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REVERSIBLE HYDROSTATIC STRAIN IN GRAPHENE/METALLIC NANOPARTICLES HYBRID MATERIAL INDUCED BY LASER IRRADIATION

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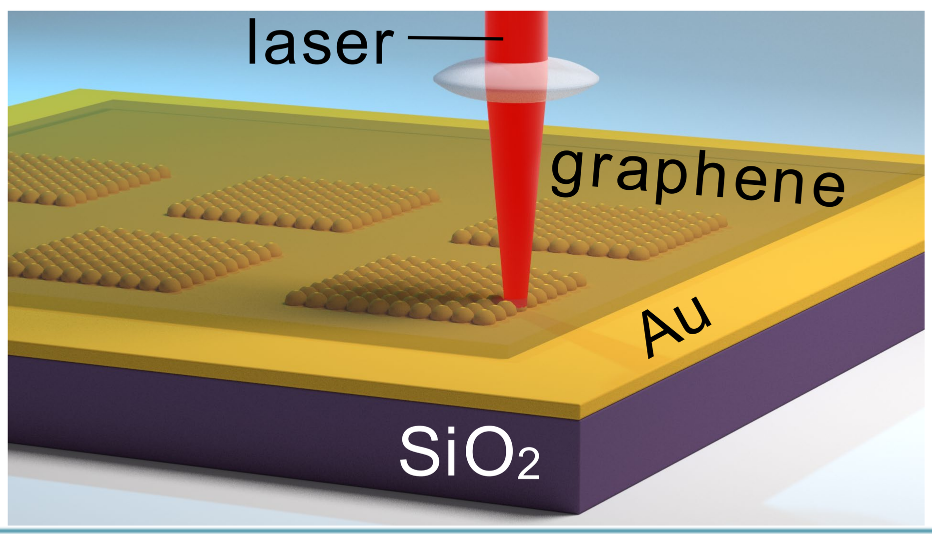
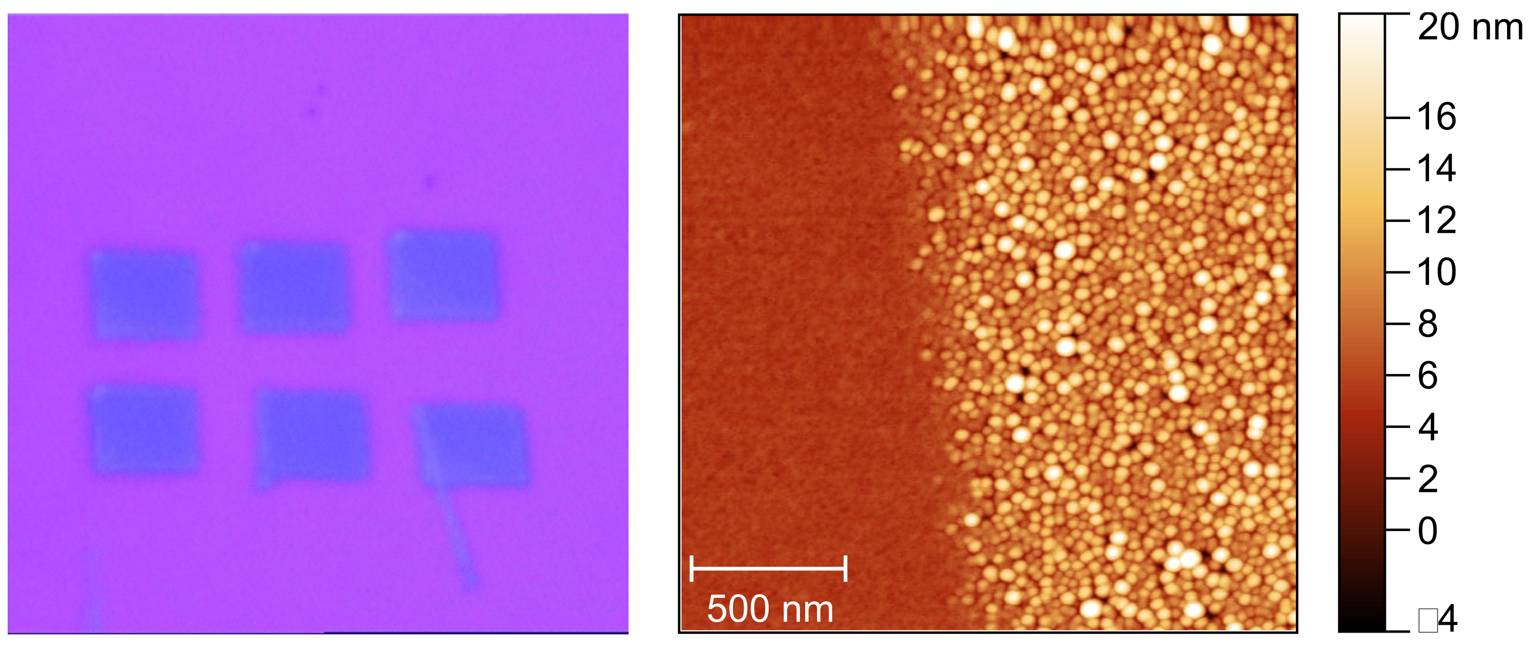


