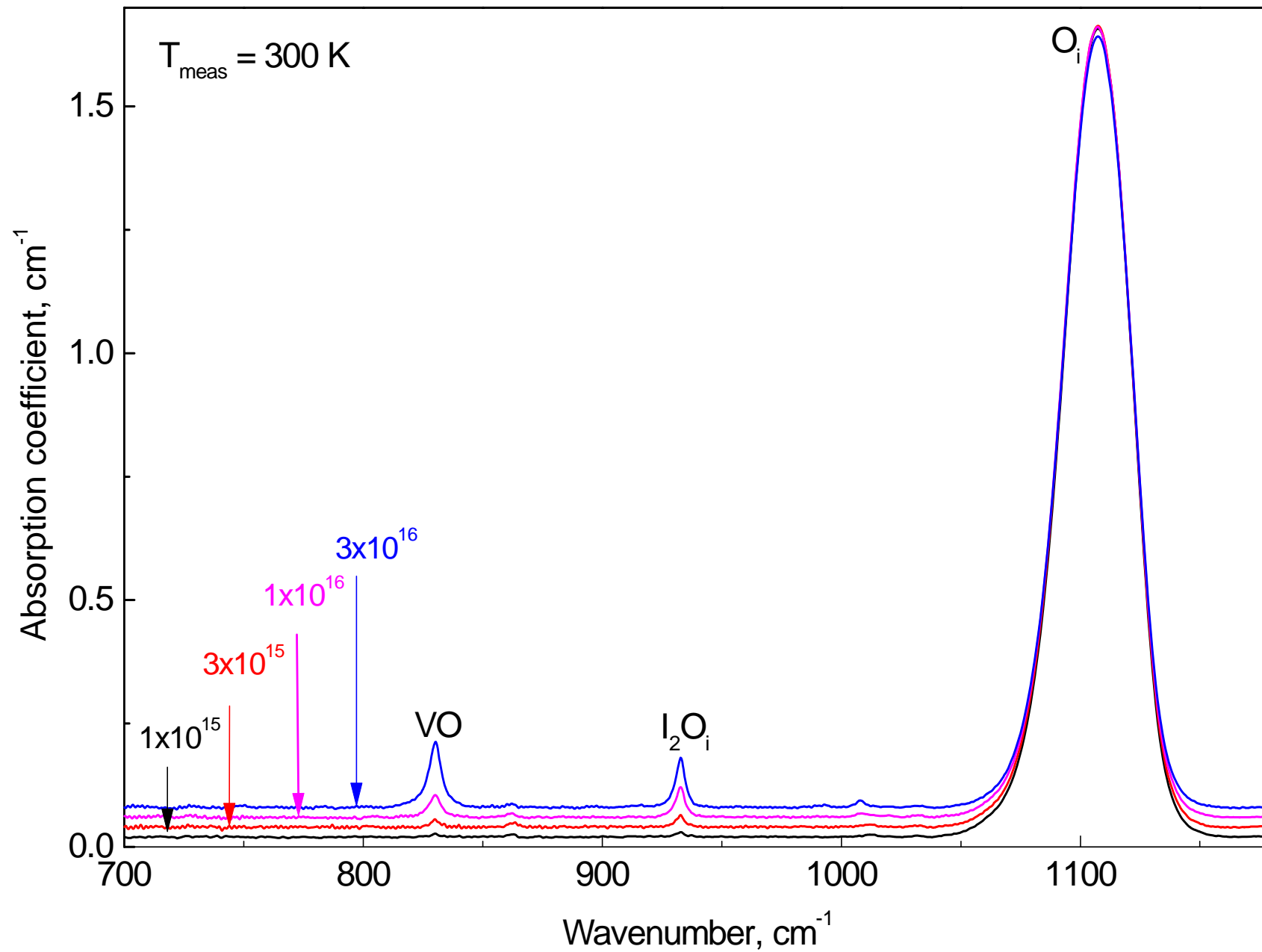
- **Treatments:**

- Room temperature neutron (1×10^{15} , 3×10^{15} , 1×10^{16} , $3 \times 10^{16} \text{ cm}^{-2}$) irradiation
- Thermal anneals in the range 80-250 °C

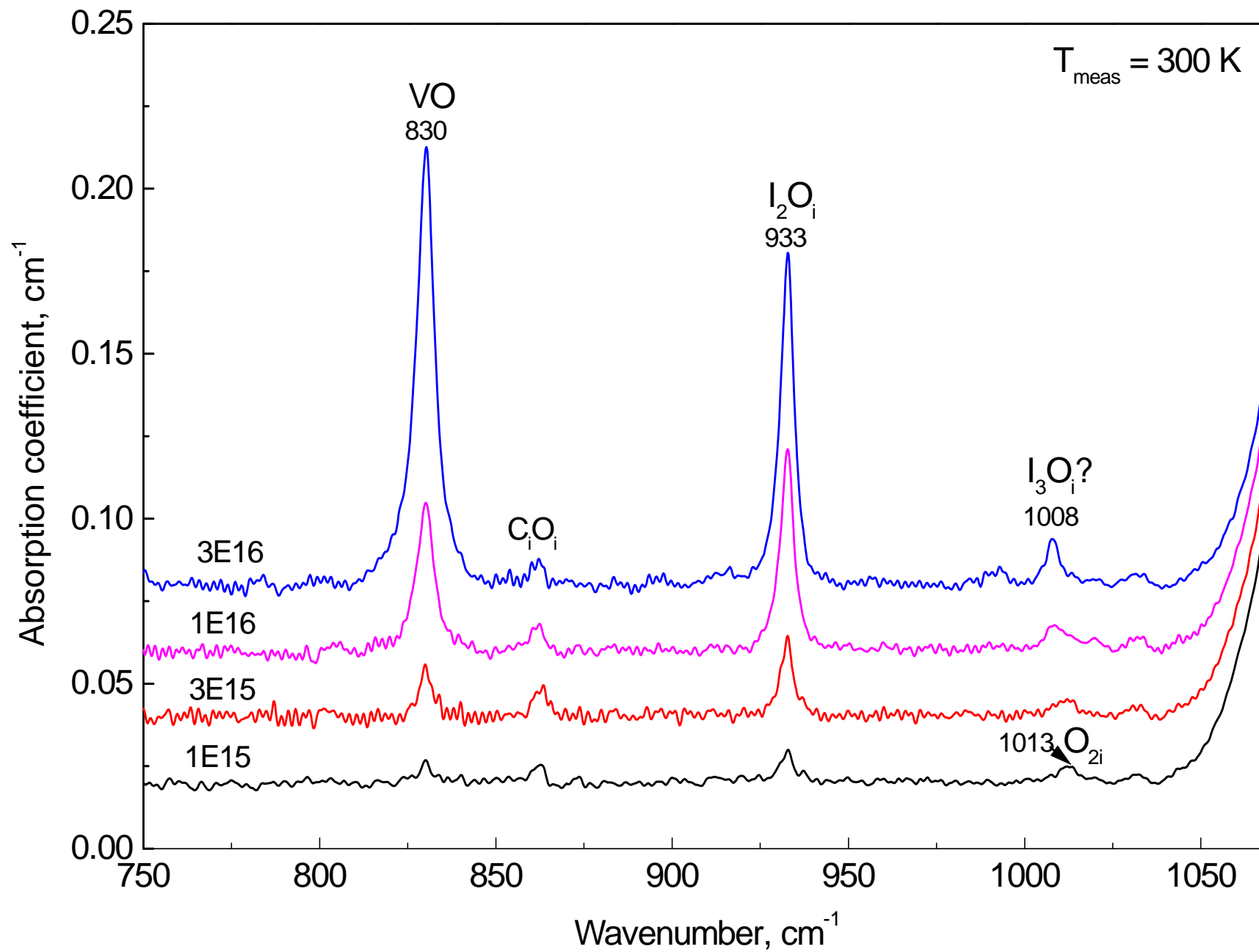
- **Measurements:**

- FTIR (Bruker IFS 113v) at 12-30 K (resolution 0.5 cm^{-1}) and/or 300 K (resolution 1.0 cm^{-1}) in the wavenumber range 400-4000 cm^{-1} .

