# NORTH SOUTH UNIVERSITY

**Department of Electrical and Computer Engineering**


**EEE 499 – Senior Design Project**

## Enhanced Third Harmonic Generation (THG) with Graphite Metasurface

**Members:**

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**Faculty Advisor:**

**Dr. Mahdy Rahman Chowdhury**

**Associate Professor**

**ECE Department**

**Spring, 2023**

# DECLARATION

This document serves to verify that the Project in question is entirely the product of our own creative endeavors. Absolutely no portion of this work has been turned in somewhere else, in whole or in part, in order to receive any other kind of degree or diploma. Any previously published work that was utilized in the creation of this project has been appropriately credited.

**Students' Name & Signature**

**Ybtida Cinderella**

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**Nasim Md Arafat Saikat**

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## APPROVAL

The capstone project by Ybtida Cinderella (1921957043) and Nasim Md Arafat Saikat (1911471643), titled "Enhanced Third Harmonic Generation (THG) with Graphite Meta surface," was approved in partial fulfillment of the requirement for the Degree of Bachelor of Science in Electrical and Electronic Engineering (EEE) on May and has been accepted as satisfactory. This project was approved in partial fulfillment of the requirement for the Degree in May.

**Department Chair's Signature**

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**Dr. Rajesh Palit**
**Professor &**
**Chair**

Department of Electrical and
Computer Engineering
(ECE)
North South University
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**Supervisor's Signature**

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**Dr. Mahdy Rahman Chowdhury**
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# ACKNOWLEDGEMENTS

We would like to begin by expressing our gratitude to Allah for allowing us to successfully finish this project. As part of the Bachelor of Science (BSc.) curriculum, the capstone project program is highly beneficial in bridging the gap between the theoretical knowledge and real-life experience that students have gained. This report was conceived with the intention of providing readers with an opportunity to gain practical experience alongside theoretical comprehension. In that case, we would like to express our profound gratitude to our supervisor, Dr. Mahdy Rahman Chowdhury, for the significant amount of interest and passion he has shown towards the project. In addition, we would like to express our utmost gratitude to the ECE department at North South University for making available to us a class such as EEE499/CSE499, in which we were able to effectively work on this project and bring it to life in the manner in which we had envisioned it.

## ABSTRACT

This project introduces an innovative concept for improving third harmonic generation (THG) at far-infrared and terahertz (THz) frequencies by employing ultrathin nonlinear meta surface designs of patterned graphite micro-ribbons. By utilizing the localized plasmonic effects, these configurations make it possible to produce an incident wave that is tightly confined and significantly amplified along the surface of the graphite. Because of the presence of a metallic substrate beneath the graphite micro-ribbons, the resonant response bandwidth is reduced, which leads to the absence of any transmission and the development of standing waves within the intermediate dielectric spacer layer. This strategy results in a significant increase in the efficiency with which THGs are converted, one that could be increased by several orders of magnitude. Additionally, the meta surface's resonant frequency can be dynamically modified by changing the Fermi energy of the graphite through either electrical or chemical doping. This can be done to get the desired effect. The stimulation of highly localized plasmons within graphite micro-ribbons are the primary topic of this paper. This stimulation ultimately results in the confinement and intensification of the incident wave along the graphite surface. In addition, the presence of a metallic substrate beneath the graphite micro ribbons results in the induction of zero transmission and the generation of standing waves within the intermediate dielectric spacer layer, which together have the effect of narrowing the bandwidth of the resonant response. In the end, these improvements in the incident field contribute greatly to the gain in the efficiency with which THGs are converted.