Electronic Supplementary Information

Exploring Time-Resolved Photoluminescence for Nanowires Using a Three-dimensional Computational Transient Model

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List of Figures and Tables

Growth of p-type GaAs nanowires on p-type Si with seeding layers

Nanowire growth was achieved by selective-area metal-organic chemical deposition (SA-MOCVD). The substrate used for this study was a lightly boron-doped (resistivity 0.8 – 1.2 Ω-cm) 4-inch on-axis Si (111) wafer. The surface root-mean-square (RMS) roughness measured by Scanning Probe Microscope was 0.14 nm, about half of a Si monolayer along the (111) plane. The wafer was first cleaned by a standard Piranha and RCA2 process, followed by a buffered oxide etch (BOE) oxide strip for 15 s. A 20 nm SiN_x film, deposited by low-pressure chemical vapor deposition (LPCVD), was used as a dielectric mask. LPCVD SiN_X was used to provide higher etch selectivity over the Si native oxide in a BOE compared with plasma-enhanced chemical vapor deposition SiN_X and thermal silicon dioxide (SiO_2). Next, E-Beam resist ZEP520A was coated and nanoholes were patterned by electron-beam lithography (EBL). The SiNx layer then was etched by reactive-ion etching (RIE) to expose the Si surface. The majority of ZEP520A was cleaned by Piranha at 120°C, and the rest was removed by O_2 downstream plasma. Immediately before the samples were loaded into the growth chamber, the native oxide in the nanoholes was stripped by BOE for 45 s.

The growth of nanowires was accomplished using a low-pressure (60 Torr) Emcore D-125 MOCVD reactor with hydrogen (H_2) as the carrier gas. The precursors were trimethylgallium (TMGa), trimethylaluminium (TMAl), tertiarybutylarsine (TBAs), and diethylzinc (DEZn). The sample was first thermally baked at a high temperature, 870°C, and held for 10 min. During this step, the thin native oxide that was formed during sample loading was fully removed by thermal deoxidation in an H_2 atmosphere. After deoxidation, the temperature was lowered to the planned seeding layer growth temperature, i.e., 450°C, 550°C, 600°C, 625°C, or 650°C. Next, TBAs was flowed at a rate of 1.97×10^{1} sccm for 5 min in order to replace the first layer of Si atoms inside the nanoholes and make an As-incorporated Si^{3+} (111)B surface.[1] The seeding layer was grown for 15 s with a gas flow of TMGa at 7.55×10^{-1} sccm and TBAs at 4.39×10^{0} sccm (V/III ratio of 58). Note that the GaAs seeding (buffer) layer was introduced at a much lower temperature than that used for the GaAs nanowire. This technique was important to achieve a high vertical yield of GaAs nanowire arrays on Si. After this, the temperature was ramped up to 730°C with TBAs overpressure, and the growth of vertical Zn-doped GaAs nanowires was carried out for 7 min. The gas flows of TMGa, TBAs, and DEZn during the nanowire growth were 1.13×10^{-1} sccm, 2.14×10^{1} sccm, and 4.31×10^{-2} sccm, respectively. Finally, a thin AlGaAs passivation shell was grown at 600 °C with a V/III of 20 for 30 s (the ratio of gas phase composition TMAl:TMGa = 1:1), followed by a thin GaAs cap to prevent the oxidation of aluminium. The schematics of growth sequence is illustrated in Fig. S1.

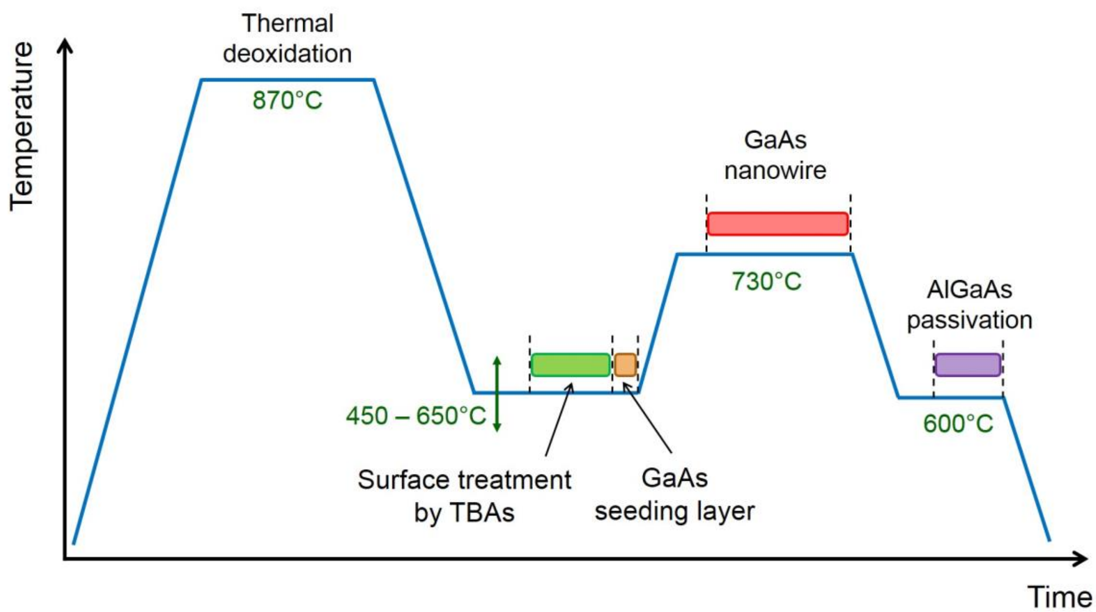

***Fig. S1** The growth sequence for GaAs nanowires on Si (111)B with GaAs seeding layers The time and the temperature are not to scale.*

Time-revolved photoluminescence (TRPL) characterization

NKT SuperK EXTREME continuum laser operated at 633 nm with a repetition rate of 40 MHz and a pulse width of 30 ps, an Acton SP-2500i spectrometer (Princeton instruments), a MPD Si single photon avalanche diode (SPAD), and a PicoHarp time-correlated single photon counting module. The laser power density was calibrated to 178 W/cm^2 by a power meter (Newport 918D-SL-OD2) and 50× objective lens (Mitutoyo M Plan APO NIR, NA = 0.42). In addition, a 695 nm longpass filter was put in front of the spectrometer input slit to block the incident 633 nm laser. Note that the TRPL measurements were performed on as-grown nanowire arrays (not individual nanowires).