MCzSi6 n-irradiated at RT

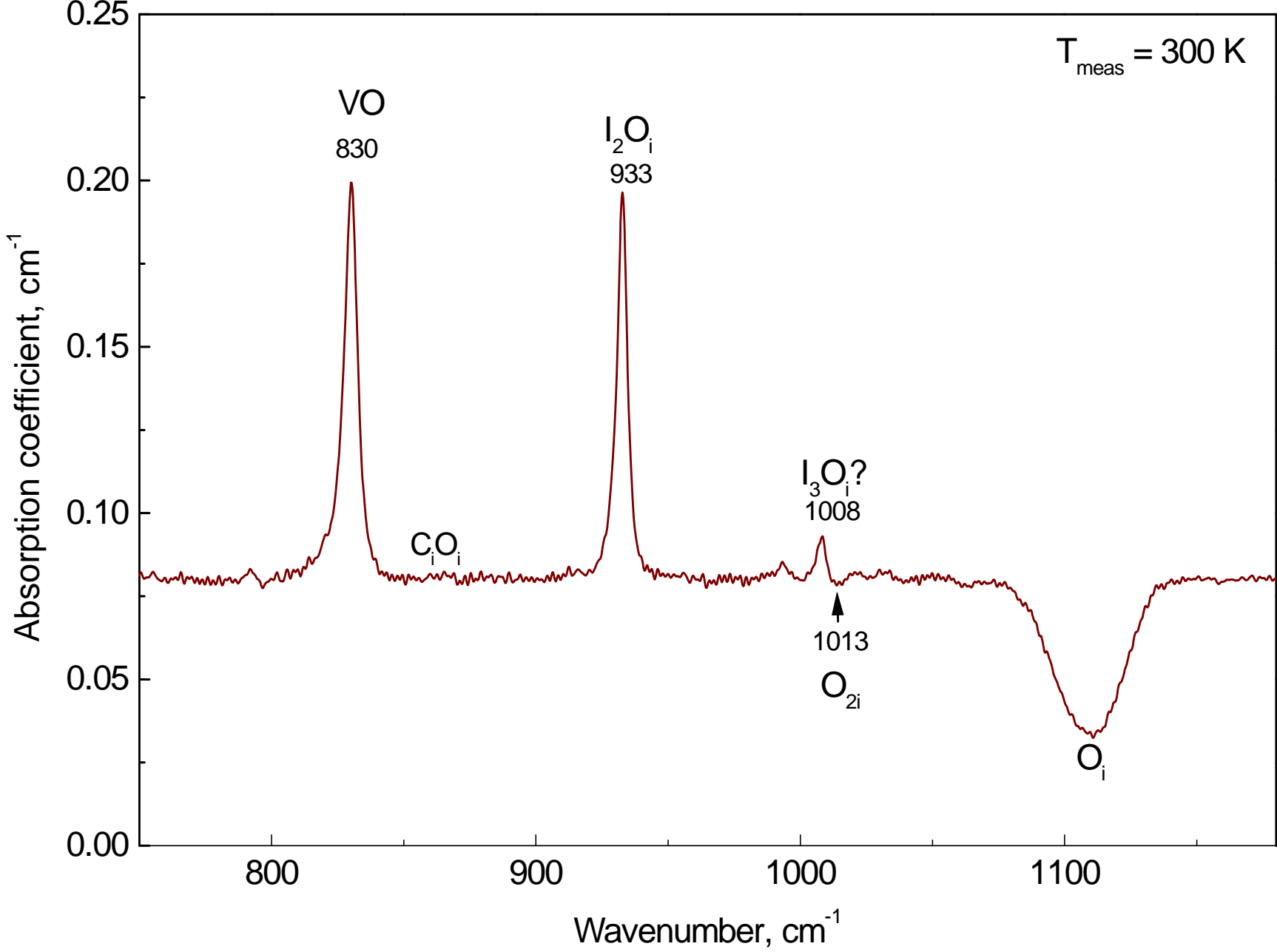


MCzSi6 n-irradiated at RT

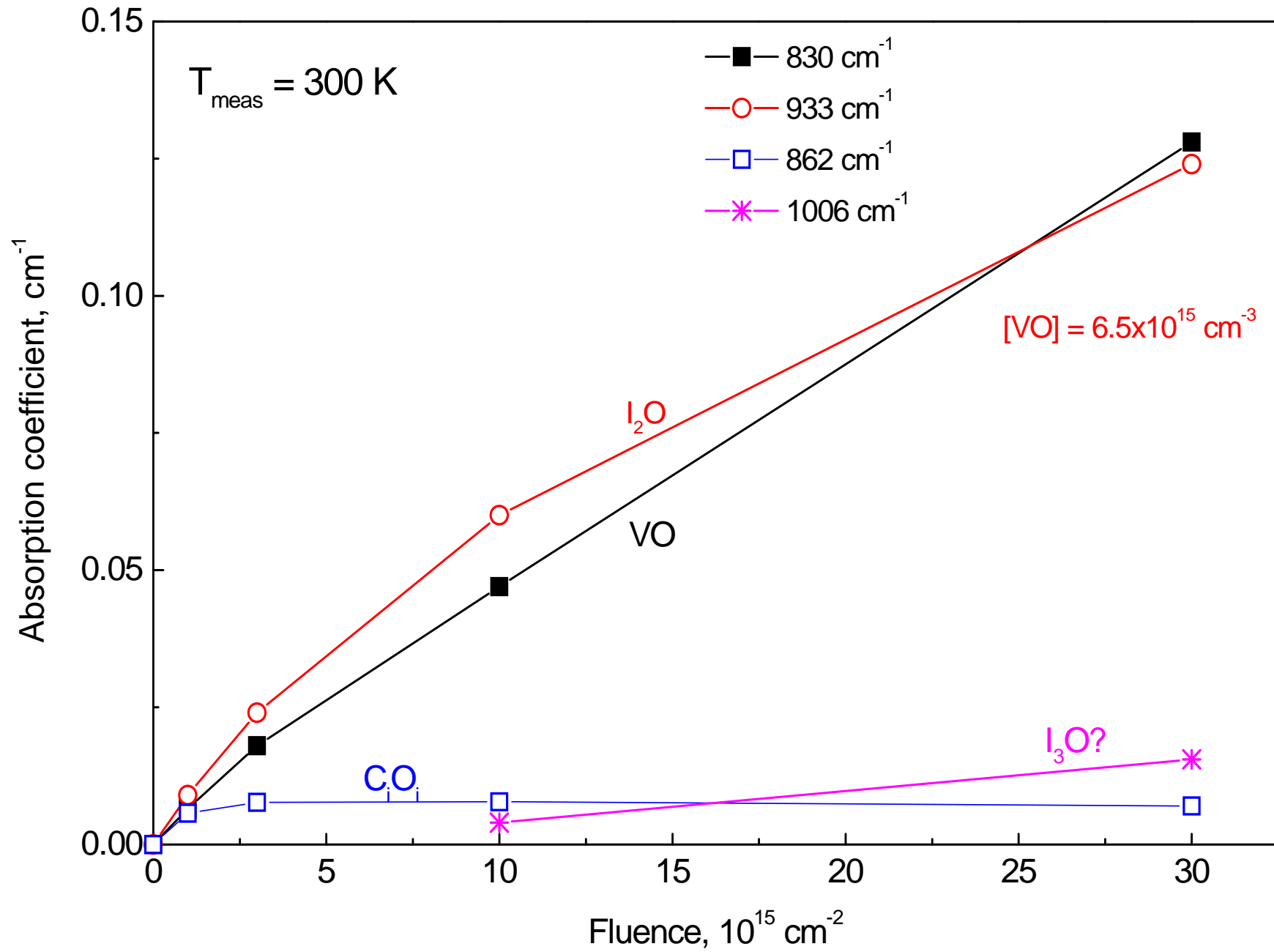


Difference: $3 \times 10^{16} - 1 \times 10^{15} \text{ cm}^{-2}$

