Femtosecond laser treatment of graphene for enhanced NO_2 gas sensing

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Air quality has to be carefully monitored due to the presence of NO_2 and other toxic gases that strongly impact human health and the environment. The advancement of gas sensing technologies integrated with IoT and wearable devices presents a promising solution for real-time gas detection, helping to maintain safe gas levels. Graphene has a high potential for being a chemiresistive gas-sensing material due to its outstanding electrical properties. However, it has to be functionalized to gain the desired sensitivity to the gas.[1] It has been demonstrated that graphene can be controllably modified by femtosecond laser irradiation.[2] In this work, graphene sensors were treated with a fs-laser using different laser parameters, and the resulting gas responses were compared to the pristine graphene sensors. Clear correspondence between gas response amplitude and the density of photoinduced surface groups (as estimated from the I_D/I_G ratio in the Raman spectrum) was observed. The stability of responses was also tested, and they remained stable for over a year. We also showed that the treatment of graphene with a high-frequency (40 MHz) fs-laser is achievable without thermal effects. 2-photon oxidation as a functionalization process was confirmed, as the I_D/I_G ratio was found to be proportional to the light intensity squared. The spatial oxidation pattern due to the laser irradiation was modeled, and the result was compared with the Raman spectra and SEM images.

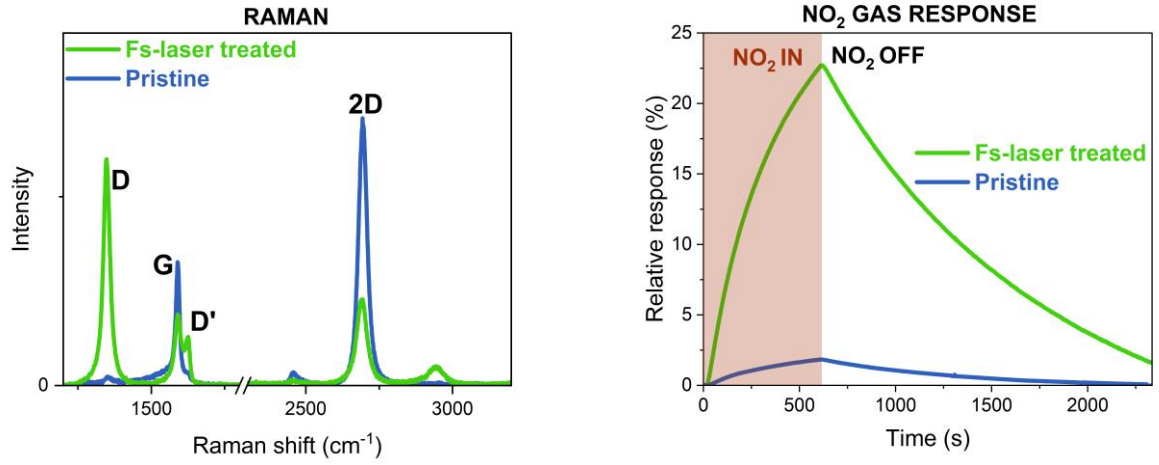

Figure 1: The left graph compares the Raman spectra of pristine and fs-laser-treated graphene with characteristic graphene bands labeled. The right graph compares the relative response of these sensors to NO_2 gas.

Acknowledgements
This work was supported by the Estonian Research Council grant PRG1580.

References

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