Scanning electron microscopy (SEM) of as-grown nanowires

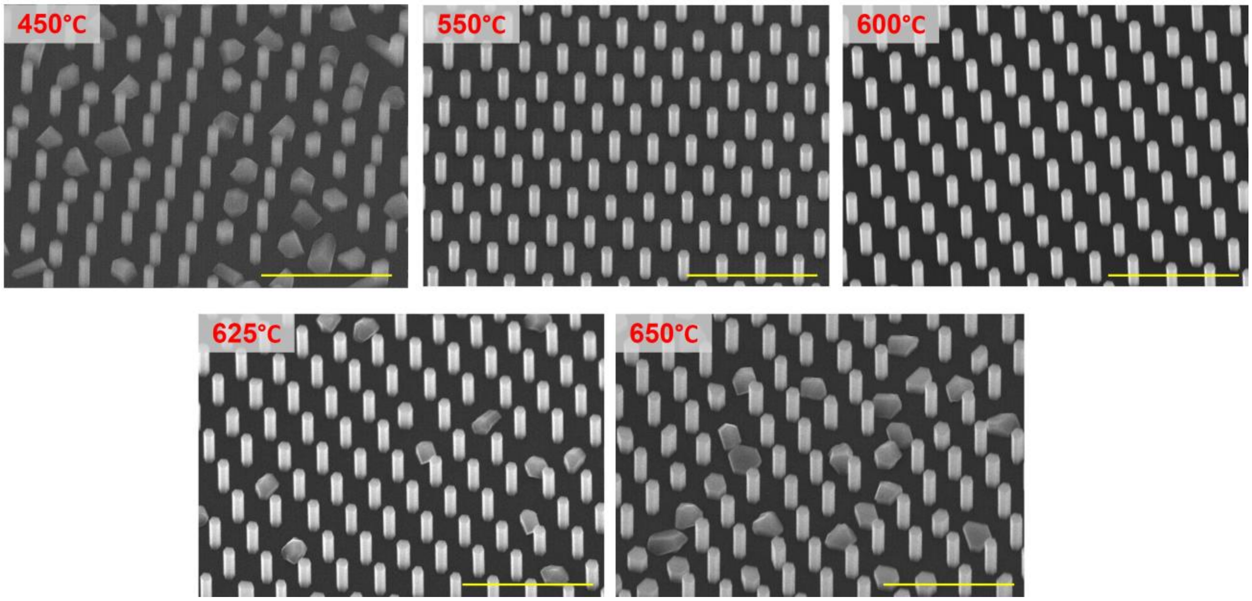

Fig. S2 *30°-tilted SEM of as-grown GaAs nanowires on Si substrates with AlGaAs passivation layers. The seeding layers were grown at 450°C, 550°C, 600°C, 620°C and 650°C, respectively. The scale bar is 2 µm.*

Nanowire dimensions

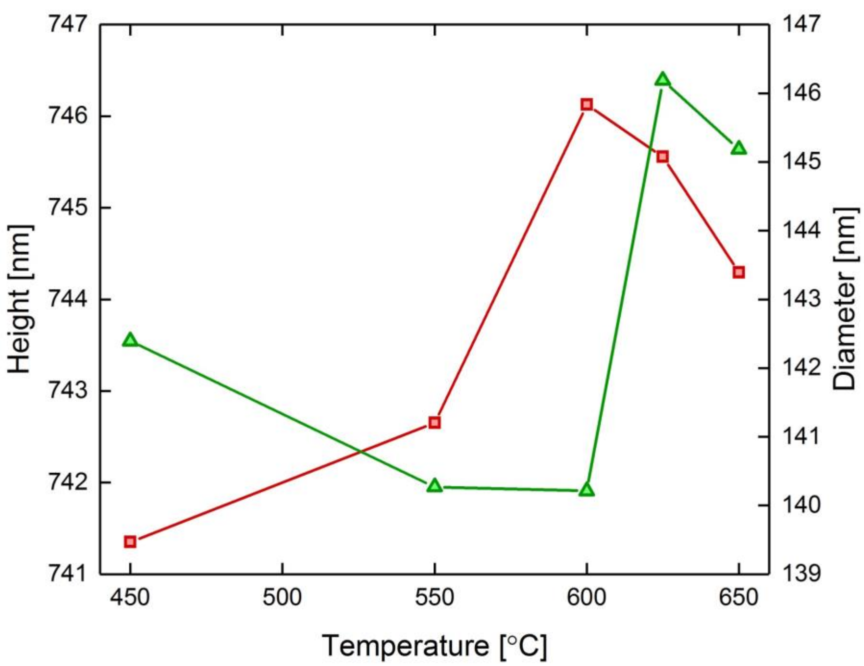

Fig. S3 *Average height and diameter of vertical nanowires of Samples A to E. The dimensions are measured by scanning electron microscope.*

Trapezoid-shaped seeding layer

The formation of such a trapezoidal seeding layer can be explained as follows. During the sample cleaning process, H_2O_2 (in the Piranha solution) and O_2 plasma (in downstream asher) oxidized the top Si surfaces inside the nanoholes, and the oxidized part was removed by BOE.