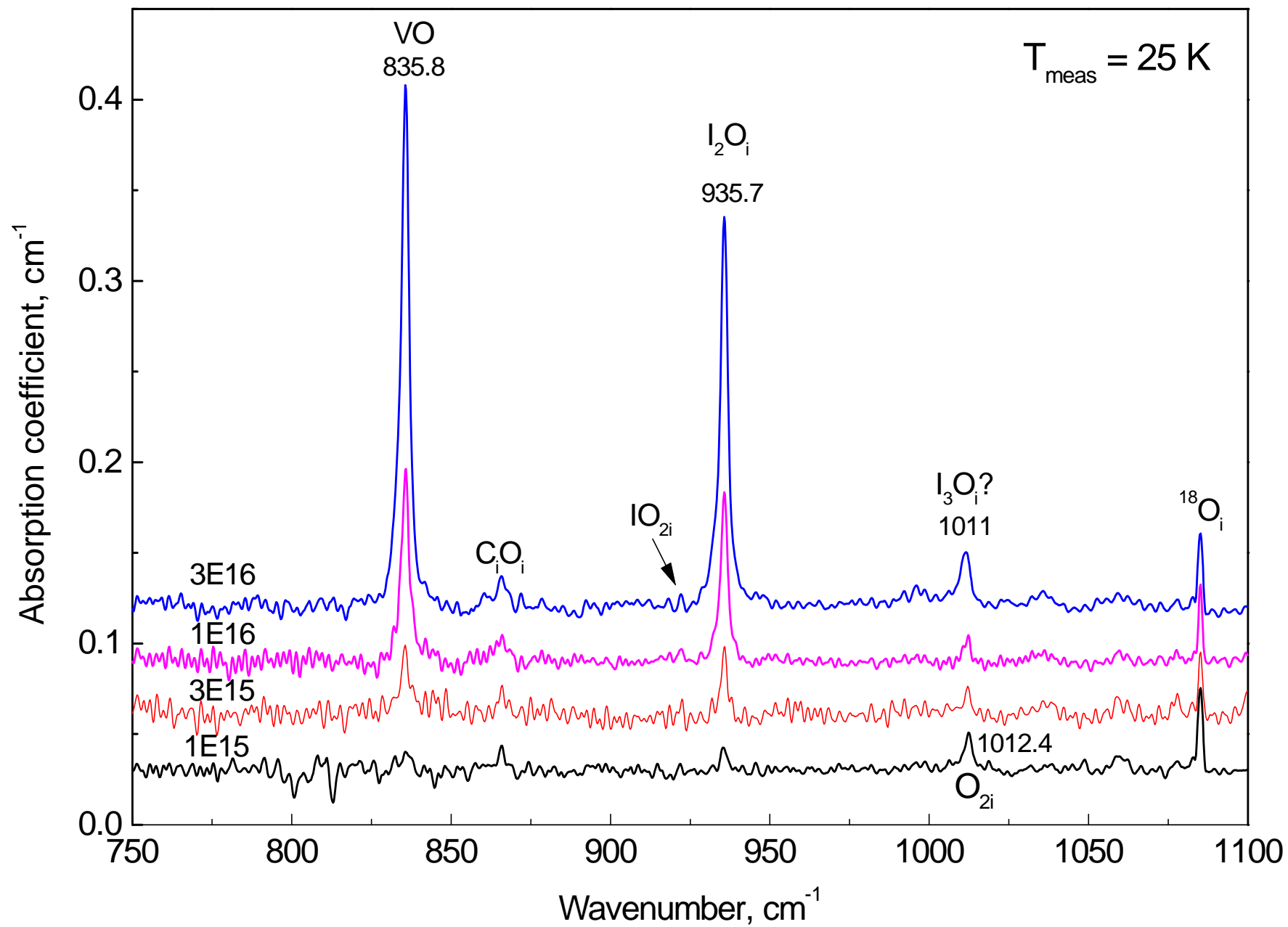
$T_{\text{meas}} = 300 \text{ K}$



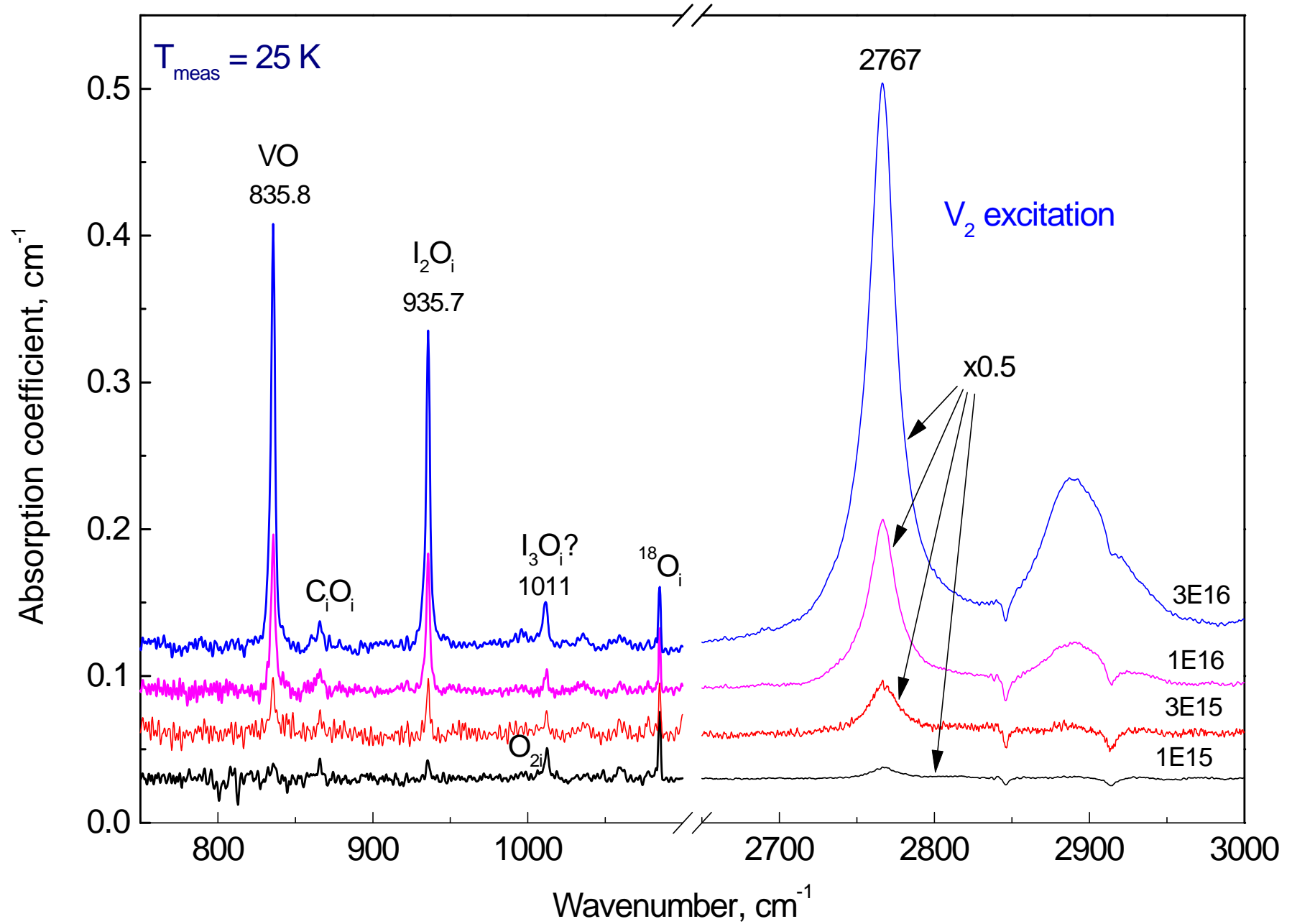
Dose dependence



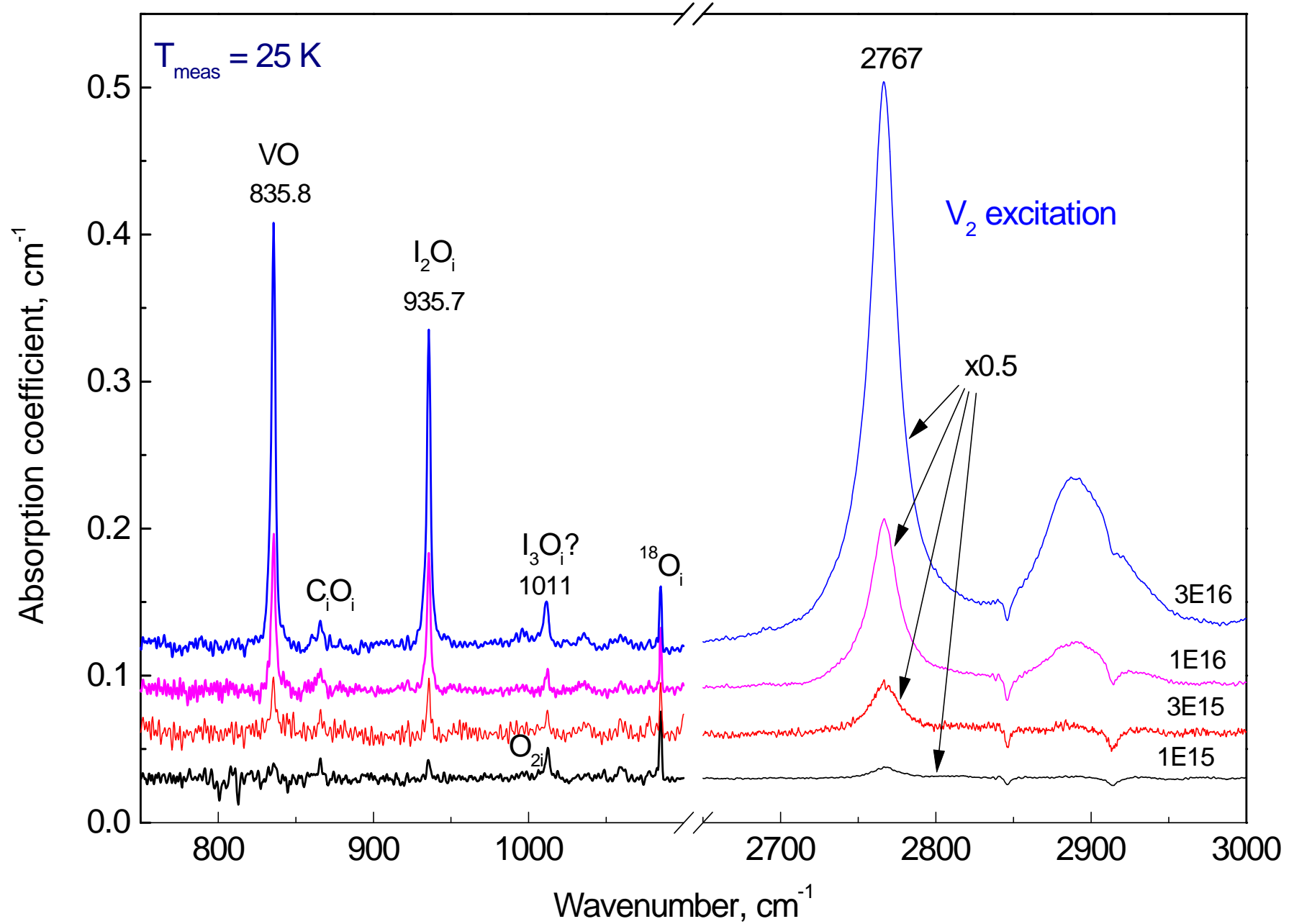
MCzSi6 n-irradiated at RT



