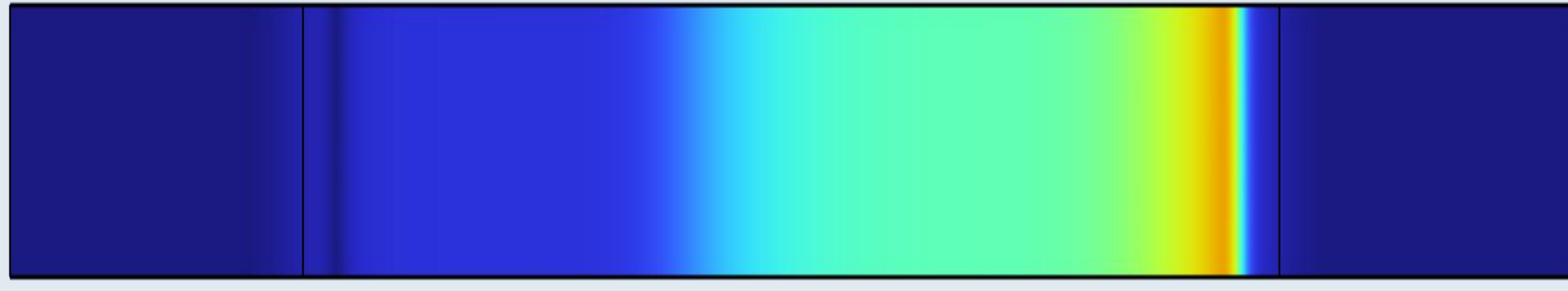


Stationary and Transient Analysis of a Planar GaAs Gunn Device Using COMSOL Multiphysics®



Develop a physics-based model of a GaAs Gunn device and investigate its stationary negative differential resistance, transient high frequency oscillations, travelling domain behaviour and RF output.

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Abstract

Planar Gunn devices can generate microwave-to-terahertz oscillations through the transferred-electron effect. Above a threshold electric field, intervalley electron transfer produces negative differential resistance (NDR), enabling high field domain formation and current oscillations [1–3].

In this work, a two-dimensional planar GaAs Gunn device was developed in COMSOL Multiphysics® 6.3 using the Semiconductor

Module. A 4 µm baseline device was used for stationary I–V and NDR analysis, while a refined 2.5 µm active region model with finite contact resistance was used for transient, FFT, domain propagation and 50 Ω RF load analysis. The refined model produced sustained terminal current oscillations near 118 GHz, with time-resolved electron concentration showing accumulation/depletion regions propagating toward the anode, consistent with travelling Gunn domain behaviour.