Growth of irregular polycrystalline structures and tilted nanowires

Such random imperfect growths may be due to three factors: (1) the sample cleaning was not sufficient, leaving a small portion of EBL resist around or inside the nanoholes; (2) the surface treatment was not appropriate, giving a mix of Si(111):As 1×1 and Si(111) 1×1; or (3) multiple types of nucleation formed during the seeding layer growth. The third case is most likely, because the formation of seeds by the vapor-solid (VS) growth mode is sensitive to the growth temperature.[2]

Table S1 Spreadsheets of simulated τ_n (ns) as a function of different material properties

μ_{n_seed} = 0.5 cm^2/(V·s)

τ_{SRH_wire} [ns]	τ_{SRH_seed} [ns]	S_n [cm^2/(V·s)]						
		1×10^0	1×10^1	1×10^2	1×10^3	1×10^4	1×10^5	1×10^6
1.0	0.1	0.684	0.684	0.684	0.681	0.662	0.626	0.613
1.0	0.2	0.688	0.688	0.688	0.685	0.664	0.626	0.613
1.0	0.3	0.690	0.690	0.690	0.686	0.665	0.626	0.613
1.0	0.4	0.692	0.692	0.692	0.688	0.666	0.626	0.613
1.0	0.5	0.693	0.693	0.692	0.689	0.666	0.626	0.613
1.0	0.6	0.694	0.693	0.693	0.690	0.667	0.626	0.613
1.0	0.7	0.694	0.694	0.694	0.690	0.667	0.626	0.613
1.0	0.8	0.695	0.695	0.694	0.691	0.667	0.626	0.613
1.0	0.9	0.695	0.695	0.695	0.691	0.668	0.626	0.613
1.0	1.0	0.695	0.695	0.695	0.692	0.668	0.626	0.613
1.5	0.1	0.934	0.933	0.933	0.927	0.889	0.821	0.801
1.5	0.2	0.942	0.942	0.942	0.935	0.892	0.821	0.801
1.5	0.3	0.946	0.945	0.945	0.938	0.894	0.821	0.801
1.5	0.4	0.949	0.949	0.949	0.941	0.896	0.822	0.801
1.5	0.5	0.951	0.951	0.950	0.943	0.896	0.822	0.801
1.5	0.6	0.953	0.953	0.952	0.945	0.897	0.822	0.801
1.5	0.7	0.954	0.954	0.953	0.946	0.898	0.822	0.801
1.5	0.8	0.955	0.955	0.954	0.947	0.898	0.822	0.801
1.5	0.9	0.955	0.955	0.955	0.947	0.898	0.822	0.801
1.5	1.0	0.956	0.956	0.956	0.948	0.899	0.822	0.801
2.0	0.1	1.133	1.133	1.133	1.123	1.064	0.967	0.940
2.0	0.2	1.147	1.146	1.146	1.135	1.070	0.967	0.940
2.0	0.3	1.152	1.152	1.151	1.140	1.072	0.967	0.940
2.0	0.4	1.158	1.157	1.157	1.145	1.074	0.968	0.940
2.0	0.5	1.160	1.160	1.159	1.148	1.076	0.968	0.940
2.0	0.6	1.163	1.163	1.162	1.150	1.077	0.968	0.940
2.0	0.7	1.164	1.164	1.163	1.151	1.077	0.968	0.939
2.0	0.8	1.166	1.166	1.165	1.153	1.078	0.968	0.939

2.0	0.9	1.167	1.167	1.166	1.154	1.078	0.968	0.939
2.0	1.0	1.168	1.168	1.167	1.155	1.079	0.968	0.939
2.5	0.1	1.295	1.295	1.294	1.282	1.204	1.080	1.046
2.5	0.2	1.313	1.313	1.312	1.298	1.211	1.080	1.046
2.5	0.3	1.321	1.320	1.319	1.305	1.214	1.080	1.046
2.5	0.4	1.328	1.328	1.326	1.311	1.217	1.080	1.046
2.5	0.5	1.331	1.331	1.330	1.315	1.218	1.080	1.046
2.5	0.6	1.335	1.335	1.333	1.318	1.220	1.080	1.046
2.5	0.7	1.337	1.337	1.335	1.320	1.220	1.080	1.046
2.5	0.8	1.339	1.339	1.337	1.321	1.221	1.080	1.046
2.5	0.9	1.340	1.340	1.339	1.323	1.222	1.080	1.046
2.5	1.0	1.342	1.342	1.340	1.324	1.222	1.080	1.046
3.0	0.1	1.429	1.428	1.427	1.412	1.317	1.169	1.130
3.0	0.2	1.451	1.451	1.449	1.432	1.325	1.169	1.130
3.0	0.3	1.460	1.460	1.458	1.440	1.329	1.169	1.130
3.0	0.4	1.469	1.469	1.467	1.449	1.332	1.170	1.130
3.0	0.5	1.473	1.473	1.471	1.452	1.334	1.170	1.130
3.0	0.6	1.477	1.477	1.475	1.456	1.336	1.170	1.130
3.0	0.7	1.480	1.480	1.478	1.458	1.337	1.170	1.130
3.0	0.8	1.482	1.482	1.480	1.461	1.338	1.170	1.130
3.0	0.9	1.484	1.484	1.482	1.462	1.338	1.170	1.130
3.0	1.0	1.486	1.486	1.484	1.464	1.339	1.170	1.130
3.5	0.1	1.540	1.539	1.538	1.521	1.410	1.241	1.198
3.5	0.2	1.566	1.565	1.564	1.544	1.420	1.242	1.198
3.5	0.3	1.576	1.576	1.574	1.554	1.424	1.242	1.198
3.5	0.4	1.587	1.587	1.585	1.563	1.428	1.242	1.198
3.5	0.5	1.592	1.592	1.590	1.568	1.430	1.242	1.198
3.5	0.6	1.597	1.597	1.594	1.572	1.431	1.242	1.198
3.5	0.7	1.600	1.600	1.597	1.575	1.433	1.242	1.198
3.5	0.8	1.603	1.602	1.600	1.577	1.434	1.242	1.198
3.5	0.9	1.605	1.604	1.602	1.579	1.434	1.242	1.198
3.5	1.0	1.607	1.606	1.604	1.581	1.435	1.242	1.198
4.0	0.1	1.633	1.633	1.631	1.612	1.487	1.301	1.254