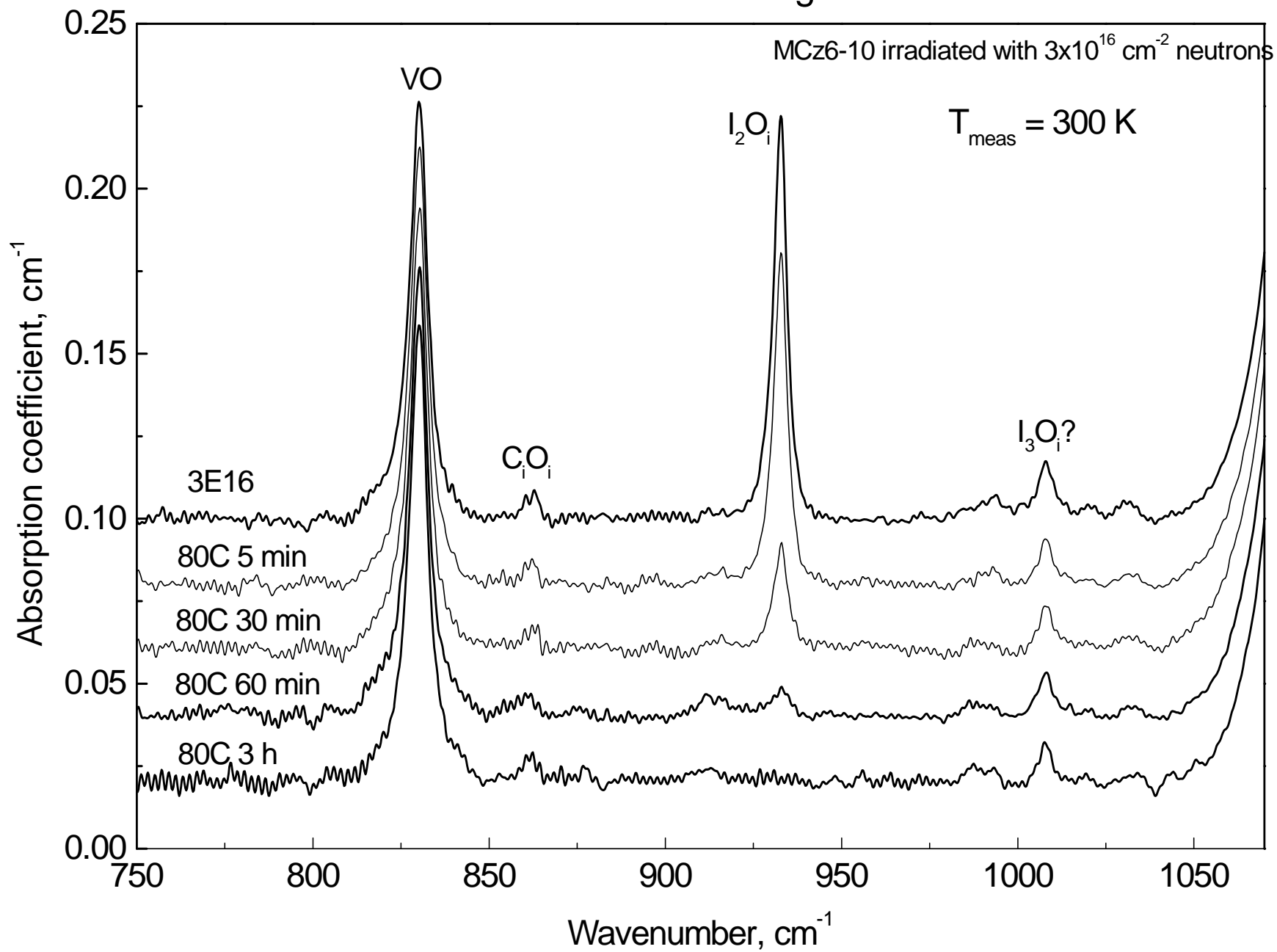
LVMs of O-related defects and V_2 electronic transitions



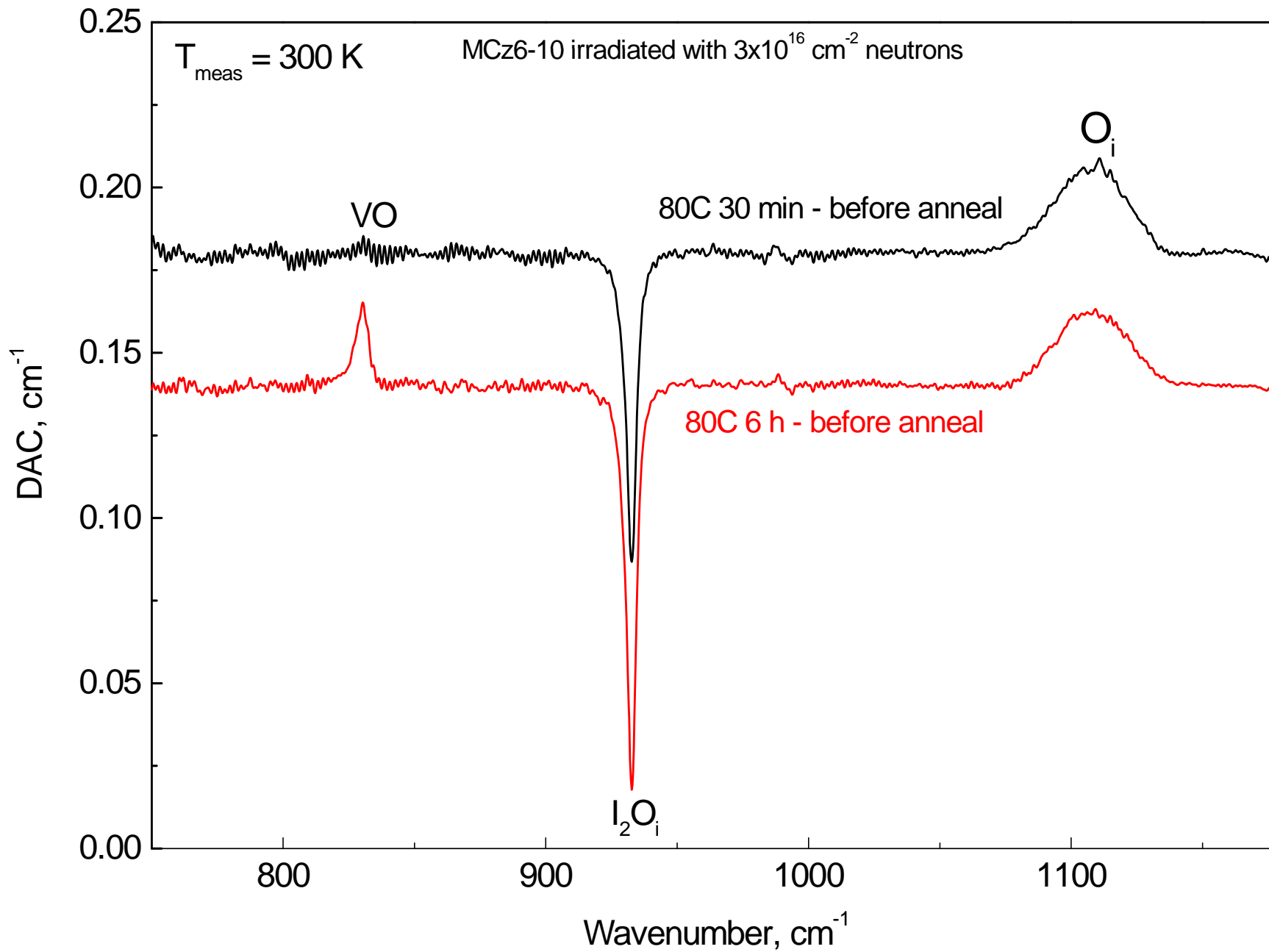
LVMs of O-related defects and V_2 electronic transitions



