

Improved RF Power Extraction from 1.55 μm Ge/Si n-i-p Photodiodes with Load Impedance Optimization

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The RF output power of Ge/Si n-i-p waveguide photodetectors is improved by increasing the load impedance. The maximum extracted RF power at 3GHz is 17.13dBm with a compression current of 42mA using a 100 Ω load.

High power photodiodes (PDs) improve signal fidelity in high-speed optoelectronic communications links by eliminating a post amplifier stage, which reduces noise figure, decreases RF insertion loss, and increases spur-free dynamic range [1][2]. Recent efforts have focused on developing photodiodes with high power handling capabilities, and a photodiode with a compression current of 199 mA has been reported [3]. Other approaches have included coherently combining the RF outputs of multiple photodiodes [4] and modifying the modulation format to compensate for the compression that occurs within the photodetector [5]. Here, we increase the power delivered to the load by increasing the impedance seen by the photodetector.

A cross section schematic of the Si-Ge photodetector studied is shown in Figure 1a. Light is evanescently coupled from the Si-waveguide layers into the Ge-absorber layer, which has a larger index of refraction than Si. These photodiodes show up to 31GHz bandwidth for a device cross section of 7.4 μm x 50 μm (width x length) and an internal responsivity of 1.1A/W for absorber lengths greater than 100 μm [6]. The fabrication and epitaxial growth of these detectors is described in [6]. These devices have been shown to be capable of dissipating a large amount of electrical power before failure (1W), which is primarily due to the relatively high thermal conductivities of the Ge and Si used [7].

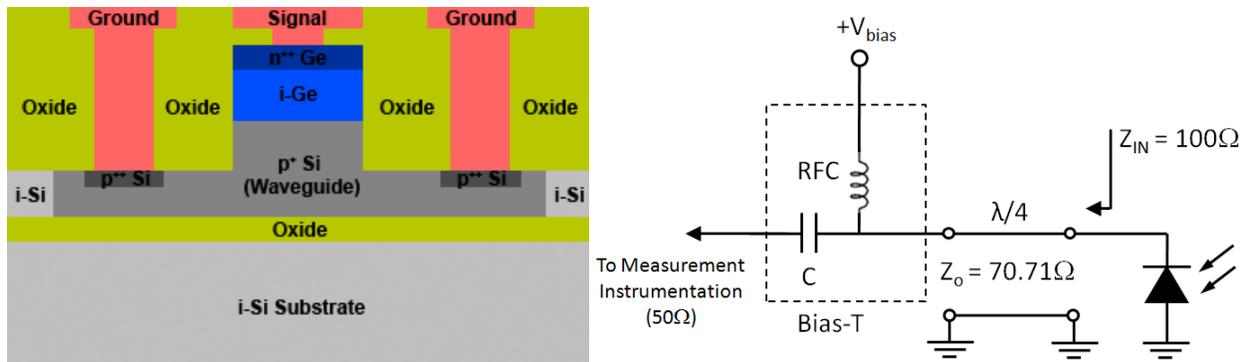


Figure 1a) Photodiode cross section schematic and 1b) measurement diagram for 3GHz RF compression measurements

Figure 1b) shows the measurement diagram for RF compression measurements at 3GHz. The load consists of a quarter-wavelength 70.71 Ω characteristic impedance thin film coplanar waveguide segment, which transforms the instrumentation impedance (50 Ω) into the desired load impedance (100 Ω) at the diode terminal. A bias-T is placed on the instrumentation end to provide external DC bias to the photodiode. Figure 2a) shows the RF power dependence on the photocurrent up to 6V reverse bias at 3GHz into this 100 Ω load for a 9 μm x 250 μm device at high optical powers. Figure 2b) illustrates the 1dB compression point for this device at 6V bias, which is 17.13dBm with a compression current of 42mA. In comparison, a recent study of these photodiodes at 1GHz demonstrates a maximum RF power output of 14.35dBm at 8V reverse bias and 60mA compression current using a 50 Ω load [8].

