Multi-channel heat transfer in CO_2 solutions with N_2O and Xe impurities

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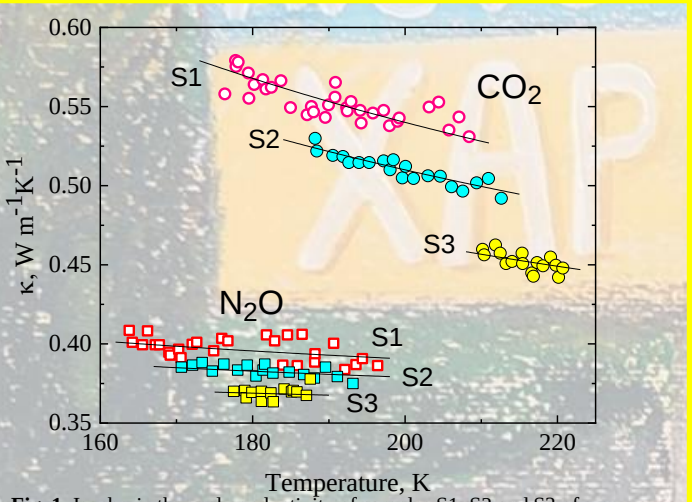

Fig. 1. Isochoric thermal conductivity of samples S1, S2 and S3 of crystalline CO_2 and N_2O at different molar volumes. Symbols are experimental data [1]. Lines are contribution $\kappa(T)$ according to equation:

$$\kappa(T) = \kappa_{ph} + \kappa_{dif} = A/T + B \qquad (1)$$

where $\kappa_{ph} = A/T$ arises from phonon-phonon scattering, and $\kappa_{dif} = B$ accounts for temperature-independent diffusons contributions [2].

	V_m, cm³/mole	A, W m⁻¹	B, W m⁻¹ K⁻¹	ΔT, K	Ref.
CO_2					
Specimen 1	27.58	50.0	0.29	176–208	[1]
Specimen 2	27.83	44.0	0.29	188–212	[1]
Specimen 3	28.36	35.0	0.29	210–220	[1]
N_2O					
Specimen 1	29.01	9.1	0.345	163–196	[1]
Specimen 2	29.14	6.8	0.345	170–193	[1]
Specimen 3	29.34	4.3	0.345	177–188	[1]

Table 1. Fitting parameters obtained in the description of experimental data on the isochoric thermal conductivity of solid molecular crystals CO_2 and N_2O: A is the intensity of three-phonon scattering processes; B is the temperature-independent contribution, V_m is the molar volume of the samples, ΔT is the temperature range where the measurements were taken.

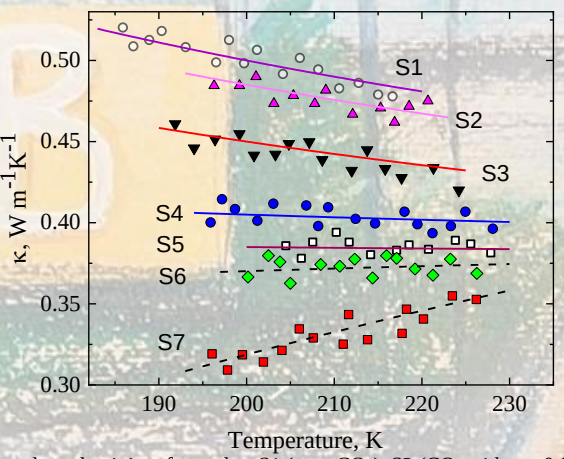

Fig. 2. Isochoric thermal conductivity of samples: S1 (pure CO_2), S2 (CO_2 with x = 0.051 N_2O admixture), S3 – S7 solid solution $(CO_2)_{1-x}Xe_x$ (x = 0.0025, 0.011, 0.013, 0.0205 and 0.091) at molar volumes ~28.0 cm³/mole. Symbols are experimental data [3]. Solid colored lines are $\kappa(T)$ according to equation (1). Black dashed lines is tunnel contribution "coherences" $\kappa_C(T)$ for the case of thermal conductivity of samples S6 and S7 according to equation:

$$\kappa_C(T) = \kappa_0 \cdot \exp(-E/T) \qquad (2)$$

where κ_0 is the pre-exponential factor, which represents the maximum tunneling heat transfer, and E denotes the dominant excitation energy and is expressed in Kelvin.

Sample/impurity concentration x	V_m, cm³/mole	A, W m⁻¹	B, W m⁻¹ K⁻¹	κ_0, Wm⁻¹K⁻¹	E, K	ΔT, K	Ref.
CO_2 with N_2O and Xe impurities							
S1 / 0.00	27.78	42.0	0.29	0	-	185-217	[3]
S2 / 0.051	27.98	39.0	0.29	0	-	195-220	[3]
S3 / 0.0025	27.85	32.0	0.29	0	-	90-225	[3]
S4 / 0.011	28.0	7.0	0.37	0	-	195-230	[3]
S5 / 0.013	28.17	2.0	0.375	0	-	205-230	[3]
S6 / 0.0205	28.05	0	0	0.405	18	200-227	[3]
S7 / 0.091	28.0	0	0	0.78	179	195-227	[3]

Table 2. Fitting parameters obtained in the description of experimental data on the isochoric thermal conductivity of solid solutions: A is the intensity of three-phonon scattering processes; B is the temperature-independent contribution, κ_0 is pre-exponential factor of the intensity of wave-like tunneling processes, E is the characteristic energy of the dominant excitations, V_m is the molar volume of the samples, ΔT is the temperature range where the measurements were taken.

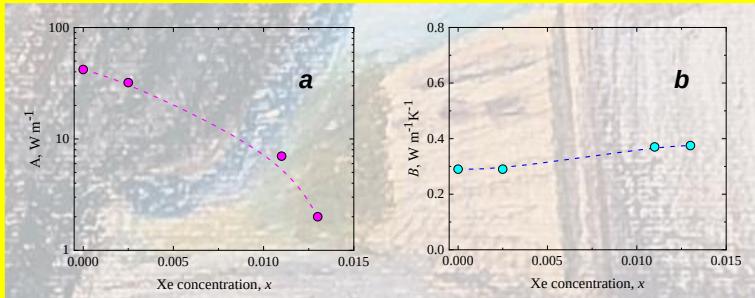

Fig. 3. Dependence of parameters A (a) and B (b) on the Xe concentration in solid $(CO_2)_{1-x}Xe_x$ solution (in samples S1, S3, S4 and S5). Lines are smoothed data.

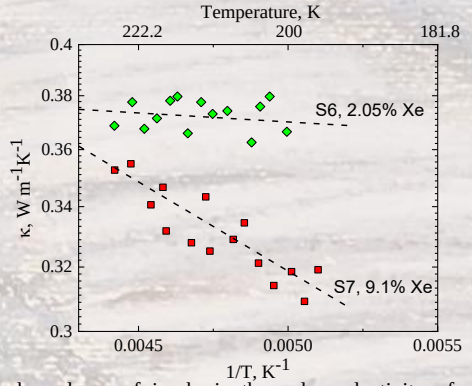

Fig. 4. The dependence of isochoric thermal conductivity of solid $(CO_2)_{1-x}Xe_x$ solution at x = 0.0205 and x = 0.091 in semi-logarithmic coordinates from the inverse temperature. Black dashed lines represent fitted functions of equation [4]:

$$\ln(\kappa_C(T)) = \ln(\kappa_{tot}(T) - \kappa_{ph}(T)) = \ln(\kappa_0) - E/T \qquad (3)$$

References

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