Characterization of Graphene UV PhotoFETs with Aluminum Oxide Passivation

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Summary

Graphene's **high carrier mobility** and **broad wavelength absorption** has caught great interest in **optoelectronic** applications. However, **further optimization is required** to improve its photo-response, particularly in the **UV region** [1].
Graphene's low percentage of light absorption and stability in ambient environments present **challenges for real world applications**. To **compensate for this challenges**, Graphene is commonly used in **combination with hybrid structures**.
Our research focuses on the **photo-response of Graphene field-effect transistors** (gFETs) **encapsulated with Aluminum Oxide** (Al_2O_3), exploring their photo-response across the UV light range.

Objectives:

Characterize photo-response of gFETs passivated with Aluminum Oxide in the 405 nm to 280 nm range.

i Analyze wavelength dependence.
ii Compare samples with and without Al_2O_3 encapsulation.

Methodology

We focus on **2 gFETs** fabricated as described in [2]. Both samples **photo-response are compared** to identify the **effects of the Al_2O_3** layer.

With Al_2O_3 - Sample with the **whole 41.75 nm layer** of Al_2O_3.
Without Al_2O_3 - Sample with the **encapsulation** layer **completely etched** away.

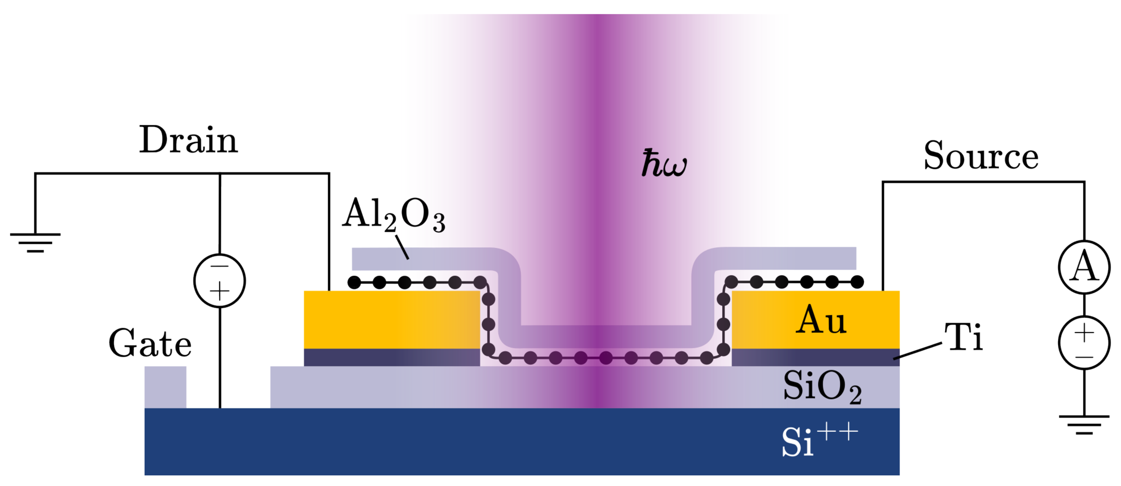

Figure 1. Side view of the encapsulated gFETs under study, and the electrical connections for measurements.

Results & Discussion

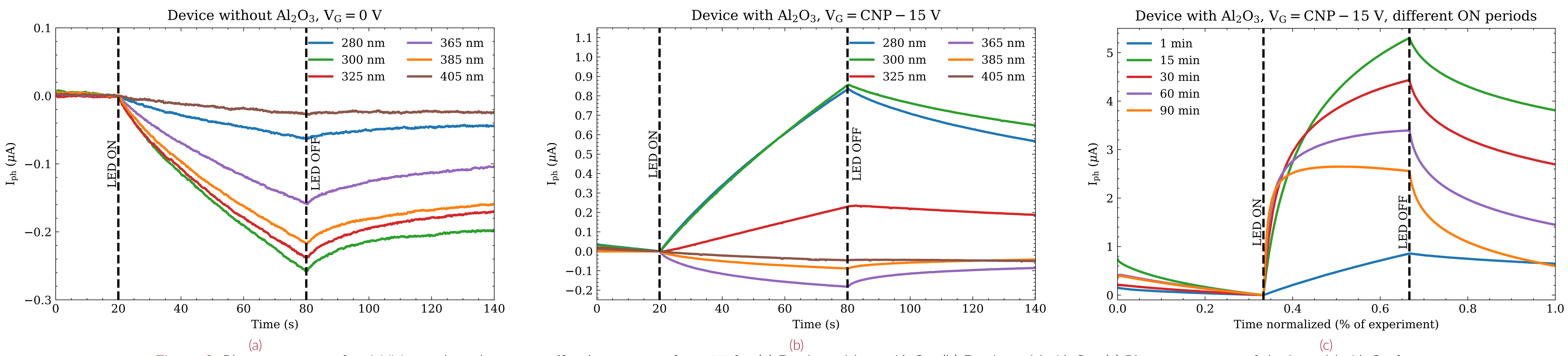

Figure 2. Photo-response for 6 UV wavelengths, same effective power of 0.1μW for (a) Device without Al_2O_3, (b) Device with Al_2O_3. (c) Photo-response of device with Al_2O_3 for different ON periods of 300 nm light at $0.1\ \mu$W effective power, experiments were done from shortest to longest with 30 minutes of relaxation in between.