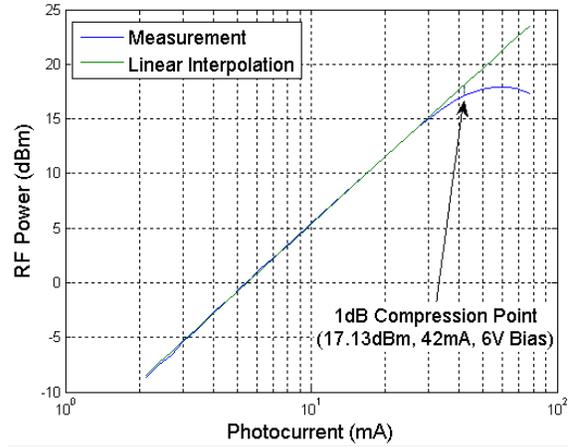
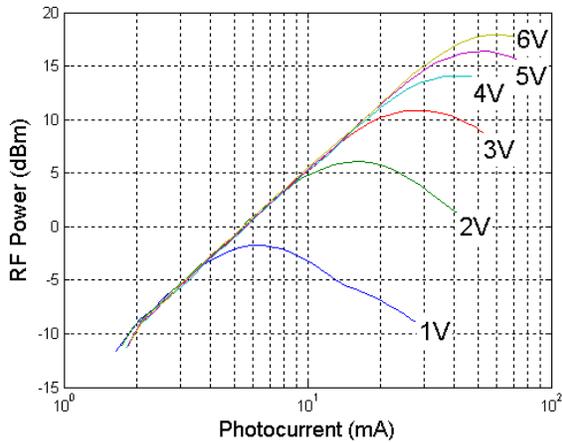


Fig 2a) RF power dependence on photocurrent for a $9\mu\text{m} \times 250\mu\text{m}$ device at 3GHz and 2b) 1dB compression at 6V reverse bias

Figure 3a) shows the 1dB compression point for a $9\mu\text{m} \times 250\mu\text{m}$ device at 1V-6V reverse bias and 3GHz modulation. This measurement is repeated for a $5.8\mu\text{m} \times 250\mu\text{m}$ device at 15MHz modulation using 50Ω, 100Ω, and 177Ω loads in figure 3b). The maximum obtainable RF power at 15MHz is 17.83dBm with 55mA compression current at 6V bias using a $5.8\mu\text{m} \times 250\mu\text{m}$ device and a 100Ω load. An RF power increase of 3dB and 5.5dB is obtained by using 100Ω and 177Ω loads, respectively, compared to a 50Ω load at similar compression currents.

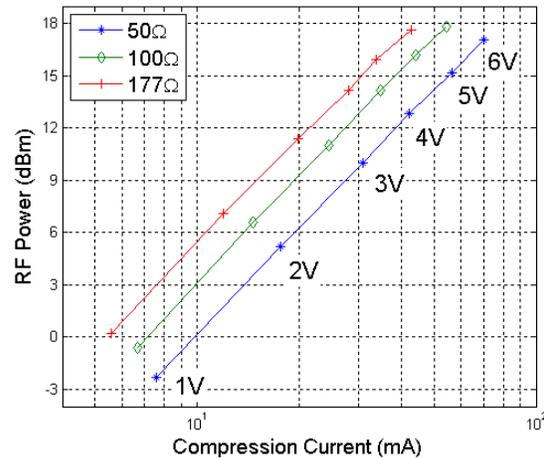
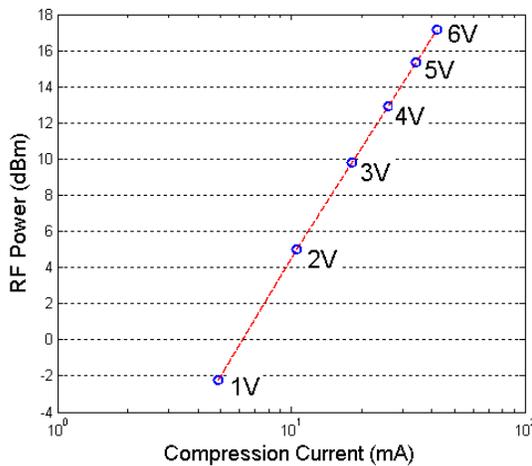


Fig 3a) RF compression for a $9\mu\text{m} \times 250\mu\text{m}$ device at 3GHz, and 3b) 15MHz RF compression for a $5.8\mu\text{m} \times 250\mu\text{m}$ device

Low frequency measurements at 15MHz show that RF power output is improved by increasing the load impedance. A 1dB compression measurement using a 100Ω load yields 17.1dBm of output power, which is nearly a 3dB increase from the RF power output (14.3dBm) obtained for these photodiodes at 1GHz in [8].

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