An AlGaN/GaN Based UV Photodetector Simulation Using COMSOL to Obtain the Fresnel Coefficients

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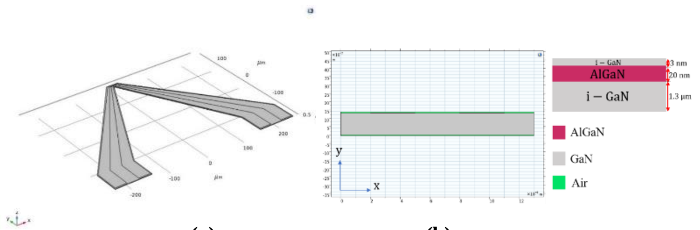
INTRODUCTION: The proposed cantilever has been modeled in COMSOL in order to compute the Fresnel coefficients like absorptance, reflectance, and transmittance in the wavelength range of 300 nm to 500 nm.

- Fresnel coefficients are calculated for different thickness of bottom GaN layer
- Fresnel coefficients are also calculated by varying Al alloy composition in $Al_xGa_{(1-x)}N$



(a) **(b)**

Figure 1. **(a)** 3D Geometry of GaN$-Al_xGa_{1-x}N-$GaN ultraviolet photodetector, **(b)** Longitudinal cross section at the tip region of the cantilever

COMPUTATIONAL METHODS: In this model, for the given 2D geometry a linearly polarized electromagnetic wave was launched in the -y axis. It was assumed that the electric (E) and magnetic (H) field components are along z and x axis, respectively. As the H-field components are along the x axis, perfect magnetic conductor (PMC) boundary condition was applied on both sides of the 2D geometry.

The reflection coefficient (R) is computed by equation (1)

$$R = |S_{11}|^2 \qquad (1)$$

The transmission coefficient (T) is computed by equation (2)

$$T = |S_{21}|^2 \qquad (2)$$

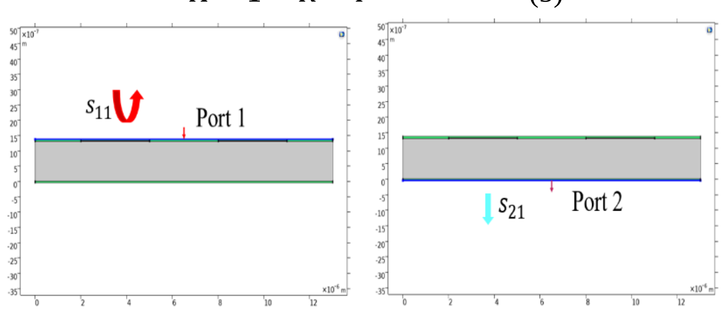
S_{11} and S_{21} are computed by equation (3) and equation (4), respectively. E_1 and E_2 are electric field pattern at port 1 and port 2 respectively.

$$S_{11} = \frac{\iint\left((E_c - E_1)\cdot E_1^*\right) dA_1}{\iint E_1\cdot E_1^*\, dA_1} \qquad (3)$$

$$S_{21} = \frac{\iint (E_c\cdot E_2^*)\, dA_2}{\iint E_2\cdot E_2^*\, dA_2} \qquad (4)$$

The absorption coefficient (R) is computed by equation (5)

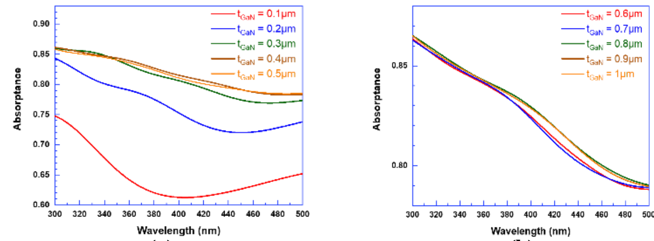
$$A = 1 - R - T \qquad (5)$$



(a) **(b)**

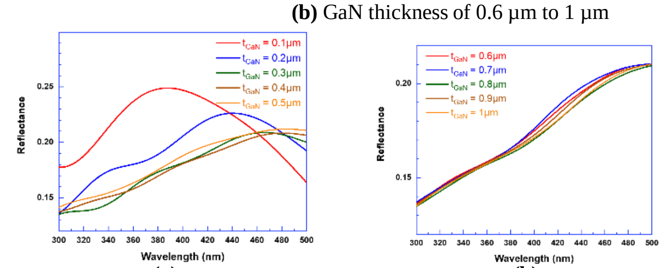
Figure 2. **(a)** Boundary condition at port 1, **(b)** Boundary condition at port 2

RESULTS: Plots of the computed Fresnel coefficients (Absorptance, Reflectance, and Transmittance)



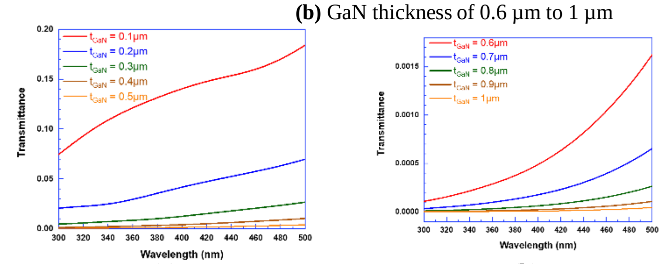
(a) **(b)**

Figure 3. Absorptance plots for **(a)** GaN thickness of 0.1 µm to 0.5 µm, **(b)** GaN thickness of 0.6 µm to 1 µm



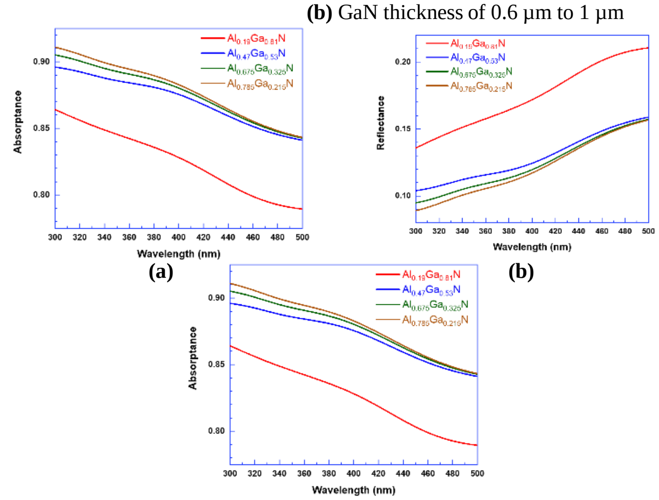
(a) **(b)**

Figure 4. Reflectance plots for **(a)** GaN thickness of 0.1 µm to 0.5 µm, **(b)** GaN thickness of 0.6 µm to 1 µm



(a) **(b)**

Figure 5. Transmittance plots for **(a)** GaN thickness of 0.1 µm to 0.5 µm, **(b)** GaN thickness of 0.6 µm to 1 µm



(c)

Figure 6. Al% variation in $Al_xGa_{(1-x)}N$ **(a)** Wavelength Vs Absorptance, **(b)** Wavelength Vs Reflectance,, **(c)** Wavelength Vs Transmittance,

CONCLUSIONS: Fresnel coefficients of the cantilever are computed in the wavelength range of 300 nm to 500 nm, using the wave optics module.

REFERENCES:

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2. N. Antoine-Vincent, et al., "Determination of the refractive indices of AlN, GaN, and AlxGa1-xN grown on (111) Si substrates," J. Appl. Phys., 93, 5222-5226 (2003).