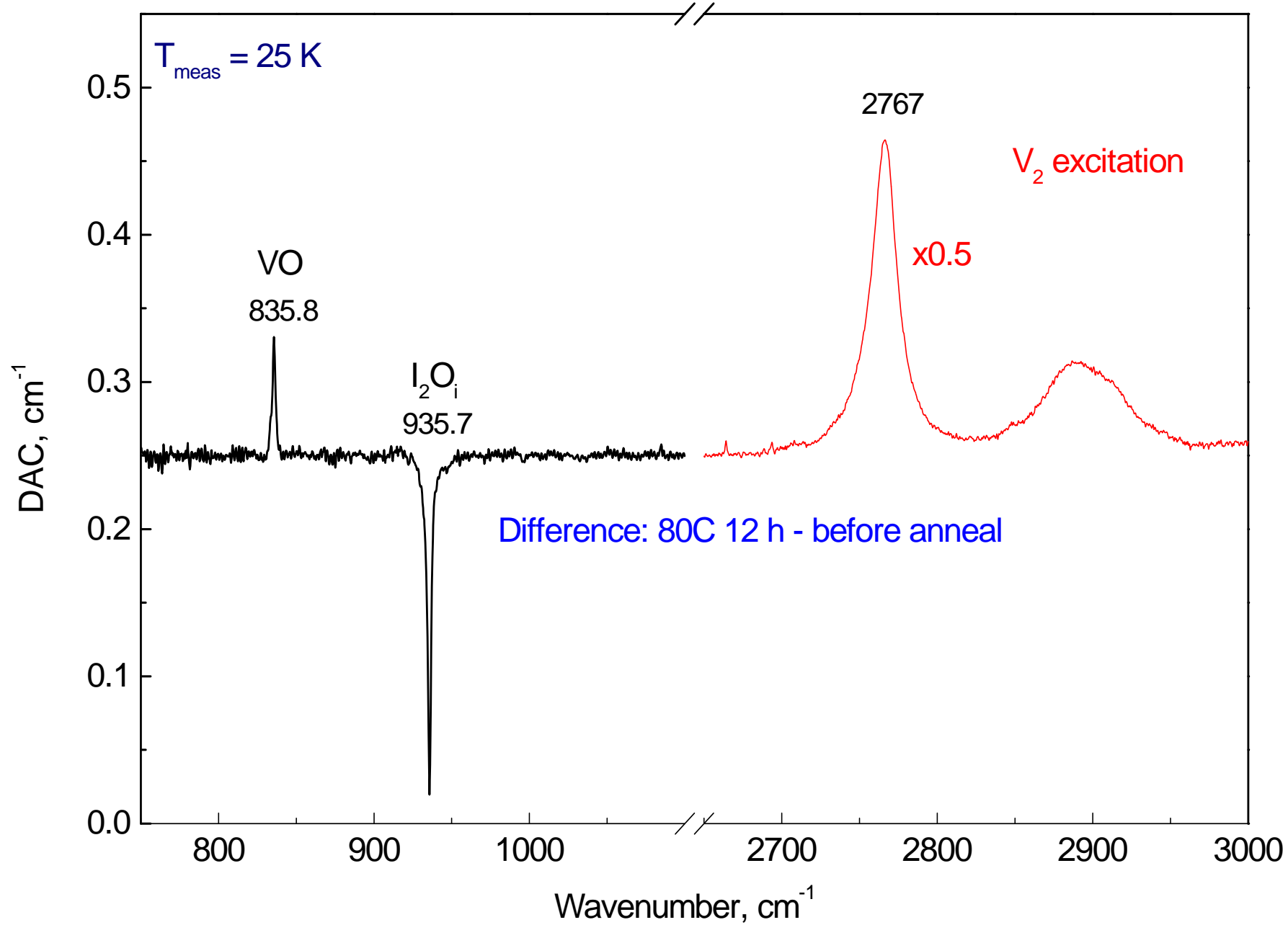
Isothermal annealing at 80 C

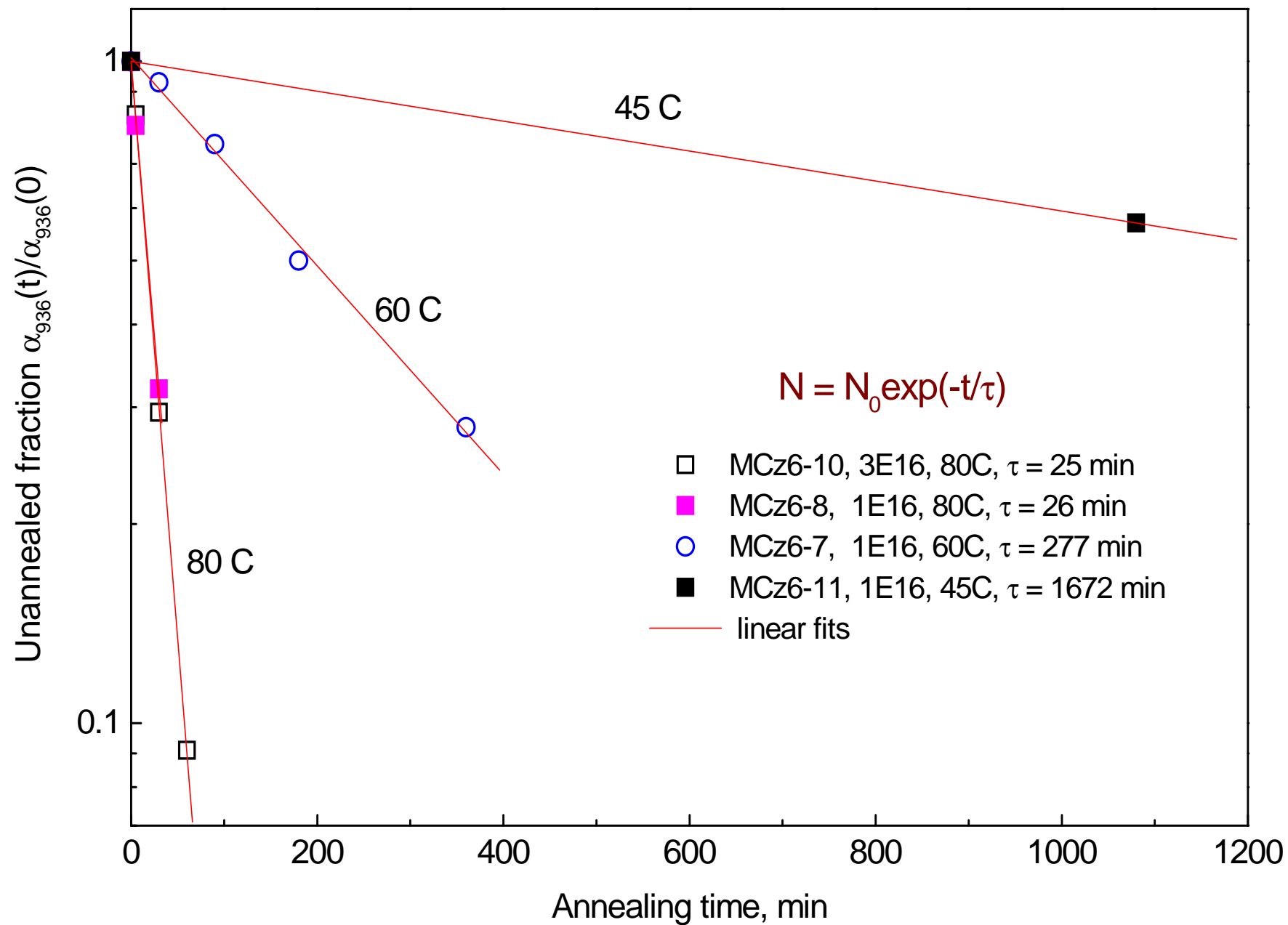


Isothermal annealing at 80 C, difference spectra

