Supplementary Information for

Thermal conductivity of aluminous garnets in Earth's deep interior

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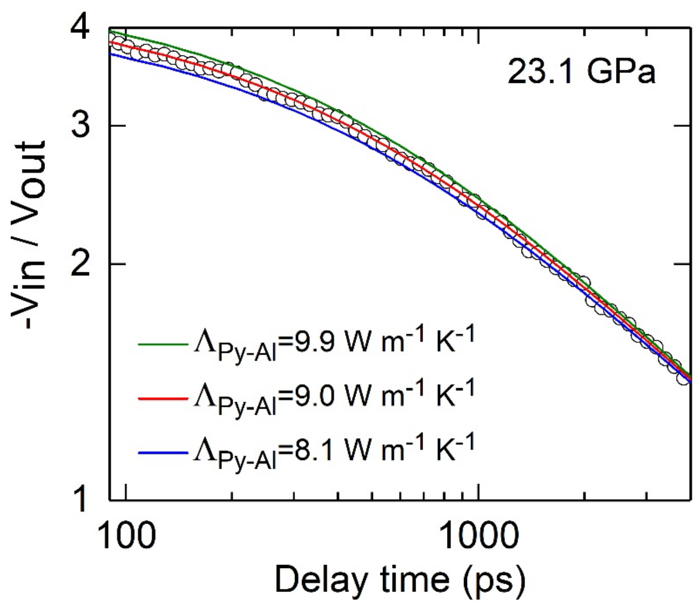
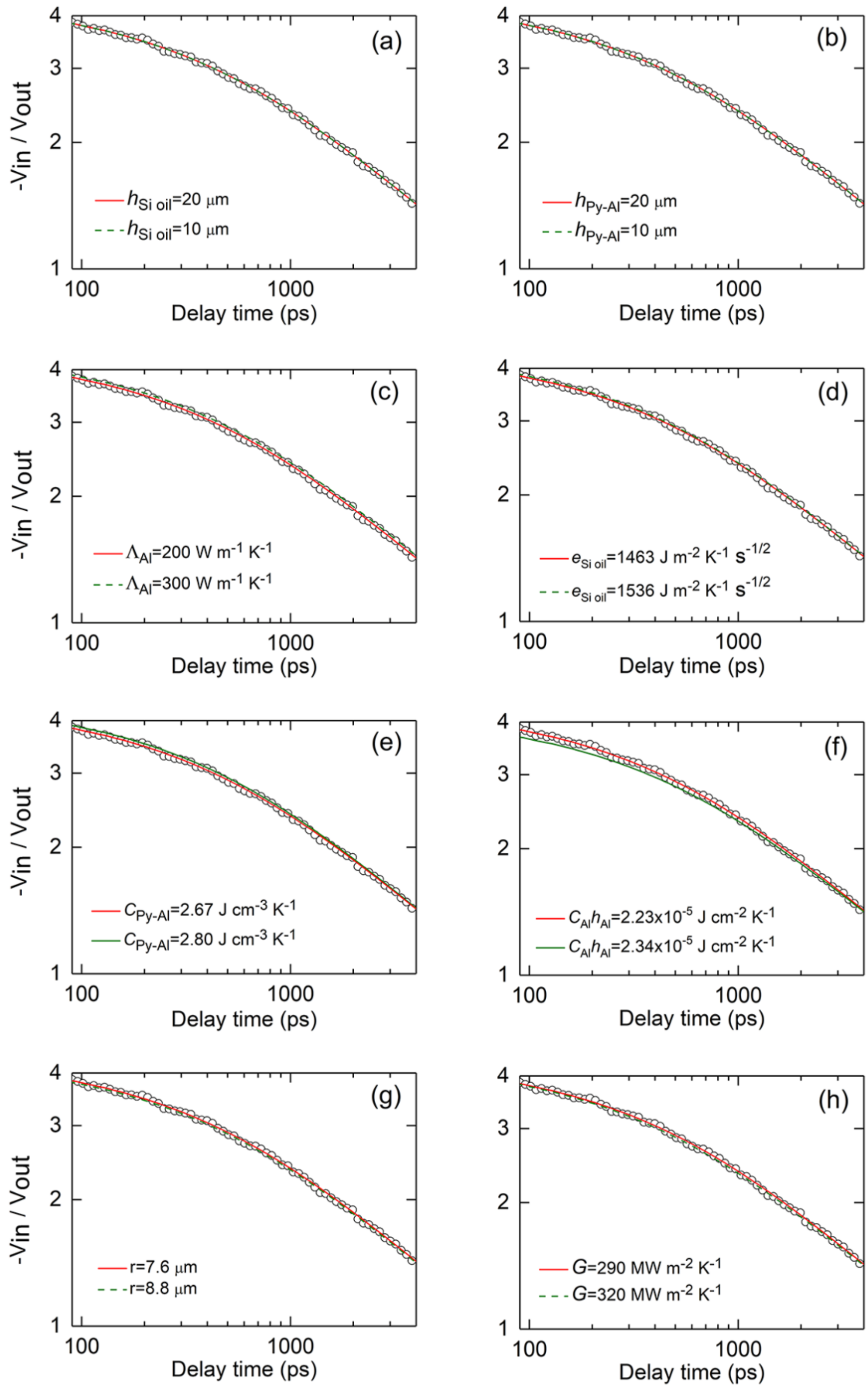


