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Nitrogen Doped Graphene With Diamond-like Bonds Achieves Unprecedented Energy Density

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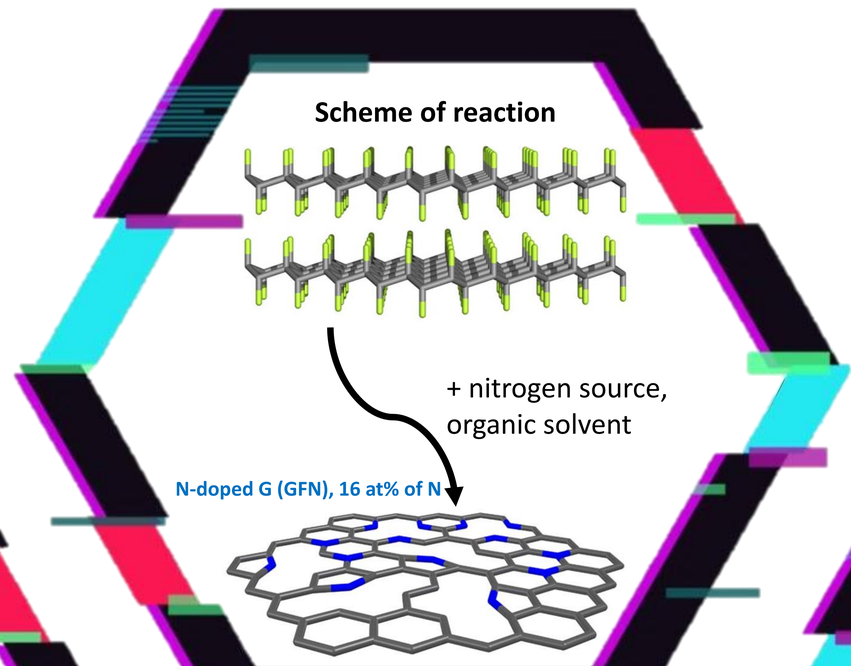

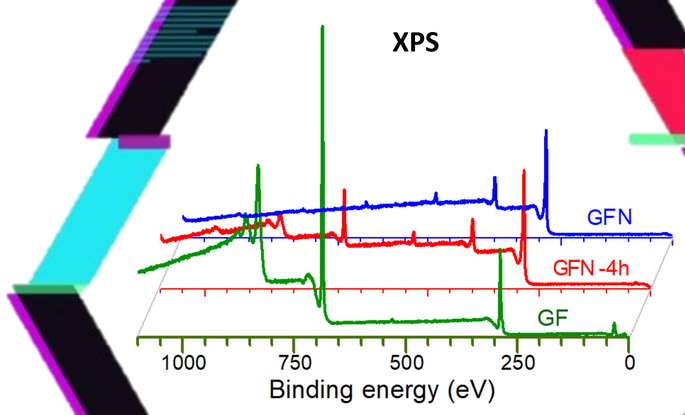

Figure 1. XPS survey spectra of starting material (GF), byproduct (GFN-4h) and final GFN material. The final material had 16 at% of N.

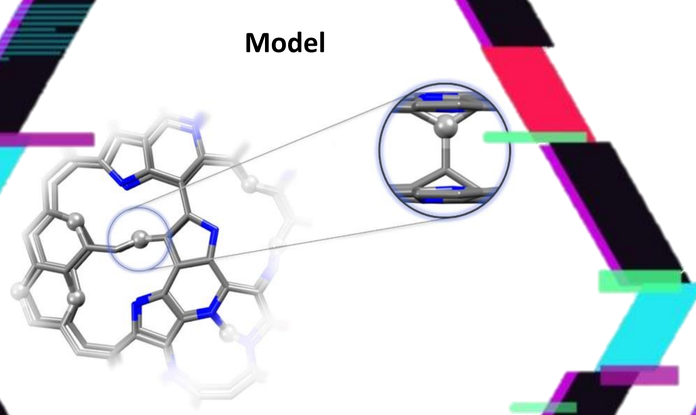

Figure 2. Theoretical model of GFN structural fragment (C:N atomic ratio of ca. 84:16) optimized by DFT calculations.). The formed nterlayer bonds are highlighted as spheres. The model simulates the structure only locally (few-atom level).

We report:

- The reaction of fluorographene with N-source produces a new graphene material with ultra-high density
- GFN combines graphene-type sp^2 layers and tetrahedral C-C bonds and nitrogen superdoping (16%)
- The C-C bonds develop only between carbon-centered radicals only in the vicity of the nitrogent dopants
- Application in energy storage, supercapacitor delivering unprecedented energy densities of 200 Wh L^{-1} at a power of 2.6 kW L^{-1} and 143 Wh L^{-1} at 52 kW L^{-1}.