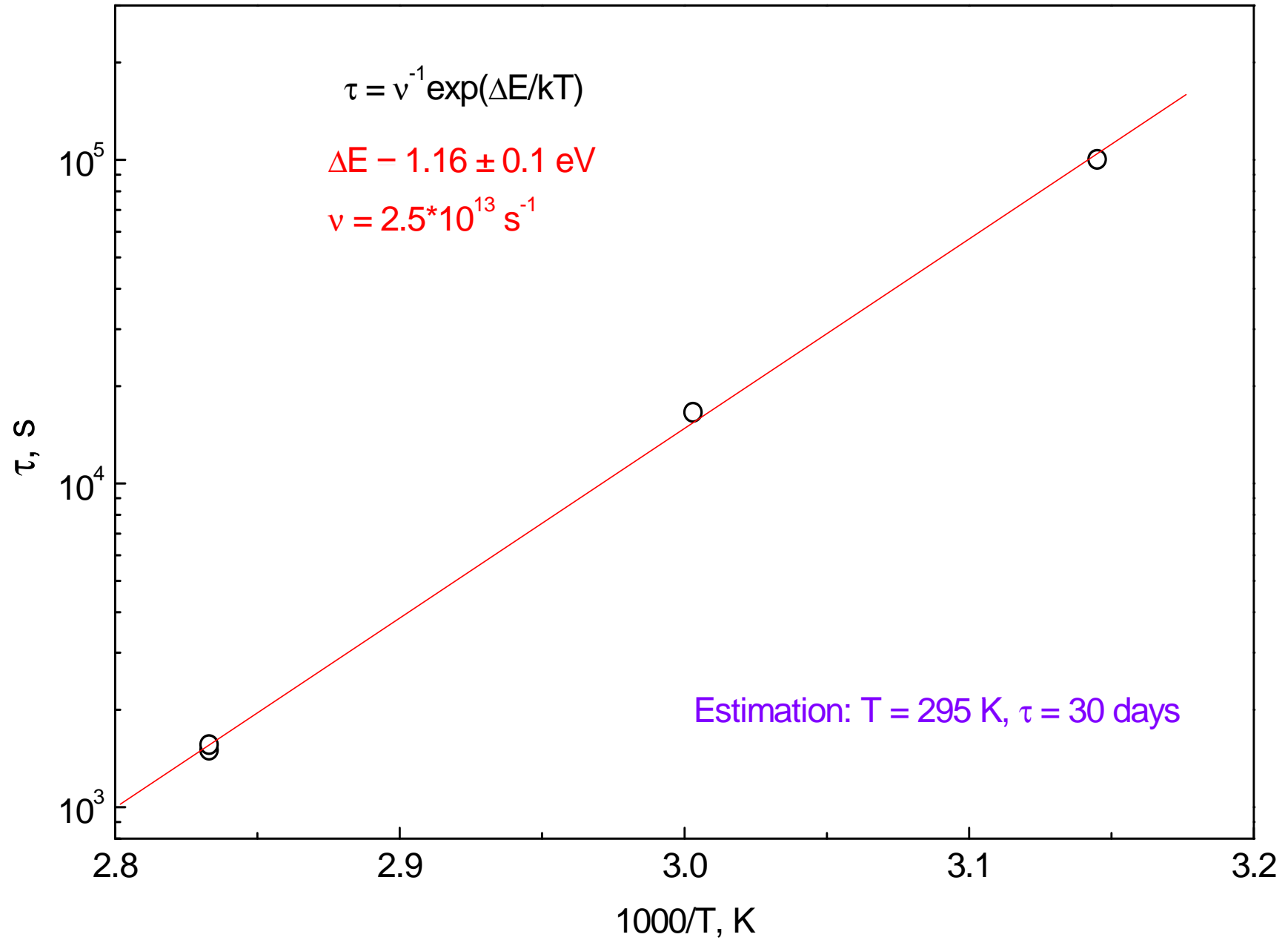


Isothermal annealing at 80 C, difference spectra



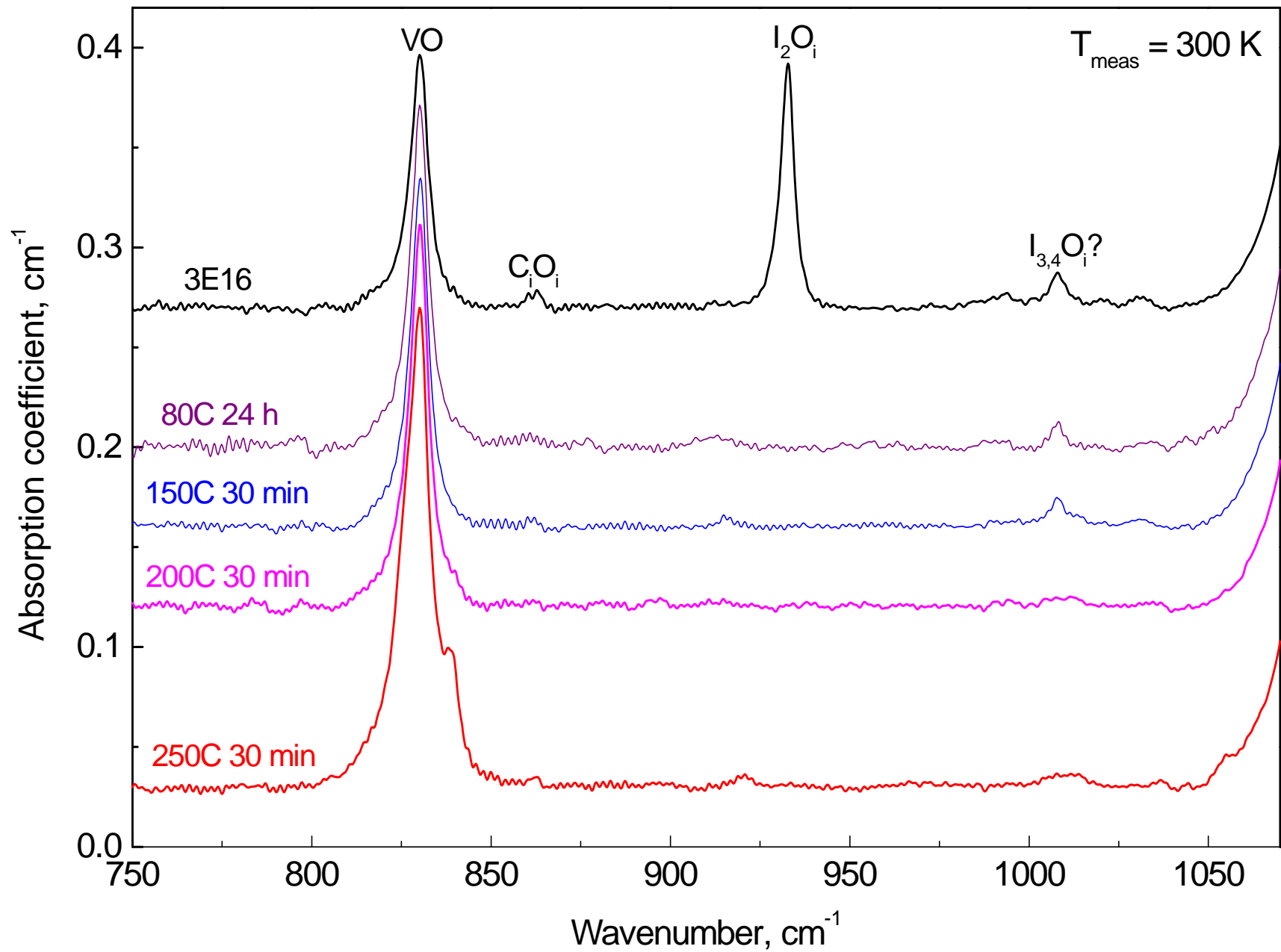


Temperature dependence of I₂O life-time
(preliminary results)



