

Modeling the frequency response of vertical and lateral Ge-on-Si waveguide photodetectors: Is 3D simulation unavoidable?

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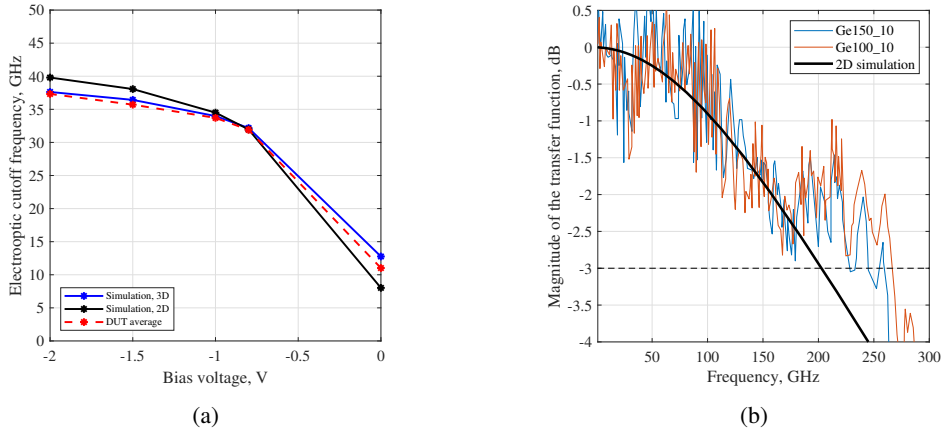


Fig. 2: (a) Measurements and simulations (both 3D and 2D) of the cutoff frequency for the reference Ge/Si vertical WPD in [8]; (b) measured and 2D-simulated electrooptical response of a lateral Si/Ge/Si WPD based on [4].

### 3. Results and outlook

Figure (2a) reports the electrooptic cutoff frequency as a function of the applied bias for the vertical WPD studied in [7], showing an excellent agreement with both experiments and 3D simulations. Also when applied to the lateral devices presented in [4], the 2D model predicts a cutoff frequency above 200 GHz, very close to the experimental values, see Figure (2b). The proposed approach should allow a significant speed-up of the optimization time for both vertical and lateral WPDs with uniform longitudinal cross section, by allowing to study the effects of the details of transverse geometry and doping profiles that do not affect significantly the longitudinal distribution of photogenerated carriers.

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### References

1. L. Viro, D. Benedikovic, B. Szelag, C. Alonso-Ramos, B. Karakus, J.-M. Hartmann, X. Le Roux, P. Crozat, E. Cassan, D. Marris-Morini *et al.*, “Integrated waveguide PIN photodiodes exploiting lateral Si/Ge/Si heterojunction,” *Opt. Express* **25**, 19487–19496 (2017).
2. D. Benedikovic, L. Viro, G. Aubin, J.-M. Hartmann, F. Amar, X. Le Roux, C. Alonso-Ramos, É. Cassan, D. Marris-Morini, J.-M. Fédéli *et al.*, “Silicon–germanium receivers for short-wave-infrared optoelectronics and communications,” *Nanophoton.* **10**, 1059–1079 (2020).
3. Y. Shi, D. Zhou, Y. Yu, and X. Zhang, “80 GHz germanium waveguide photodiode enabled by parasitic parameter engineering,” *Photon. Res.* **9**, 605–609 (2021).
4. S. Lischke, A. Peczek, J. S. Morgan, K. Sun, D. Steckler, Y. Yamamoto, F. Korndörfer, C. Mai, S. Marschmeyer, M. Fräschke *et al.*, “Ultra-fast germanium photodiode with 3-dB bandwidth of 265 GHz,” *Nat. Photon.* pp. 1–7 (2021).
5. M. Vallone, A. Palmieri, M. Calciati, F. Bertazzi, M. Goano, G. Ghione, and F. Forghieri, “3D physics-based modelling of Ge-on-Si waveguide *p-i-n* photodetectors,” in *17th International Conference on Numerical Simulation of Optoelectronic Devices (NUSOD 2017)*, (Copenhagen, Denmark, 2017), pp. 207–208.
6. A. Palmieri, M. Vallone, M. Calciati, A. Tibaldi, F. Bertazzi, G. Ghione, and M. Goano, “Heterostructure modeling considerations for Ge-on-Si waveguide photodetectors,” *Opt. Quantum Electron.* **50**, 71 (2018).
7. M. G. C. Alasio, M. Goano, A. Tibaldi, F. Bertazzi, S. Namnabat, D. Adams, P. Gothoskar, F. Forghieri, G. Ghione, and M. Vallone, “Ge-on-Si waveguide photodetectors: multiphysics modeling and experimental validation,” in *21st International Conference on Numerical Simulation of Optoelectronic Devices (NUSOD 2021)*, (online, 2021), pp. 37–38.
8. M. G. C. Alasio, M. Goano, A. Tibaldi, F. Bertazzi, S. Namnabat, D. Adams, P. Gothoskar, F. Forghieri, G. Ghione, and M. Vallone, “Bias effects on the electro-optic response of Ge-on-Si waveguide photodetectors,” in *IEEE Photonics Conference*, (online, 2021).