Supplementary information

Room-temperature spin-conserved electron transport to semiconductor quantum dots using a superlattice barrier

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Note S1. Rate equation analysis

In this study, we performed a rate equation analysis to examine the electron transport time to the QDs. This rate equation model includes transport and relaxation processes of excitons initially generated in the GaAs QW around the QDs or in the SL barrier. The initial number of excitons can be expressed by N_0. The rate equation can be written as follows:

$$\frac{dN_{QW(SL)}}{dt} = \frac{-N_{QW(SL)}}{\tau_{tr}}\left(1 - \frac{N_{QD}}{D_{QD}}\right), \qquad \text{(S1)}$$

$$\frac{dN_{QD}}{dt} = \frac{N_{QW(SL)}}{\tau_{tr}}\left(1 - \frac{N_{QD}}{D_{QD}}\right) - \frac{N_{QD}}{\tau_r}, \qquad \text{(S2)}$$

where the generated excitons are transported to the QD states with a time constant of τ_{tr} and relax with a time constant of τ_r. Here, the parameter τ_r can be expressed by the radiative and nonradiative decay processes, as follows:

$$\frac{1}{\tau_r} = \frac{1}{\tau_{rad}} + \frac{1}{\tau_{nr}}, \qquad \text{(S3)}$$

where τ_{nr} includes the trapping by the defects, energy relaxation into the lower-energy QD states and thermal escape from the QDs. A state-filling effect is also considered in this model. If the QD states are fully occupied, the population of the states (N_{QD}) is equal to the density of the states (D_{QD}). In this case, the carrier injection stops. This situation can be expressed by introducing the parameter $1 - N_{QD}/D_{QD}$.