4.0	0.2	1.663	1.663	1.660	1.639	1.499	1.302	1.254
4.0	0.3	1.675	1.675	1.672	1.649	1.503	1.302	1.254
4.0	0.4	1.687	1.687	1.684	1.660	1.508	1.302	1.254
4.0	0.5	1.692	1.692	1.690	1.665	1.510	1.302	1.254
4.0	0.6	1.698	1.698	1.695	1.670	1.512	1.302	1.254
4.0	0.7	1.701	1.701	1.699	1.673	1.513	1.302	1.254
4.0	0.8	1.705	1.704	1.702	1.676	1.514	1.302	1.254
4.0	0.9	1.707	1.707	1.704	1.678	1.515	1.302	1.254
4.0	1.0	1.709	1.709	1.706	1.680	1.516	1.302	1.254
4.5	0.1	1.713	1.713	1.711	1.690	1.553	1.351	1.301
4.5	0.2	1.746	1.746	1.743	1.719	1.566	1.352	1.301
4.5	0.3	1.759	1.759	1.756	1.731	1.570	1.352	1.301
4.5	0.4	1.772	1.772	1.769	1.743	1.575	1.352	1.301
4.5	0.5	1.779	1.778	1.776	1.748	1.578	1.352	1.301
4.5	0.6	1.785	1.784	1.782	1.754	1.580	1.352	1.301
4.5	0.7	1.788	1.788	1.785	1.757	1.581	1.352	1.301
4.5	0.8	1.792	1.792	1.789	1.760	1.582	1.352	1.301
4.5	0.9	1.794	1.794	1.791	1.762	1.583	1.352	1.301
4.5	1.0	1.797	1.797	1.794	1.765	1.584	1.352	1.301
5.0	0.1	1.782	1.782	1.780	1.757	1.610	1.394	1.341
5.0	0.2	1.818	1.817	1.815	1.789	1.623	1.394	1.341
5.0	0.3	1.832	1.832	1.829	1.802	1.628	1.394	1.341
5.0	0.4	1.846	1.846	1.843	1.814	1.634	1.395	1.341
5.0	0.5	1.853	1.853	1.850	1.820	1.636	1.395	1.341
5.0	0.6	1.860	1.859	1.856	1.826	1.638	1.395	1.341
5.0	0.7	1.864	1.863	1.860	1.830	1.640	1.395	1.341
5.0	0.8	1.868	1.867	1.864	1.833	1.641	1.395	1.341
5.0	0.9	1.870	1.870	1.867	1.836	1.642	1.395	1.341
5.0	1.0	1.873	1.872	1.869	1.838	1.643	1.395	1.341

Table S2 Spreadsheets of simulated τ_n (ns) as a function of different material properties

μ_{n_seed} = 1.0 cm^2/(V·s)

τ_{SRH_wire} [ns]	τ_{SRH_seed} [ns]	S_n [cm^2/(V·s)]						
		1×10^0	1×10^1	1×10^2	1×10^3	1×10^4	1×10^5	1×10^6
1.0	0.1	0.653	0.653	0.653	0.650	0.631	0.596	0.585
1.0	0.2	0.659	0.659	0.659	0.656	0.634	0.596	0.585
1.0	0.3	0.662	0.662	0.662	0.658	0.635	0.596	0.585
1.0	0.4	0.664	0.664	0.664	0.660	0.637	0.596	0.585
1.0	0.5	0.665	0.665	0.665	0.661	0.637	0.596	0.585
1.0	0.6	0.666	0.666	0.666	0.662	0.638	0.596	0.585
1.0	0.7	0.667	0.667	0.667	0.663	0.638	0.596	0.585
1.0	0.8	0.668	0.668	0.667	0.663	0.638	0.596	0.585
1.0	0.9	0.668	0.668	0.668	0.664	0.638	0.596	0.585
1.0	1.0	0.668	0.668	0.668	0.664	0.639	0.596	0.585
1.5	0.1	0.887	0.886	0.886	0.881	0.844	0.780	0.762
1.5	0.2	0.898	0.898	0.898	0.891	0.849	0.780	0.762
1.5	0.3	0.903	0.903	0.903	0.896	0.851	0.780	0.762
1.5	0.4	0.908	0.908	0.908	0.900	0.853	0.780	0.762
1.5	0.5	0.910	0.910	0.910	0.902	0.854	0.780	0.762
1.5	0.6	0.912	0.912	0.912	0.904	0.855	0.780	0.762
1.5	0.7	0.914	0.913	0.913	0.905	0.856	0.780	0.762
1.5	0.8	0.915	0.915	0.914	0.906	0.856	0.780	0.762
1.5	0.9	0.916	0.916	0.915	0.907	0.856	0.780	0.762
1.5	1.0	0.916	0.916	0.916	0.908	0.857	0.780	0.762
2.0	0.1	1.070	1.070	1.070	1.061	1.007	0.916	0.892
2.0	0.2	1.088	1.088	1.088	1.078	1.015	0.916	0.892
2.0	0.3	1.096	1.096	1.095	1.085	1.018	0.916	0.892
2.0	0.4	1.103	1.103	1.102	1.091	1.021	0.916	0.892
2.0	0.5	1.106	1.106	1.105	1.094	1.022	0.916	0.892
2.0	0.6	1.109	1.109	1.108	1.097	1.023	0.916	0.892
2.0	0.7	1.111	1.111	1.110	1.099	1.024	0.916	0.892
2.0	0.8	1.113	1.113	1.112	1.100	1.025	0.916	0.892
2.0	0.9	1.114	1.114	1.113	1.101	1.025	0.916	0.892