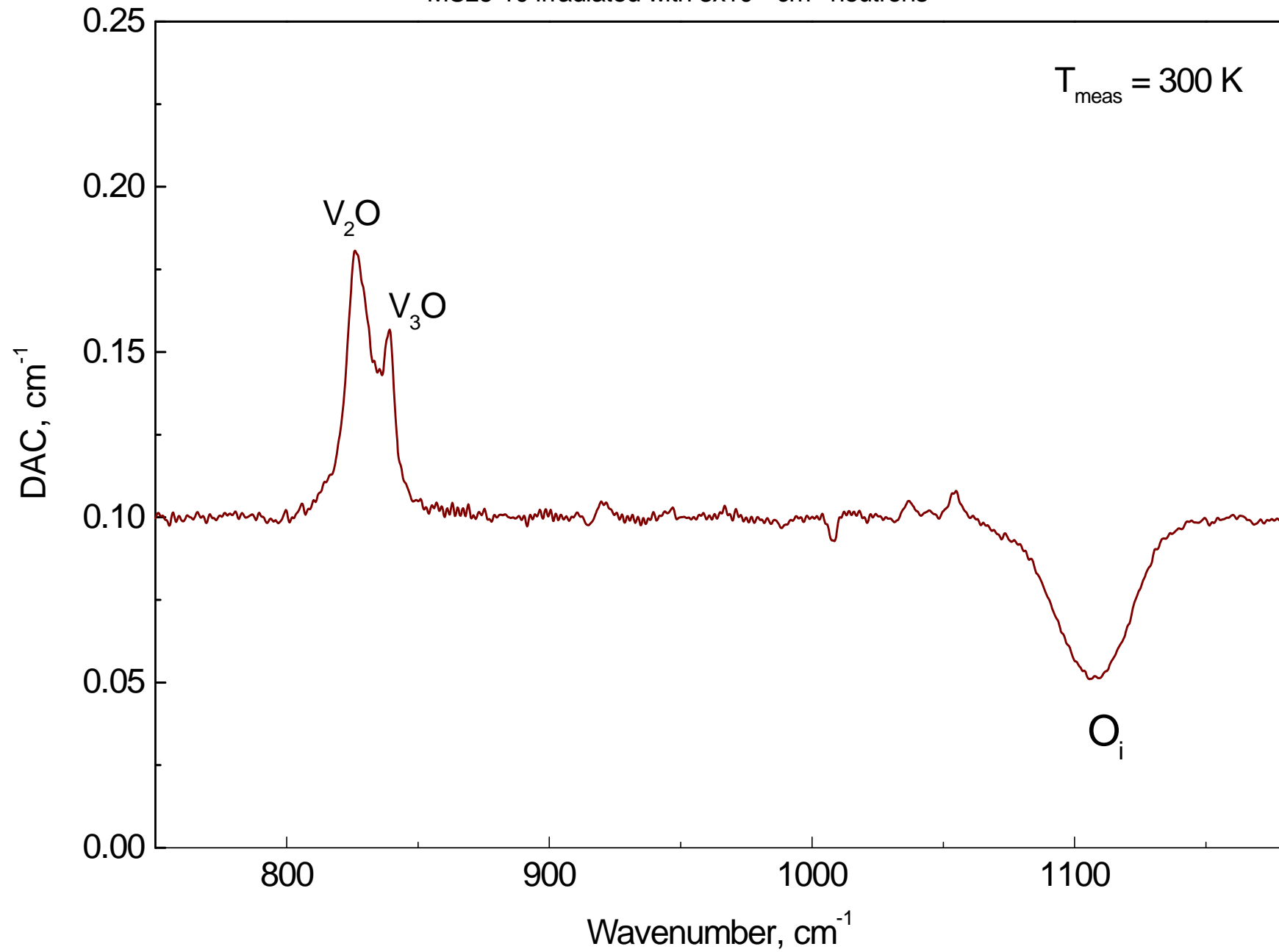
Annealing 80-250 C

MCz6-10 irradiated with $3 \times 10^{16} \text{ cm}^{-2}$ neutrons



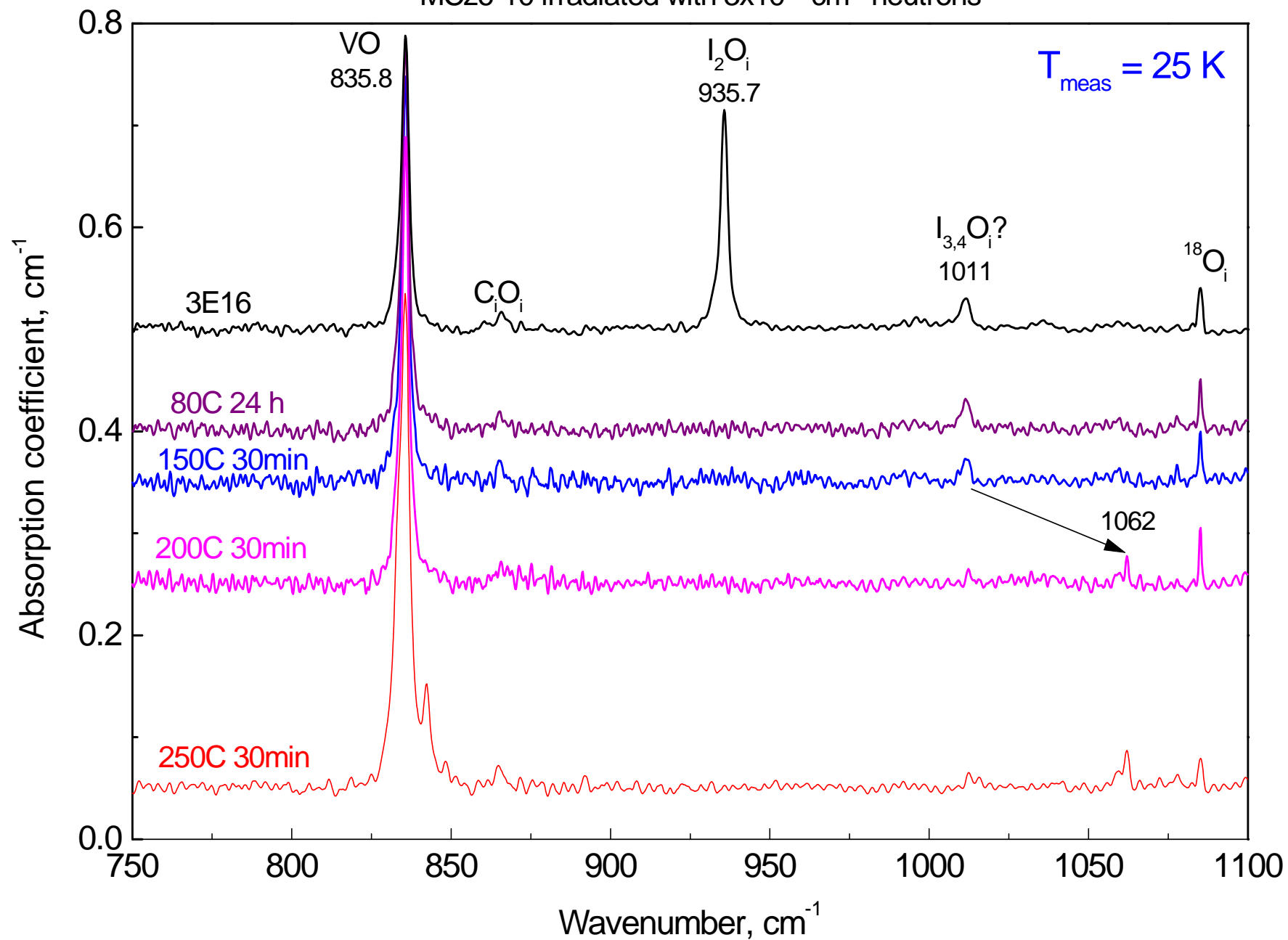
Difference spectrum, 250C 30min - 150C 30min

