An Equivalent Circuit Model for the Long-Wavelength Quantum Well Infrared Detectors

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Abstract-**We present an equivalent circuit model for AlGaAs/GaAs long wavelength quantum well infrared photodetectors (LW-QWIPs). Bias dependence of the dark current and photocurrent is described with the aid of analogue circuit modelling technique in TINA software. This model can be integrated with the readout circuit for the whole device circuit optimization further. The temperature dependence of dark current has also been incorporated into this circuit model. The designed parameters of the LW-QWIPs can be fed into this model as user-defined inputs to simulate the detector performance. The obtained results agree well with the experimental measurements.**

I. INTRODUCTION

The development of quantum well infrared photodetectors (QWIPs) has prompted its application in large area focal plane arrays[1-5]. Such applications require the integration of readout circuit with the photodetectors. For the optimization of the readout circuit, it is necessary to simulate the circuit along with the QWIPs. The operation of the QWIPs is usually represented by a set of equations based on its semiconductor device physics. However, these physical equations cannot be used directly when the photodetectors are connected with there readout circuit for the whole circuit simulation. To overcome this difficulty and make it applicable for a wide range of device operating conditions, this paper is trying to employ a few current sources in parallel with the device resistance and provide the bias and temperature dependence of the dark current.

Ⅱ. Circuit design

The operation of AlGaAs/GaAs long wavelength QWIPs (LW-QWIPs) can be represented by two equations that take into account the dark current and photocurrent as a function of bias across the device and working temperature. These equations have been incorporated for circuit simulation using the analogue circuit modelling technology in TINA software. This model can be convenient integrated with the readout circuit for the whole circuit simulations further. Circuit model has been simulated in TINA software. Transient and DC current-voltage(*I-V*) analysis has been performed. Simulated results from this model are in good agreement with the experimental data in a wide range of operating conditions verifying the validity of the model.

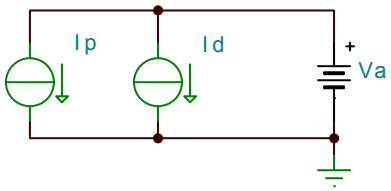

FIG. 1. Current composition of a QWIP

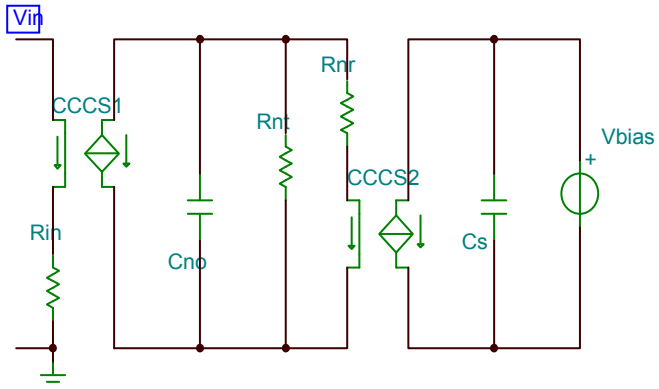

FIG. 2. Photocurrent circuit model of QWIP

Figure 1 shows the current composition of the LW-QWIPs where I_p is photocurrent and I_d is dark current. The transient equivalent circuit has been shown in Figure 2. Figure 3 presents the photocurrent circuit model with input signal. Figure 4 shows the total current response of the pulse signal input where VM2 is the equivalent input voltage and AM1 is the response photocurrent in figure.3. Figure 4 shows the pulse signal input and current response. Figure 5 and 6 present the complete equivalent circuit. And figure 7 give a comparison of the simulated dark current and the experiment

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data at different working temperatures.

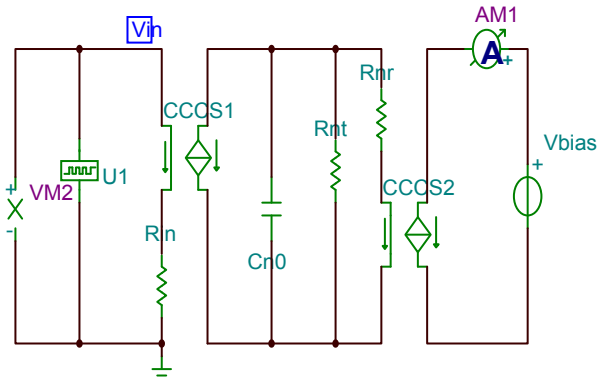

FIG. 3. Photocurrent circuit model with input signal

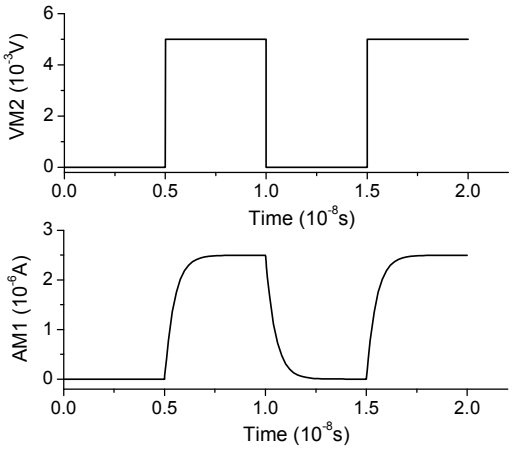

FIG. 4. Pulse signal input and current response

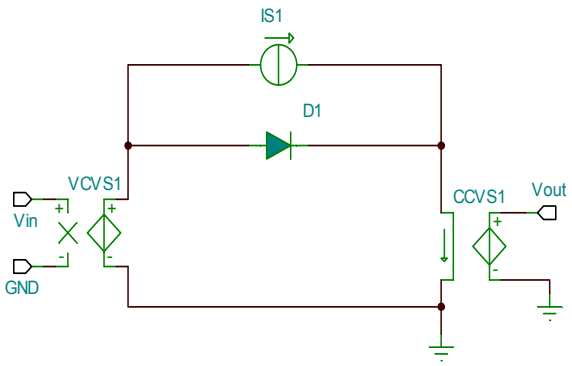

FIG. 5. Equivalent circuit of $n(V)$

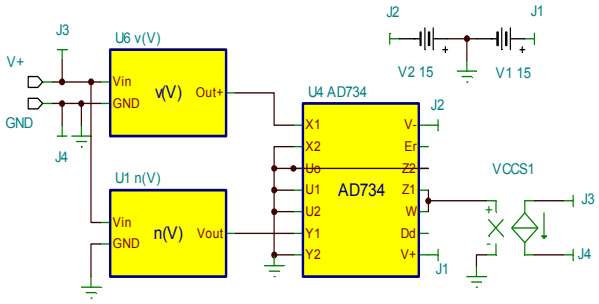

FIG. 6. Dark current equivalent circuit

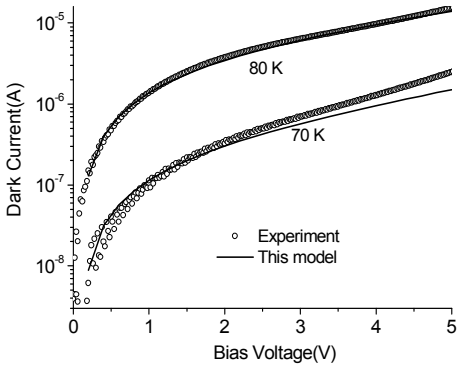

FIG. 7. Comparison of the simulated dark current and the experiment data

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