Supplementary Material:

Picosecond Carrier Recombination Dynamics in Chalcogen-Hyperdoped Silicon

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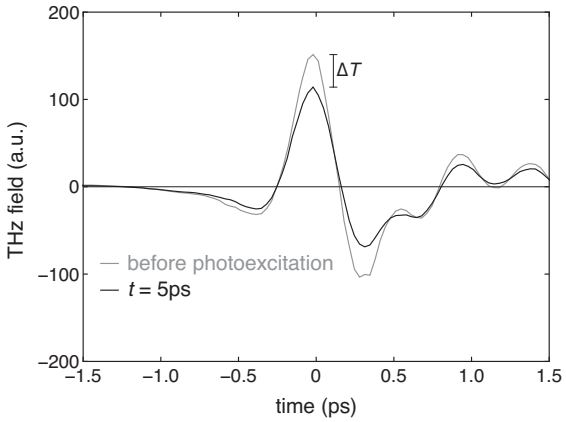
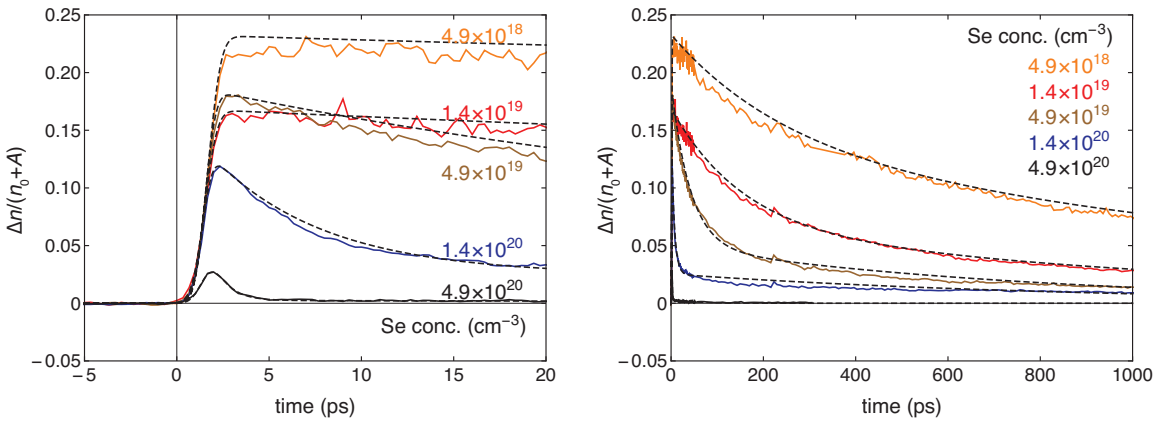


Supplementary Figure 1: THz pulse shape before and after the arrival of a pump pulse (fluence at 200 μJ/cm^2). After optical excitation, no phase shift is detected in the THz transmission and the change in THz transmission as a function of time is measured at the maximum of the THz pulse.