2.0	1.0	1.116	1.115	1.114	1.102	1.026	0.916	0.892
2.5	0.1	1.218	1.218	1.217	1.206	1.135	1.020	0.991
2.5	0.2	1.242	1.242	1.241	1.228	1.145	1.021	0.991
2.5	0.3	1.252	1.251	1.250	1.237	1.149	1.021	0.991
2.5	0.4	1.261	1.261	1.260	1.245	1.153	1.021	0.991
2.5	0.5	1.265	1.265	1.264	1.249	1.155	1.021	0.991
2.5	0.6	1.270	1.269	1.268	1.253	1.157	1.021	0.991
2.5	0.7	1.272	1.272	1.271	1.255	1.157	1.021	0.991
2.5	0.8	1.274	1.274	1.273	1.257	1.158	1.021	0.991
2.5	0.9	1.276	1.276	1.274	1.259	1.159	1.021	0.991
2.5	1.0	1.277	1.277	1.276	1.260	1.160	1.021	0.991
3.0	0.1	1.338	1.338	1.337	1.324	1.239	1.103	1.070
3.0	0.2	1.368	1.368	1.366	1.351	1.251	1.103	1.070
3.0	0.3	1.379	1.379	1.378	1.362	1.256	1.103	1.070
3.0	0.4	1.391	1.391	1.389	1.372	1.260	1.104	1.070
3.0	0.5	1.396	1.396	1.395	1.377	1.262	1.104	1.070
3.0	0.6	1.401	1.401	1.400	1.381	1.264	1.104	1.070
3.0	0.7	1.404	1.404	1.402	1.384	1.266	1.104	1.070
3.0	0.8	1.407	1.407	1.405	1.387	1.267	1.104	1.070
3.0	0.9	1.409	1.409	1.407	1.388	1.267	1.104	1.070
3.0	1.0	1.411	1.411	1.409	1.390	1.268	1.104	1.070
3.5	0.1	1.438	1.438	1.437	1.422	1.324	1.170	1.133
3.5	0.2	1.472	1.472	1.471	1.453	1.338	1.170	1.133
3.5	0.3	1.486	1.486	1.484	1.465	1.343	1.170	1.133
3.5	0.4	1.499	1.499	1.497	1.478	1.349	1.170	1.133
3.5	0.5	1.505	1.505	1.503	1.483	1.351	1.170	1.133
3.5	0.6	1.511	1.511	1.509	1.488	1.353	1.171	1.133
3.5	0.7	1.515	1.515	1.513	1.491	1.354	1.171	1.133
3.5	0.8	1.518	1.518	1.516	1.494	1.356	1.171	1.133
3.5	0.9	1.520	1.520	1.518	1.496	1.357	1.171	1.133
3.5	1.0	1.522	1.522	1.520	1.498	1.357	1.171	1.133
4.0	0.1	1.522	1.522	1.521	1.504	1.395	1.225	1.185
4.0	0.2	1.560	1.560	1.558	1.539	1.410	1.225	1.185

4.0	0.3	1.576	1.575	1.574	1.553	1.416	1.226	1.185
4.0	0.4	1.591	1.591	1.589	1.566	1.422	1.226	1.185
4.0	0.5	1.598	1.597	1.595	1.572	1.425	1.226	1.185
4.0	0.6	1.604	1.604	1.602	1.578	1.428	1.226	1.185
4.0	0.7	1.608	1.608	1.606	1.582	1.429	1.226	1.185
4.0	0.8	1.612	1.612	1.609	1.585	1.430	1.226	1.185
4.0	0.9	1.614	1.614	1.612	1.587	1.431	1.226	1.185
4.0	1.0	1.617	1.616	1.614	1.590	1.432	1.226	1.185
4.5	0.1	1.594	1.593	1.592	1.574	1.455	1.271	1.229
4.5	0.2	1.636	1.635	1.633	1.612	1.472	1.272	1.228
4.5	0.3	1.652	1.652	1.650	1.627	1.478	1.272	1.228
4.5	0.4	1.669	1.669	1.666	1.642	1.485	1.272	1.228
4.5	0.5	1.676	1.676	1.674	1.649	1.488	1.272	1.228
4.5	0.6	1.684	1.683	1.681	1.655	1.491	1.272	1.228
4.5	0.7	1.688	1.687	1.685	1.659	1.492	1.272	1.228
4.5	0.8	1.692	1.692	1.689	1.663	1.494	1.272	1.228
4.5	0.9	1.694	1.694	1.692	1.665	1.495	1.272	1.228
4.5	1.0	1.697	1.697	1.694	1.667	1.496	1.272	1.228
5.0	0.1	1.655	1.655	1.653	1.634	1.507	1.311	1.266
5.0	0.2	1.700	1.700	1.698	1.675	1.525	1.311	1.265
5.0	0.3	1.718	1.718	1.716	1.691	1.532	1.311	1.265
5.0	0.4	1.736	1.736	1.734	1.708	1.539	1.311	1.265
5.0	0.5	1.744	1.744	1.741	1.715	1.542	1.311	1.265
5.0	0.6	1.752	1.752	1.749	1.722	1.545	1.311	1.265
5.0	0.7	1.757	1.756	1.753	1.726	1.546	1.311	1.265
5.0	0.8	1.761	1.761	1.758	1.730	1.548	1.311	1.265
5.0	0.9	1.764	1.763	1.761	1.732	1.549	1.311	1.265
5.0	1.0	1.767	1.766	1.763	1.735	1.550	1.311	1.265