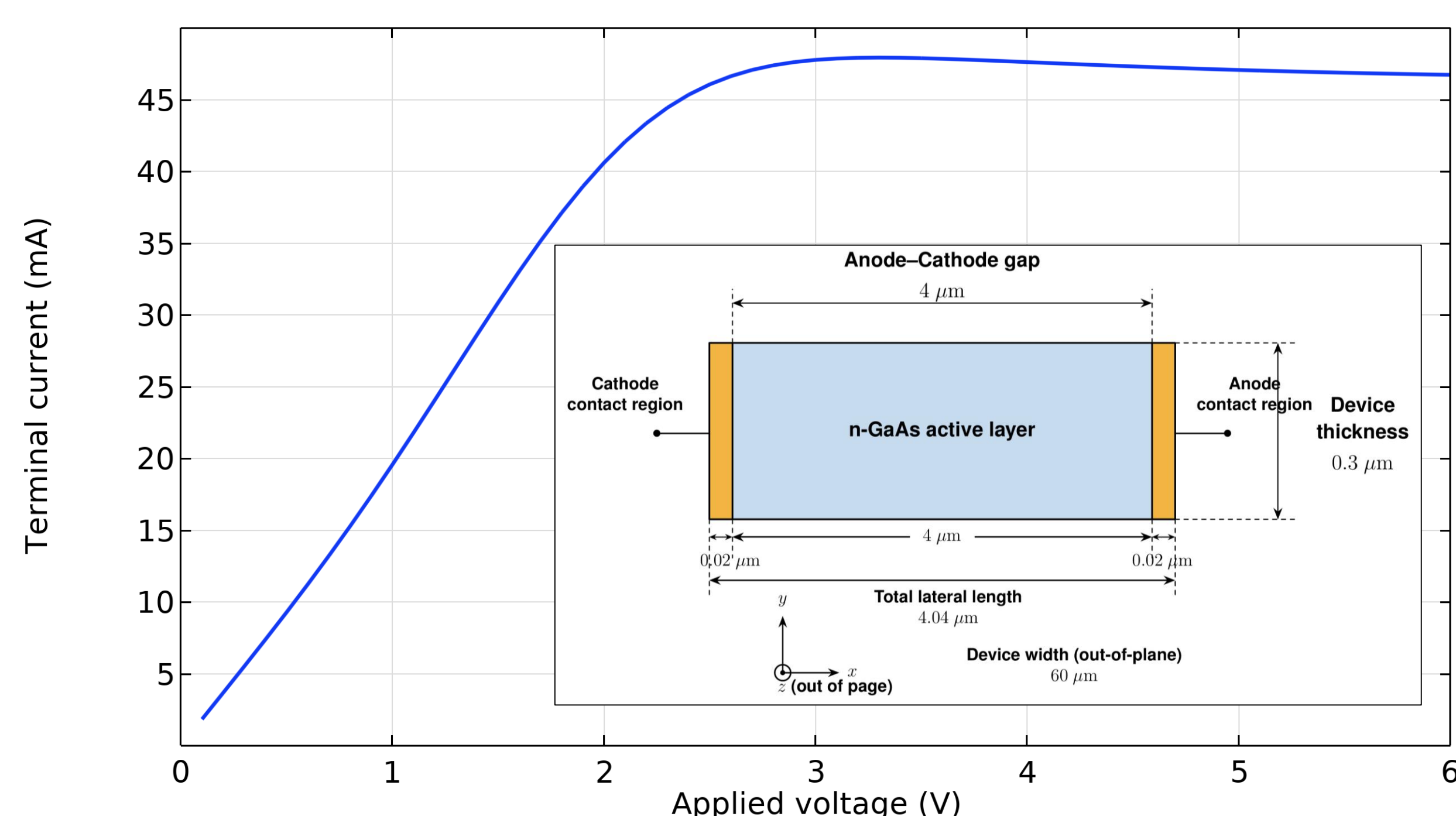


Figure 1. Simulated I–V characteristic of the 4 µm baseline GaAs Gunn device showing NDR, with the device geometry shown in the inset.

Methodology

- 4 µm baseline device: 0.3 µm thickness, 60 µm width, $N_D = 8 \times 10^{16} \text{ cm}^{-3}$.
- Drift–diffusion transport with a field-dependent GaAs mobility model:

$$\mu(E) = \frac{\mu_0 + \frac{v_{sat} E^3}{E_0^4}}{1 + \left(\frac{E}{E_0}\right)^4}$$

where μ_0 is the low field mobility, v_{sat} is the saturation velocity and E_0 is the characteristic field.

- Stationary voltage sweeps for I–V and NDR analysis.
- Refined 2.5 µm model with $\rho_c = 1 \times 10^{-6} \Omega \cdot \text{cm}^2$ (5.56 Ω/contact).
- Transient, FFT, domain propagation and 50 Ω RF load analysis.

Results

- The 4 µm baseline model showed a current peak of 48 mA at 3.3 V, followed by NDR, with the current decreasing to 46.5 mA at 6 V, as shown in Fig. 1.
- The refined 2.5 µm active region model produced sustained current oscillations with a mean current of 47.70 mA at 4.5 V.
- FFT analysis showed a dominant oscillation at 118.2 GHz, with harmonic components near 236.4, 354.5 and 472.6 GHz.
- When connected to a 50 Ω RF load, the output spectrum retained a dominant component at 118.05 GHz, with a peak spectral component of –23.51 dBm.