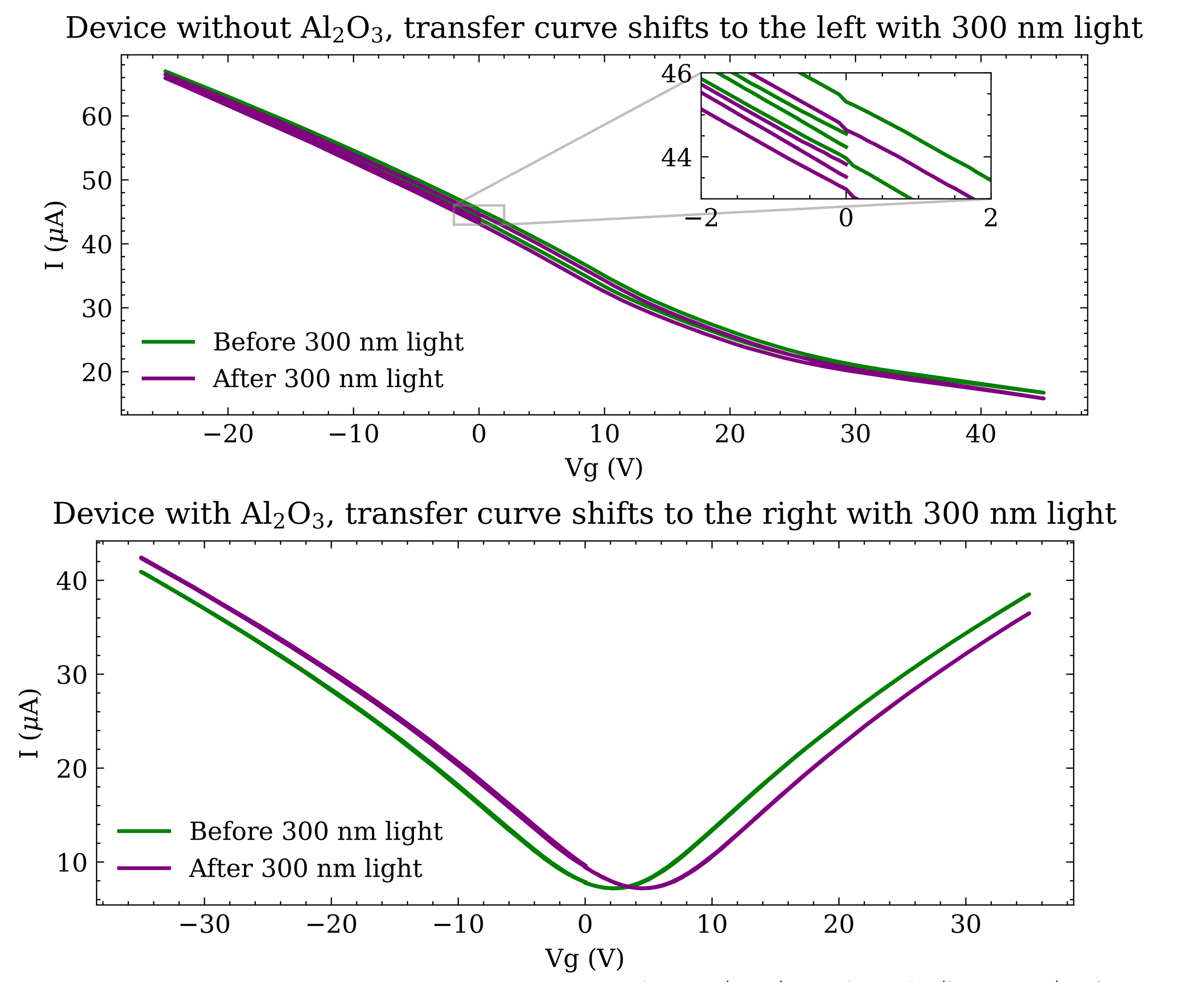

Figure 3. Transfer curves of Devices without (top) and with (bottom) Al_2O_3. Before and after 4 minutes of illumination with 300 nm light at $0.1\ \mu$W effective power.

I_{ph} of device **without Al_2O_3**:

- $I_{ph} < 0\ \mu A$ for every wavelength.
- $|I_{ph}|$ tends to increase as the incident wavelength decreases, reaching a peak response for 300 nm and falls drastically for 280 nm.
- $I_{ph} < 0\ \mu A$ relates to the shift to the left of the transfer curve, suggesting a photogating mechanism.
- Negative photogating is consistent with [3].
- I_{ph} experiments where done for $V_G = 0$ V because the CNP is beyond 45 V. However, the device photo-response remains stable for different gate voltages.

I_{ph} of device **with Al_2O_3**:

- Still $I_{ph} < 0\ \mu A$ for wavelengths from 405 to 365 nm.
- $I_{ph} > 0\ \mu A$ for wavelengths from 325 to 280 nm for which I_{ph} increases rapidly in time.
- The positive photogating effect for shorter wavelengths has a longer timescale of 30 minutes.
- I_{ph} decreases as the channel saturates when illuminated sequentially.
- $I_{ph} > 0\ \mu A$ suggests a photogating effect mechanism as the transfer curve shifts to the right and its shape remains stable.
- The device reaches a $\mathcal{R} \approx 50\ \mathrm{AW}^{-1}$ for 300 nm light with an effective power of $\mathrm{P} = 0.1\ \mu\mathrm{W}$, considering the responsivity as $\mathcal{R} = \frac{I_{ph}}{P}$.

Conclusions

- Photo-current experiments suggest that a **photogating mechanism** occurs in the **Al_2O_3 encapsulation** layer for wavelengths of **325 nm and shorter**.
- **The positive** I_{ph} relates to a **shift to the right** of the transfer curves when illuminated. The **effect does not revert** completely with time, giving us a way of **tuning the position of the device's CNP**.
- **Current & Future work**:
  - Experiment and characterize power dependence in UV.
  - Identify mechanisms where the Al_2O_3 layer is involved.
  - Experiment with annealing techniques to revert the persistent gating.

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