Sensors utilizing the SERS effect

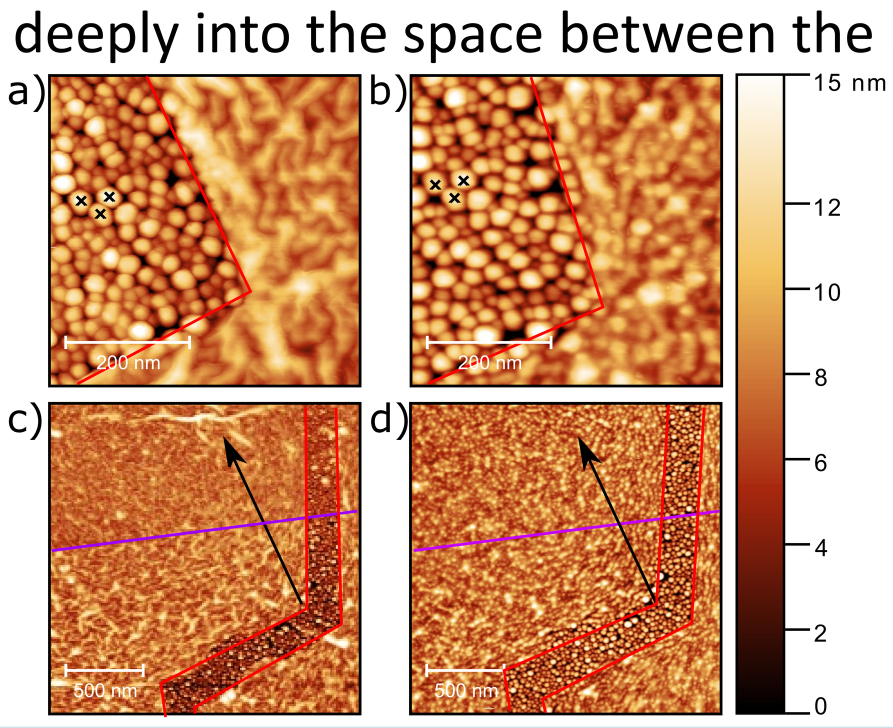
Devices based on graphene covered gold nanoparticles are prominent candidates for sensors, with single-molecule detection capabilities. The applied laser intensity should be carefully set with respect to preserving device integrity and a good signal-to-noise ratio. While we found that successive higher intensity (6 mW) laser irradiation increased gradually the doping and the defect concentration in SiO_2 supported graphene, the same irradiation procedure did not induce such irreversible effects in the graphene supported by gold NPs.