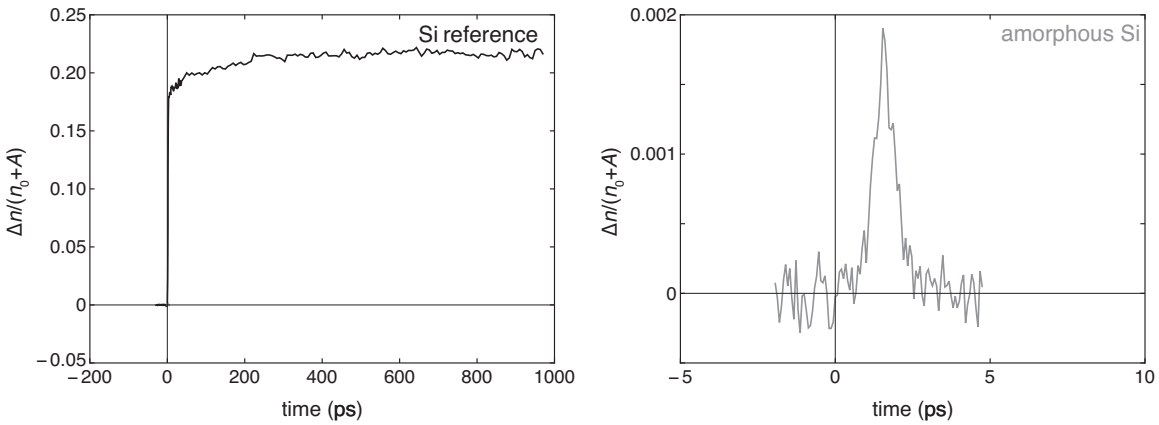


Supplementary Figure 2: Change in free carrier concentration in Se-hyperdoped Si after photoexcitation with a fs-laser pulse at 400 nm. Left panel shows short time scale dynamics and right panel shows dynamics up to 1 ns. We model the data with a bi-exponential decay and the dashed lines show the best fits.

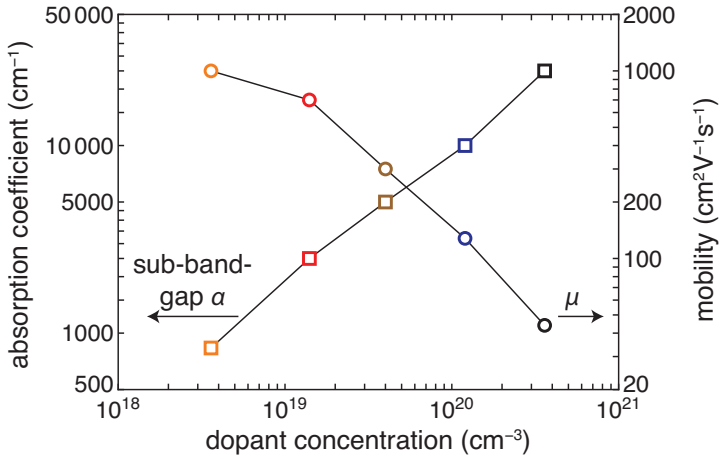
Supplementary Table 1: relative weight and decay times for the bi-exponential photoconductivity decay

$$G(t-t_0)\otimes\left(a_1\exp(-(t-t_0)/\tau_{fast})+a_2\exp(-(t-t_0)/\tau_{slow})\right)$$

S-hyperdoped silicon	Excitation wavelength = 400nm				2300 nm			
Dopant concentration N (cm^{-3})	a_1	a_2	τ_{fast} (ps)	τ_{slow} (ps)	a_1	a_2	τ_{fast} (ps)	τ_{slow} (ps)
3.6×10^{18}	0.55	0.45	210	1600	0.39	0.61	120	1100
1.4×10^{19}	0.53	0.48	90	750	0.52	0.48	70	820
4.0×10^{19}	0.75	0.25	29	590	0.80	0.20	34	810
1.2×10^{20}	0.87	0.13	6.4	1210	0.93	0.07	6.4	830
3.6×10^{20}	0.96	0.05	1.3	2200	0.93	0.07	1.3	990



Supplementary Figure 3: Change in free carrier concentration in the bare Si substrate (left) and amorphous part of Se implanted silicon (right). The implant dose is 1×10^{14} cm^{-2}, corresponding to the N=4.9×10^{18} cm^{-3} sample in Figure S1. For the bare Si substrate, after photoexcitation, the change in THz conductivity shows no appreciable decay within the 1-ns duration we probed, reflecting long carrier lifetimes as expected. For the amorphous part of the implanted wafer, the change in THz transmission is small (25 times smaller than the smallest time zero response shown in Figure 1) and quickly decays to zero within 2 ps.



Supplementary Figure 4: Literature values of sub-band-gap light absorption coefficient (at 0.5 eV) and carrier mobility (Refs. 12, 16, 34).