Table S3 Spreadsheets of simulated τ_n (ns) as a function of different material properties

μ_{n_seed} = 5.0 cm^2/(V·s)

τ_{SRH_wire} [ns]	τ_{SRH_seed} [ns]	S_n [cm^2/(V·s)]						
		1×10^0	1×10^1	1×10^2	1×10^3	1×10^4	1×10^5	1×10^6
1.0	0.1	0.578	0.578	0.578	0.576	0.564	0.534	0.526
1.0	0.2	0.584	0.584	0.584	0.582	0.568	0.535	0.526
1.0	0.3	0.586	0.586	0.586	0.584	0.569	0.535	0.526
1.0	0.4	0.589	0.588	0.589	0.586	0.570	0.535	0.526
1.0	0.5	0.589	0.589	0.589	0.587	0.571	0.535	0.526
1.0	0.6	0.590	0.590	0.590	0.588	0.571	0.535	0.526
1.0	0.7	0.590	0.590	0.590	0.588	0.571	0.535	0.526
1.0	0.8	0.591	0.591	0.591	0.588	0.572	0.535	0.526
1.0	0.9	0.591	0.591	0.591	0.589	0.572	0.535	0.526
1.0	1.0	0.591	0.591	0.591	0.589	0.572	0.535	0.526
1.5	0.1	0.766	0.766	0.766	0.763	0.743	0.695	0.682
1.5	0.2	0.777	0.777	0.777	0.773	0.749	0.695	0.682
1.5	0.3	0.780	0.780	0.780	0.776	0.751	0.695	0.682
1.5	0.4	0.783	0.783	0.783	0.779	0.754	0.695	0.682
1.5	0.5	0.784	0.784	0.784	0.781	0.754	0.695	0.682
1.5	0.6	0.785	0.785	0.785	0.782	0.755	0.695	0.682
1.5	0.7	0.786	0.786	0.786	0.782	0.755	0.695	0.682
1.5	0.8	0.787	0.787	0.787	0.783	0.756	0.695	0.682
1.5	0.9	0.787	0.787	0.787	0.783	0.756	0.695	0.682
1.5	1.0	0.787	0.787	0.787	0.784	0.756	0.695	0.682
2.0	0.1	0.907	0.907	0.907	0.903	0.876	0.811	0.794
2.0	0.2	0.921	0.921	0.921	0.917	0.885	0.811	0.794
2.0	0.3	0.925	0.925	0.925	0.921	0.887	0.811	0.794
2.0	0.4	0.929	0.929	0.929	0.925	0.890	0.811	0.794
2.0	0.5	0.931	0.931	0.931	0.926	0.891	0.811	0.794
2.0	0.6	0.933	0.933	0.932	0.928	0.892	0.811	0.794
2.0	0.7	0.933	0.933	0.933	0.928	0.893	0.811	0.794
2.0	0.8	0.934	0.934	0.934	0.929	0.893	0.812	0.794
2.0	0.9	0.935	0.935	0.934	0.930	0.893	0.812	0.794

2.0	1.0	0.935	0.935	0.935	0.930	0.894	0.812	0.794
2.5	0.1	1.016	1.016	1.016	1.012	0.979	0.899	0.879
2.5	0.2	1.033	1.033	1.033	1.028	0.989	0.899	0.879
2.5	0.3	1.038	1.038	1.038	1.033	0.992	0.900	0.879
2.5	0.4	1.043	1.043	1.043	1.037	0.996	0.900	0.879
2.5	0.5	1.045	1.045	1.045	1.039	0.997	0.900	0.879
2.5	0.6	1.047	1.047	1.047	1.041	0.998	0.900	0.879
2.5	0.7	1.048	1.048	1.048	1.042	0.999	0.900	0.879
2.5	0.8	1.049	1.049	1.049	1.043	0.999	0.900	0.879
2.5	0.9	1.049	1.049	1.049	1.043	1.000	0.900	0.879
2.5	1.0	1.050	1.050	1.050	1.044	1.000	0.900	0.879
3.0	0.1	1.103	1.103	1.103	1.098	1.060	0.968	0.945
3.0	0.2	1.122	1.122	1.122	1.116	1.072	0.969	0.945
3.0	0.3	1.128	1.128	1.128	1.122	1.076	0.969	0.945
3.0	0.4	1.134	1.134	1.134	1.127	1.079	0.969	0.945
3.0	0.5	1.136	1.136	1.136	1.129	1.081	0.969	0.945
3.0	0.6	1.138	1.138	1.138	1.131	1.082	0.969	0.945
3.0	0.7	1.139	1.139	1.139	1.132	1.083	0.969	0.945
3.0	0.8	1.140	1.140	1.140	1.133	1.083	0.969	0.945
3.0	0.9	1.141	1.141	1.141	1.134	1.084	0.969	0.945
3.0	1.0	1.142	1.142	1.141	1.135	1.084	0.969	0.945
3.5	0.1	1.174	1.174	1.173	1.168	1.126	1.024	0.998
3.5	0.2	1.195	1.195	1.195	1.188	1.139	1.024	0.998
3.5	0.3	1.202	1.202	1.201	1.194	1.143	1.025	0.998
3.5	0.4	1.208	1.208	1.208	1.201	1.147	1.025	0.998
3.5	0.5	1.210	1.210	1.210	1.203	1.149	1.025	0.998
3.5	0.6	1.213	1.213	1.212	1.205	1.150	1.025	0.998
3.5	0.7	1.214	1.214	1.213	1.206	1.151	1.025	0.998
3.5	0.8	1.215	1.215	1.214	1.207	1.152	1.025	0.998
3.5	0.9	1.216	1.216	1.215	1.208	1.152	1.025	0.998
3.5	1.0	1.217	1.216	1.216	1.209	1.153	1.025	0.998
4.0	0.1	1.232	1.232	1.232	1.226	1.181	1.069	1.042
4.0	0.2	1.256	1.255	1.255	1.248	1.195	1.070	1.042