MCz6-10 irradiated with $3 \times 10^{16} \text{ cm}^{-2}$ neutrons

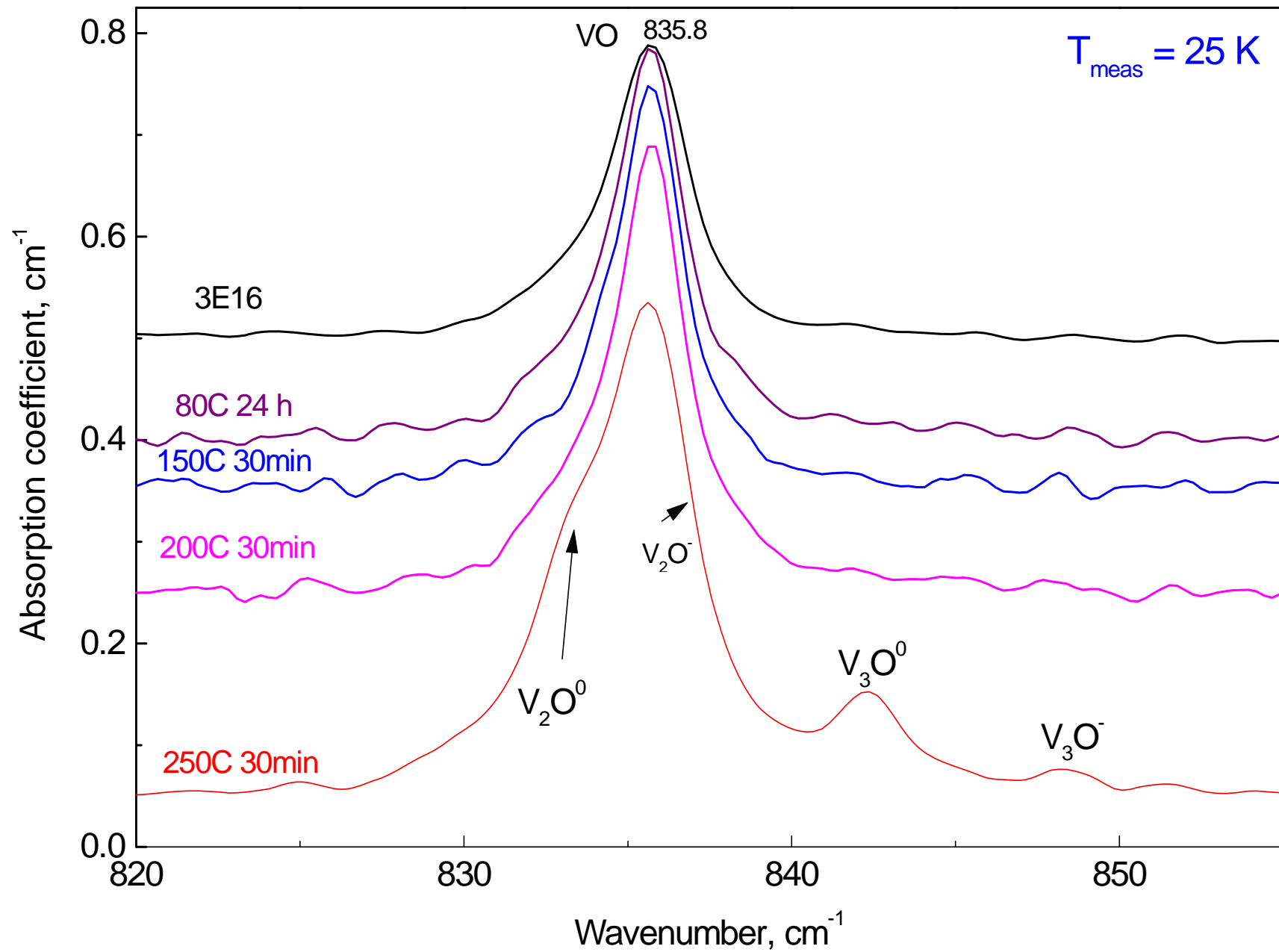


Annealing 80-250 C

MCz6-10 irradiated with $3 \times 10^{16} \text{ cm}^{-2}$ neutrons

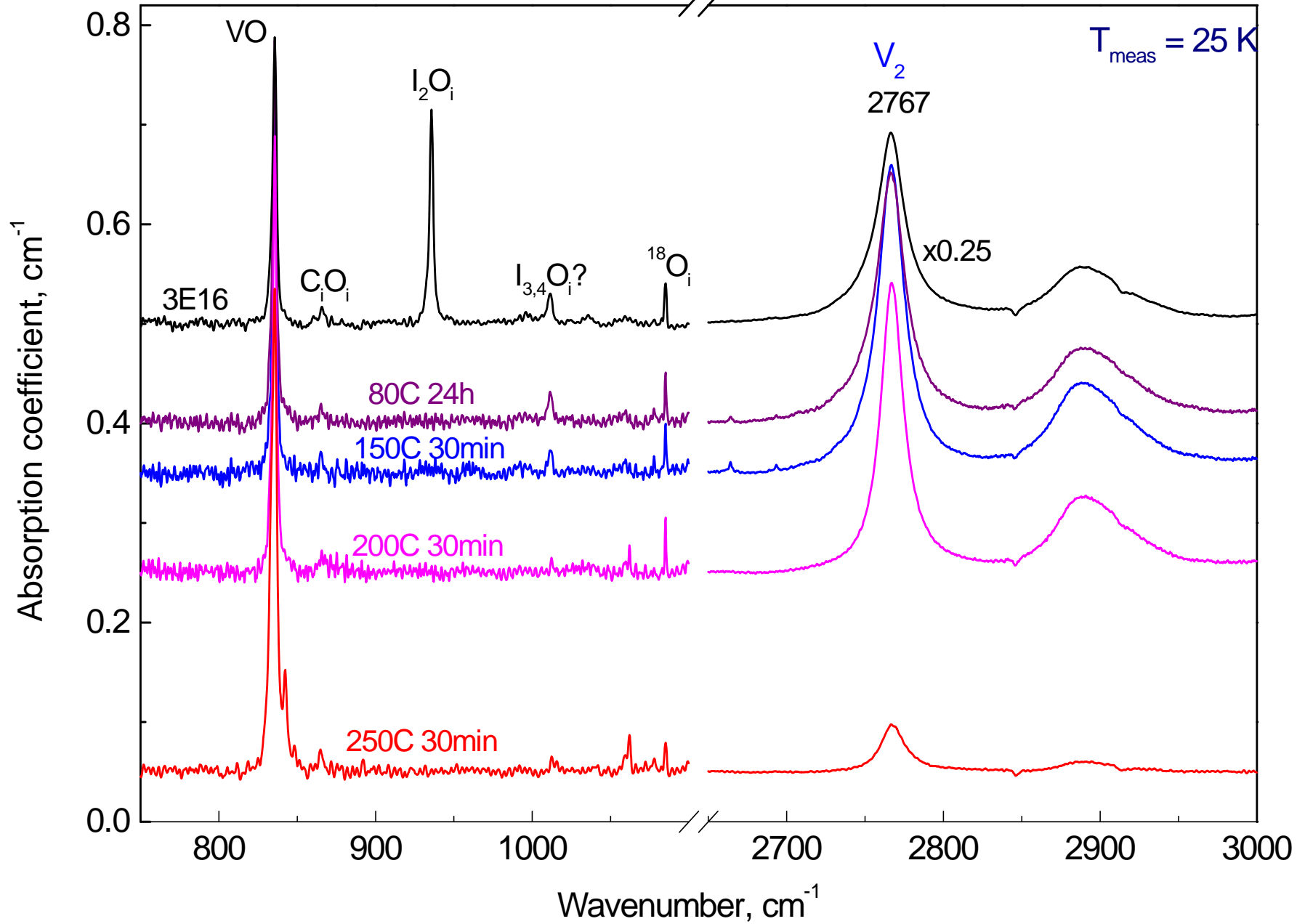


Annealing 80-250 C
MCz6-10 irradiated with $3 \times 10^{16} \text{ cm}^{-2}$ neutrons



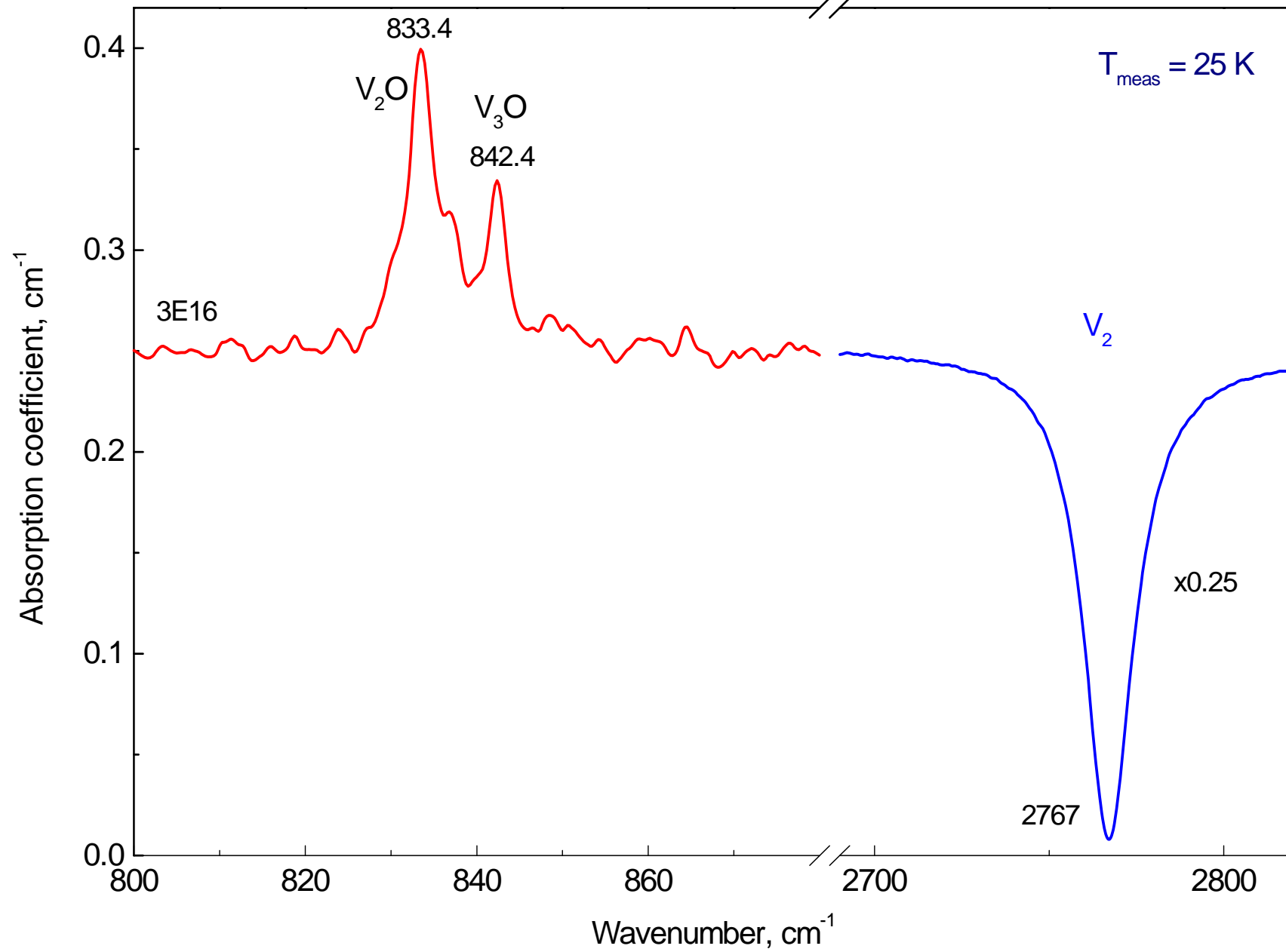
Annealing 80-250 C

MCz6-10 irradiated with $3 \times 10^{16} \text{ cm}^{-2}$ neutrons



Difference spectrum, 250C 30min - 200C 30min

MCz6-10 irradiated with $3 \times 10^{16} \text{ cm}^{-2}$ neutrons



I₂, I₂O - WHAT IS KNOWN

I₂ defect

I₂O defect

Some latest publications

Davies G., Hayama S., Murin L., Krause-Rehberg R., Bondarenko V., Sengupta A., Davia C., and Karpenko A. **Radiation damage in silicon exposed to high-energy protons** // Phys. Rev. B. – 2006. - Vol. 73, N 16. – P.165202 (1-10).

Hermansson J., Murin L.I., Hallberg T., Markevich V.P., Lindstrom J.L., Kleverman M., and Svensson B.G. **Complexes of the self-interstitial with oxygen in irradiated silicon: a new assignment of the 936 cm⁻¹ band** // Physica B: Condensed Matter. - 2001. - Vols. 302-303. - P. 188-192.

Some conclusions

- - The dominant infrared absorption bands observed in neutron-irradiated bulk MCzSi are the bands related to VO and I_2O (vibrational modes) and V_2 (electronic transitions). The C_iO_i -related LVMs are already saturated after a dose of about $1 \times 10^{15} \text{ cm}^{-2}$. Some traces of IC_iO_i , IO_{2i} and I_2O_{2i} could be detected as well.
- -After irradiation with doses $(1-3) \times 10^{16} \text{ cm}^{-2}$ a new band at 1011 cm^{-1} is appearing, which could be related to I_3O or I_4O defects. The 1011 cm^{-1} band anneals out at 200 C .
- -Annealing at 80C results in elimination of I_2O (monitored by an absorption band at 936 cm^{-1}) and in growth of VO (absorption band at 836 cm^{-1}). Annealing of I_2O obeys the 1-st order kinetics with an activation energy of about $1.1-1.2 \text{ eV}$ and pre-factor $2.5 \times 10^{13} \text{ s}^{-1}$.
- - Annealing at 250C results in elimination of V_2 (monitored by an absorption band at 2767 cm^{-1}) and in growth of V_2O (band at 833.4 cm^{-1}) and V_3O (band at 842.4 cm^{-1}) defects.