Supplementary Fig. S1. Example TDTR data (open circles) as a function of delay time between pump and probe pulses for pyrope-almandine solid solution at 23.1 GPa and room temperature. A fitting curve using a thermal conductivity $\Lambda_{Py\text{-}Al}$= 9.0 W m^{-1} K^{-1} (red curve) provides a best-fit to the data. A testing 10% change in $\Lambda_{Py\text{-}Al}$ (green and blue curves) results in a clearly poor fitting to the data. This indicates that our high-quality data fitted well by the thermal model derives a precise thermal conductivity for the pyrope-almandine solid solution.



Supplementary Fig. S2. Sensitivity tests of the thermal model to input parameters for pyrope-almandine solid solution at 23.1 GPa and room temperature. Here the thermal conductivity of pyrope-almandine solid solution, $\Lambda_{\text{Py-Al}}$, is fixed at 9.0 W m^{-1} K^{-1}, as obtained in Supplementary Fig. S1. (a) and (b) Even though the thicknesses of silicone oil ($h_{\text{Si oil}}$) and pyrope-almandine solid solution ($h_{\text{Py-Al}}$) vary by 50%, respectively, during compression and heating, they have essentially no influence on the thermal model calculations, i.e., their uncertainties do not affect the derived $\Lambda_{\text{Py-Al}}$. (c) A large change in the high thermal conductivity of Al film by 50% also has very minor effect on the $\Lambda_{\text{Py-Al}}$. (d) Assuming the thermal effusivity of the pressure medium silicone oil, $e=(\Lambda_{\text{Si}}C_{\text{Si}})^{1/2}$, has an example 5% uncertainty, it requires the $\Lambda_{\text{Py-Al}}$ to decrease to 8.9 W m^{-1} K^{-1} to re-fit the data, meaning that such uncertainty translates ~1% uncertainty in the $\Lambda_{\text{Py-Al}}$. (e) If the error of volumetric heat capacity of pyrope-almandine solid solution, $C_{\text{Py-Al}}$, is 5%, one needs a slightly smaller $\Lambda_{\text{Py-Al}}$ (8.8 W m^{-1} K^{-1}) to re-fit the data, i.e., translating ~2% uncertainty. (f) In our data analysis, the total uncertainty is mainly from the uncertainty in the heat capacity of Al film per unit area, i.e., volumetric heat capacity times thickness, $C_{\text{Al}}h_{\text{Al}}$ (Zheng et al. 2007). Assuming there is an example 5% uncertainty, it requires ~11% change in the $\Lambda_{\text{Py-Al}}$ to re-fit the data. (g) Even if the laser spot size has a 15% off, it does not significantly change the model calculation and the derived $\Lambda_{\text{Py-Al}}$. (h) A 10% change in the thermal conductance G of Al/pyrope-almandine solid solution and Al/silicone oil interfaces, again, has essentially no influence in the model calculation.

Supplementary Table S1. Input parameters used in the thermal model for pyrope-almandine solid solution at 23.1 GPa and 300 K.

P (GPa)	$C_{\text{Py-Al}}$ (J cm^{-3} K^{-1})	C_{Al} (J cm^{-3} K^{-1})	h_{Al} (nm)*	$e=(\Lambda_{\text{Si oil}}C_{\text{Si oil}})^{1/2}$ (J m^{-2} K^{-1} s$^{-1/2}$)	r (μm)	$h_{\text{Py-Al/Si oil}}$ (μm)	Λ_{Al} (W m^{-1} K^{-1})	G (MW m^{-2} K^{-1})
23.1	2.67	2.64	84.6	1463	7.6	20/20	200	290

*In this experimental run, the Al thickness at ambient pressure is 94.4 nm.
$C_{\text{Py-Al}}$: pyrope-almandine solid solution's heat capacity, C_{Al}: Al heat capacity, h_{Al}: Al thickness, e: Si oil thermal effusivity, r: laser spot size, $h_{\text{Py-Al}}$: pyrope-almandine solid solution's thickness, $h_{\text{Si oil}}$: Si oil thickness, Λ_{Al}: Al thermal conductivity, G: thermal conductance of Al/Si oil and Al/pyrope-almandine solid solution interfaces.

Reference

Zheng, X., Cahill, D.G., Krasnochtchekov, P., Averback, R.S., and Zhao, J.C. (2007) High-throughput thermal conductivity measurements of nickel solid solutions and the applicability of the Wiedemann-Franz law. Acta Materialia, 55, 5177–5185.