4.0	0.3	1.262	1.262	1.262	1.255	1.199	1.070	1.042
4.0	0.4	1.269	1.269	1.269	1.261	1.204	1.070	1.042
4.0	0.5	1.272	1.272	1.271	1.264	1.205	1.071	1.042
4.0	0.6	1.274	1.274	1.274	1.266	1.207	1.071	1.042
4.0	0.7	1.276	1.276	1.275	1.267	1.208	1.071	1.042
4.0	0.8	1.277	1.277	1.276	1.269	1.209	1.071	1.042
4.0	0.9	1.278	1.278	1.277	1.269	1.209	1.071	1.042
4.0	1.0	1.279	1.278	1.278	1.270	1.209	1.071	1.042
4.5	0.1	1.282	1.282	1.281	1.275	1.226	1.108	1.079
4.5	0.2	1.306	1.306	1.306	1.298	1.242	1.108	1.078
4.5	0.3	1.314	1.314	1.313	1.305	1.246	1.109	1.078
4.5	0.4	1.321	1.321	1.320	1.312	1.251	1.109	1.078
4.5	0.5	1.324	1.324	1.323	1.315	1.253	1.109	1.078
4.5	0.6	1.326	1.326	1.326	1.318	1.254	1.109	1.078
4.5	0.7	1.328	1.328	1.327	1.319	1.255	1.109	1.078
4.5	0.8	1.329	1.329	1.328	1.320	1.256	1.109	1.078
4.5	0.9	1.330	1.330	1.329	1.321	1.257	1.109	1.078
4.5	1.0	1.331	1.331	1.330	1.322	1.257	1.109	1.078
5.0	0.1	1.324	1.324	1.323	1.317	1.265	1.140	1.109
5.0	0.2	1.350	1.350	1.349	1.341	1.282	1.141	1.109
5.0	0.3	1.357	1.357	1.357	1.349	1.287	1.141	1.109
5.0	0.4	1.365	1.365	1.365	1.356	1.291	1.141	1.109
5.0	0.5	1.368	1.368	1.367	1.359	1.293	1.141	1.109
5.0	0.6	1.371	1.371	1.370	1.361	1.295	1.141	1.109
5.0	0.7	1.372	1.372	1.372	1.363	1.296	1.141	1.109
5.0	0.8	1.374	1.374	1.373	1.364	1.297	1.141	1.109
5.0	0.9	1.375	1.375	1.374	1.365	1.297	1.141	1.109
5.0	1.0	1.376	1.375	1.375	1.366	1.298	1.141	1.109

Table S4 Spreadsheets of simulated τ_n (ns) as a function of different material properties

μ_{n_seed} = 10.0 cm^2/(V·s)

τ_{SRH_wire} [ns]	τ_{SRH_seed} [ns]	S_n [cm^2/(V·s)]						
		1×10^0	1×10^1	1×10^2	1×10^3	1×10^4	1×10^5	1×10^6
1.0	0.1	0.542	0.542	0.542	0.541	0.535	0.514	0.507
1.0	0.2	0.545	0.545	0.545	0.544	0.537	0.514	0.507
1.0	0.3	0.546	0.546	0.546	0.545	0.538	0.514	0.507
1.0	0.4	0.547	0.547	0.547	0.546	0.539	0.514	0.507
1.0	0.5	0.547	0.547	0.547	0.546	0.539	0.514	0.507
1.0	0.6	0.548	0.548	0.548	0.547	0.539	0.514	0.507
1.0	0.7	0.548	0.548	0.548	0.547	0.539	0.514	0.507
1.0	0.8	0.548	0.548	0.548	0.547	0.539	0.514	0.507
1.0	0.9	0.548	0.548	0.548	0.547	0.539	0.514	0.507
1.0	1.0	0.548	0.548	0.548	0.547	0.539	0.514	0.507
1.5	0.1	0.709	0.709	0.709	0.708	0.698	0.665	0.655
1.5	0.2	0.713	0.713	0.713	0.712	0.702	0.666	0.655
1.5	0.3	0.715	0.715	0.715	0.713	0.703	0.666	0.655
1.5	0.4	0.716	0.716	0.716	0.715	0.704	0.666	0.655
1.5	0.5	0.716	0.716	0.717	0.715	0.704	0.666	0.655
1.5	0.6	0.717	0.717	0.717	0.715	0.704	0.666	0.655
1.5	0.7	0.717	0.717	0.717	0.716	0.704	0.666	0.655
1.5	0.8	0.717	0.717	0.717	0.716	0.705	0.666	0.655
1.5	0.9	0.717	0.717	0.718	0.716	0.705	0.666	0.655
1.5	1.0	0.718	0.718	0.718	0.716	0.705	0.666	0.655
2.0	0.1	0.831	0.831	0.831	0.829	0.817	0.775	0.761
2.0	0.2	0.837	0.837	0.837	0.835	0.822	0.775	0.761
2.0	0.3	0.838	0.838	0.838	0.837	0.823	0.775	0.761
2.0	0.4	0.840	0.840	0.840	0.838	0.824	0.775	0.761
2.0	0.5	0.840	0.840	0.840	0.839	0.825	0.775	0.761
2.0	0.6	0.841	0.841	0.841	0.839	0.825	0.775	0.761
2.0	0.7	0.841	0.841	0.841	0.839	0.825	0.776	0.761
2.0	0.8	0.842	0.842	0.842	0.840	0.825	0.776	0.761
2.0	0.9	0.842	0.842	0.842	0.840	0.826	0.776	0.761