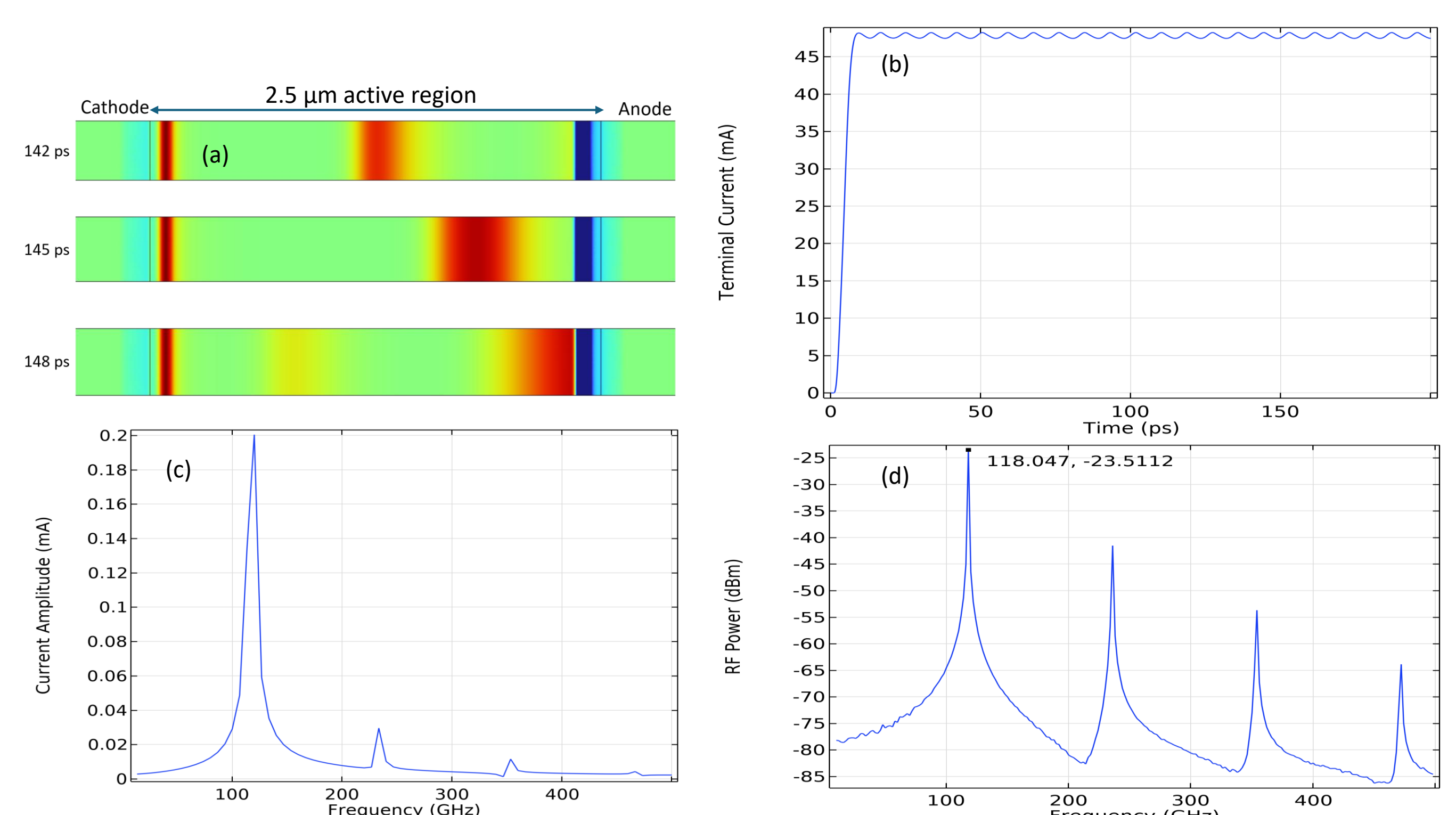


Figure 2. Transient and RF response of the refined 2.5 µm model: (a) travelling Gunn domain evolution, (b) terminal current oscillations, (c) FFT spectrum and (d) RF power spectrum delivered to a 50 Ω load.

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