Graphene nanoribbons (GNRs) can exhibit a uniform electronic band gap and emergent electronic properties that are promising for nano-electronic devices, such as field effect transistors (FETs), when synthesized with atomic precision. Bottom-up, on-surface synthesis approaches can provide the necessary precision to access these desirable properties, but the potential of these bottom-up synthesized GNRs for electronic devices has remained unexplored. Herein, we study the electrical properties of the FETs based on bottom-up synthesized nine-atom wide armchair GNRs (9-AGNRs) with varying channel lengths, a local back gate geometry of ~5 nm HfO2 gate dielectric, and Palladium contacts. The GNR FETs exhibit high on-state current and excellent switching performance. The current-voltage characteristics indicate a strong correlation between the channel lengths and key performance metrics, such as subthreshold swing (SS), on current ($I_{on}$), and on/off current ratio ($I_{on}/I_{off}$). The present work provides important insights into the design of high-performance graphene-based electronic devices.

**Abstract**

**Introduction**

- **Motivation:** Bottom-up synthesized ultranarrow (0.95 nm) 9-AGNRs with a theoretical band gap of 2.10 eV, a theoretical $I_{on}$ of 30 μA, and a theoretical $I_{on}/I_{off}$ of $\sim 10^5$ is a promising transistor channel material for future transistor technologies.[1,2]
- **Problem:** The experimental results obtained for 9-AGNR FETs are much lower than the theoretically predicted values.[3,4]
- **Goal:** This study aims to understand the impact of the device geometries, especially channel lengths, on the GNR FET device performance.
- **Broader impact:** This understanding would help pinpoint the improvements needed to realize GNR FET metrics close to the projected values for high performance logic applications.

**Methods**

**Bottom-up synthesis**

**GNR Transfer and device fabrication**

**Results**

- **Subthreshold swing and off-state current performance**
- **On-state current and switching performance**
- **Conclusion**

**References**

**Acknowledgements**

**Contact Information**

Darren Munoz
Email: darren.munoz@my.hancockcollege.edu

**Support Information**

This work was funded by National Science Foundation Award ECCS-0659541 & ECCS-1461157

2021 Transfer-to-Excellence Research Experiences for Undergraduates Program (TTE REU Program)