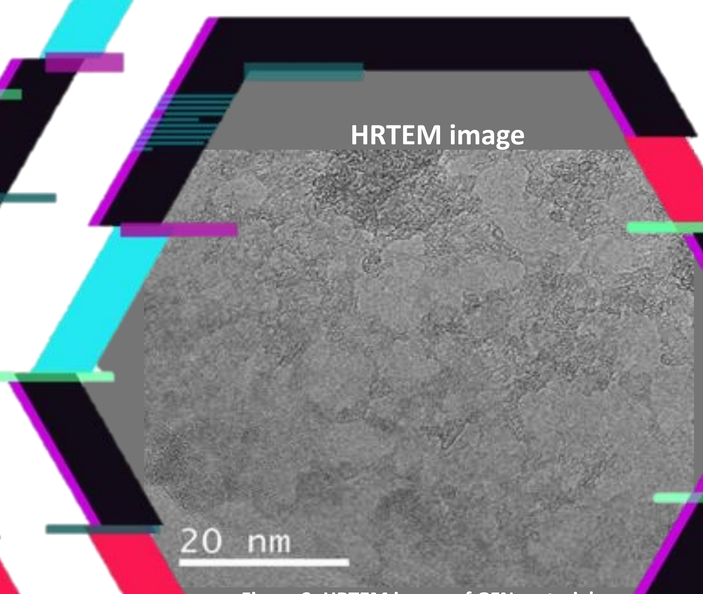

Figure 3. HRTEM image of GFN material, showing its hollow structure at high magnification.

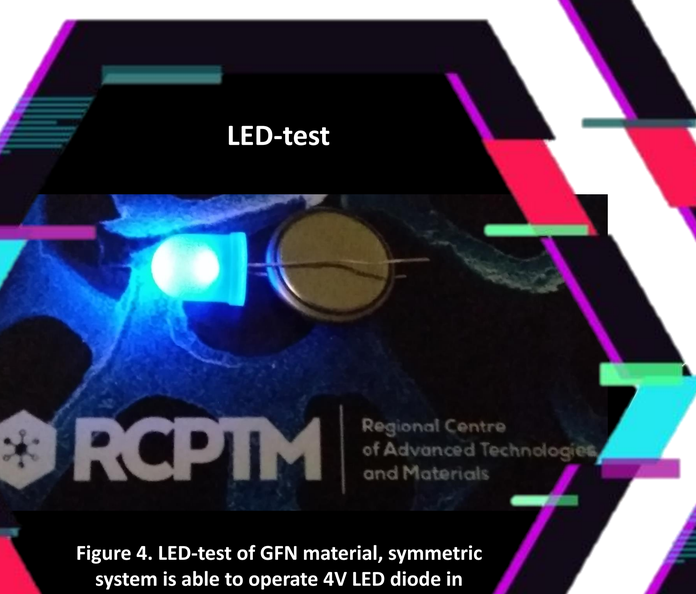

Figure 4. LED-test of GFN material, symmetric system is able to operate 4V LED diode in commercial coin-cell setup.

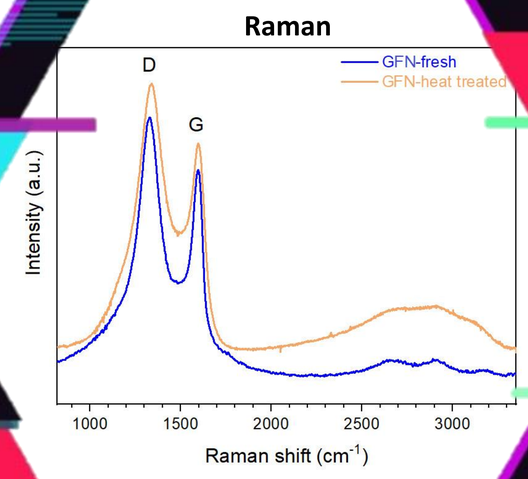

Figure 5. Raman spectra of GFN material before and after heat treatment (at 1000 °C in an argon atmosphere).

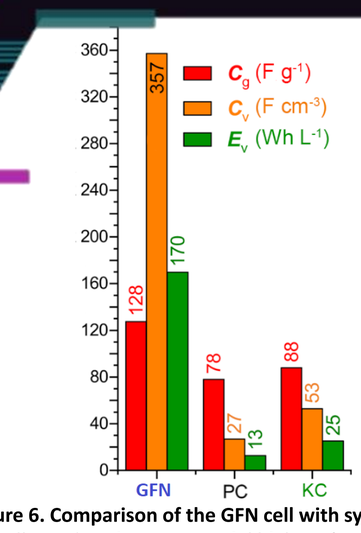

Figure 6. Comparison of the GFN cell with symmetric cells made using commercial high surface area porous carbons (PC and KC) at 2 A g^{-1}.

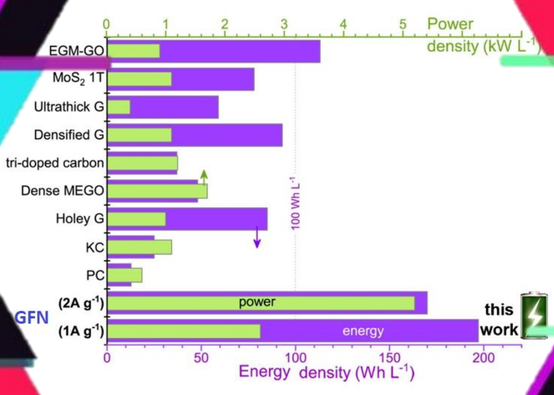

Figure 7. Comparison of the GFN cell performance with analogues from literature, recalculated to use the same metrics.

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REFERENCES and ACKNOWLEDGEMENTS

Šedajová, V., Bakandritsos, A. et al. Nitrogen doped graphene with diamond-like bonds achieves unprecedented energy density at high power in a symmetric sustainable supercapacitor, revisions in Energy & Environmental Science.

Zaoralová, D., Hrubý, V. et al. Tunable Synthesis of Nitrogen Doped Graphene from Fluorographene under Mild Conditions. ACS Sustainable Chem. Eng. 2020, 8, 12, 4764–4772.

A European patent with the application number EP 20173178.3 has been filed.

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