2.0	1.0	0.842	0.842	0.842	0.840	0.826	0.776	0.761
2.5	0.1	0.924	0.924	0.924	0.922	0.908	0.857	0.841
2.5	0.2	0.931	0.931	0.931	0.929	0.913	0.858	0.841
2.5	0.3	0.933	0.933	0.933	0.931	0.915	0.858	0.841
2.5	0.4	0.935	0.935	0.935	0.932	0.916	0.858	0.841
2.5	0.5	0.935	0.935	0.935	0.933	0.916	0.858	0.841
2.5	0.6	0.936	0.936	0.936	0.934	0.917	0.858	0.841
2.5	0.7	0.936	0.936	0.936	0.934	0.917	0.858	0.841
2.5	0.8	0.937	0.937	0.937	0.934	0.917	0.858	0.841
2.5	0.9	0.937	0.937	0.937	0.935	0.918	0.858	0.841
2.5	1.0	0.937	0.937	0.937	0.935	0.918	0.858	0.841
3.0	0.1	0.997	0.997	0.997	0.995	0.979	0.922	0.903
3.0	0.2	1.005	1.005	1.005	1.003	0.985	0.923	0.903
3.0	0.3	1.007	1.007	1.007	1.005	0.987	0.923	0.903
3.0	0.4	1.009	1.009	1.009	1.007	0.988	0.923	0.903
3.0	0.5	1.010	1.010	1.010	1.007	0.989	0.923	0.903
3.0	0.6	1.011	1.011	1.011	1.008	0.989	0.923	0.903
3.0	0.7	1.011	1.011	1.011	1.009	0.990	0.923	0.903
3.0	0.8	1.011	1.011	1.011	1.009	0.990	0.923	0.903
3.0	0.9	1.012	1.012	1.012	1.009	0.990	0.923	0.903
3.0	1.0	1.012	1.012	1.012	1.009	0.990	0.923	0.903
3.5	0.1	1.056	1.056	1.056	1.054	1.037	0.974	0.953
3.5	0.2	1.065	1.065	1.065	1.062	1.043	0.974	0.953
3.5	0.3	1.067	1.067	1.067	1.064	1.045	0.975	0.953
3.5	0.4	1.069	1.069	1.069	1.067	1.046	0.975	0.953
3.5	0.5	1.070	1.070	1.070	1.068	1.047	0.975	0.953
3.5	0.6	1.071	1.071	1.071	1.068	1.048	0.975	0.953
3.5	0.7	1.071	1.071	1.071	1.069	1.048	0.975	0.953
3.5	0.8	1.072	1.072	1.072	1.069	1.048	0.975	0.953
3.5	0.9	1.072	1.072	1.072	1.069	1.048	0.975	0.953
3.5	1.0	1.072	1.072	1.072	1.070	1.049	0.975	0.953
4.0	0.1	1.105	1.105	1.105	1.103	1.084	1.016	0.994
4.0	0.2	1.114	1.114	1.114	1.111	1.091	1.017	0.993

4.0	0.3	1.117	1.116	1.116	1.114	1.093	1.017	0.993
4.0	0.4	1.119	1.119	1.119	1.116	1.094	1.017	0.993
4.0	0.5	1.120	1.120	1.120	1.117	1.095	1.017	0.993
4.0	0.6	1.121	1.121	1.121	1.118	1.096	1.017	0.993
4.0	0.7	1.121	1.121	1.121	1.118	1.096	1.017	0.993
4.0	0.8	1.122	1.122	1.122	1.119	1.096	1.018	0.993
4.0	0.9	1.122	1.122	1.122	1.119	1.097	1.018	0.993
4.0	1.0	1.122	1.122	1.122	1.119	1.097	1.018	0.993
4.5	0.1	1.146	1.146	1.146	1.143	1.124	1.052	1.028
4.5	0.2	1.155	1.155	1.155	1.153	1.131	1.052	1.027
4.5	0.3	1.158	1.158	1.158	1.155	1.133	1.053	1.027
4.5	0.4	1.161	1.161	1.160	1.158	1.134	1.053	1.027
4.5	0.5	1.161	1.161	1.161	1.158	1.135	1.053	1.027
4.5	0.6	1.162	1.162	1.162	1.159	1.136	1.053	1.027
4.5	0.7	1.163	1.163	1.163	1.160	1.136	1.053	1.027
4.5	0.8	1.163	1.163	1.163	1.160	1.137	1.053	1.027
4.5	0.9	1.164	1.164	1.163	1.161	1.137	1.053	1.027
4.5	1.0	1.164	1.164	1.164	1.161	1.137	1.053	1.027
5.0	0.1	1.181	1.181	1.181	1.178	1.157	1.082	1.056
5.0	0.2	1.190	1.190	1.190	1.187	1.164	1.082	1.056
5.0	0.3	1.193	1.193	1.193	1.190	1.167	1.083	1.056
5.0	0.4	1.196	1.196	1.196	1.193	1.169	1.083	1.056
5.0	0.5	1.197	1.197	1.197	1.194	1.169	1.083	1.056
5.0	0.6	1.198	1.198	1.198	1.195	1.170	1.083	1.056
5.0	0.7	1.198	1.198	1.198	1.195	1.170	1.083	1.056
5.0	0.8	1.199	1.199	1.199	1.196	1.171	1.083	1.056
5.0	0.9	1.199	1.199	1.199	1.196	1.171	1.083	1.056
5.0	1.0	1.199	1.199	1.199	1.196	1.171	1.083	1.056

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