# Unconventional Electroluminescence in an Intrinsic Gateable Semiconductor

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Electroluminescence (EL), electrical generation of electron-hole pairs followed by radiative recombination, is a key principle exploited in the development of light emitters for optoelectronic applications. We report on a form of EL observed in a dopant-free, ambipolar, gateable GaAs/AlGaAs quantum well (QW), where electron-hole pairs are formed by an unconventional mechanism. By periodically swapping the polarity of the top gate of an ambipolar field-effect transistor (FET), free carriers already present under the top gate of the FET recombine radiatively with incoming carrier of the opposite charge. Due to the incoming and outgoing flow of carriers during every top gate voltage swap, we call this the *tidal effect*.

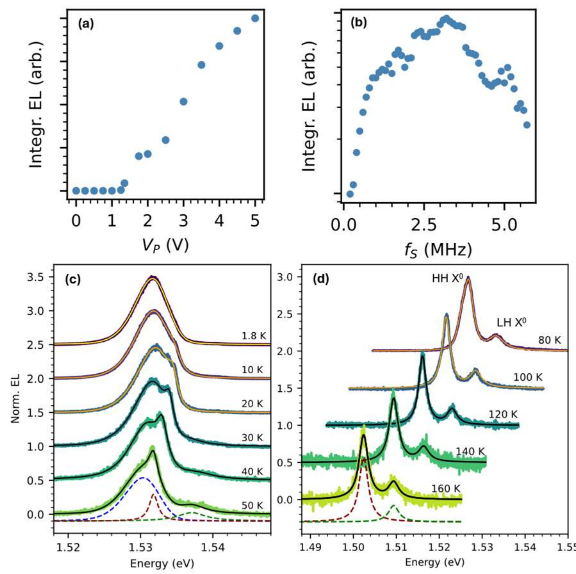


Fig.1. (a)-(b) Frequency and voltage amplitude dependence of EL intensity ($T$=1.8 K) (a) Integrated EL intensity as a function of peak voltage amplitude $V_p$ of square wave with $f_s$ = 800 kHz. (b) Integrated EL intensity as a function of swapping frequency $f_s$ with $V_p$ = 5 V. (c)-(d) Temperature dependence of EL at (c) low temperatures and (d) high temperature with data traces offset for clarity. Solid lines are best fits. Below the bottom spectrum on both panels, the individual functions used to obtain the best fit are shown. The dashed blue curve represents an asymmetric Voigt function, and the dashed green and dark red curves are Lorentzians.

EL increases with increasing top gate voltage amplitude beyond a threshold value [Fig.1 (a)], consistent with carrier accumulation in the QW. EL intensity inititally increases linearly with swapping frequency, before saturating and eventually decreasing [Fig.1 (b)]. A phenomenological model is developed to explain the emission intensity as a function swapping frequency, which agrees well with experiment.

Temperture-dependent measurements allow the unambiguous identification of the excitonic species responsible for the observed EL. At low temperature, the emission spectrum is dominated by the negatively charged exciton ($X^-$) [Fig.1 (c)]. As the temperature is increased, neutral excitons ($X^0$) (with both heavy (HH) and light holes (LH)) increase in prominence relative to $X^-$ until only HH $X^0$ and LH $X^0$ are observed [Fig.1 (d)].

Our devices exhibit EL at much further distances from the contacts (~400 μm) compared to prior reports of this effect in 2D materials [1,2] (≲10 μm), which we attribute to the higher carrier mobility in high quality GaAs/AlGaAs heterostrutures, and are also stable in time (≫1000 s). Our results indicate the tidal effect is a promising candidate for efficient AC driven light sources in III-V material systems.

References

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