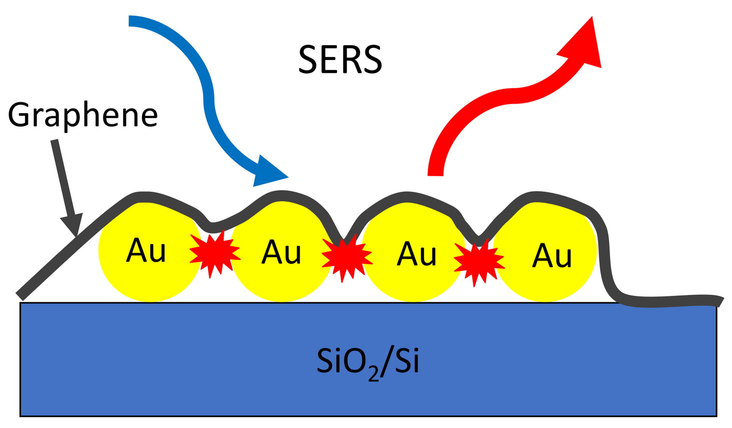
AFM measurements

Gold nanoparticles were prepared by local annealing of gold thin films using focused laser beam.



CVD graphene was transferred onto the closely spaced gold NPs. After annealing with high laser power the graphene wrinkles were ironed out and the suspended regions penetrate more deeply into the space between the NPs.



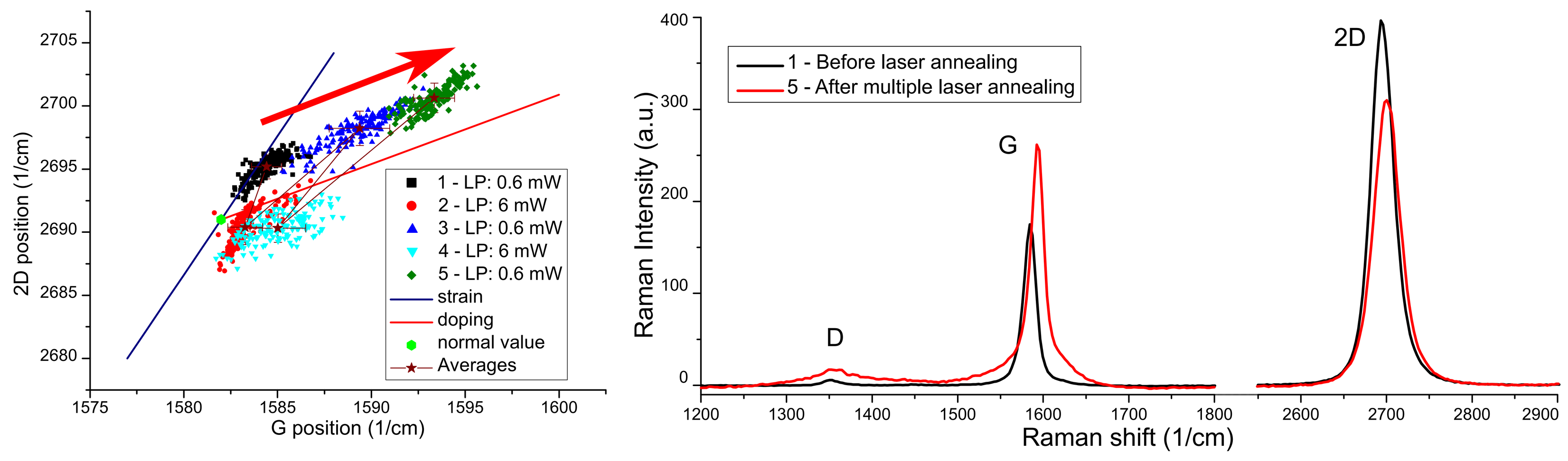


The effect of laser irradiation

Multiple Raman-spectroscopy measurements were performed with low (0.6 mW) and high (6 mW) laser power.

Graphene on SiO_2:

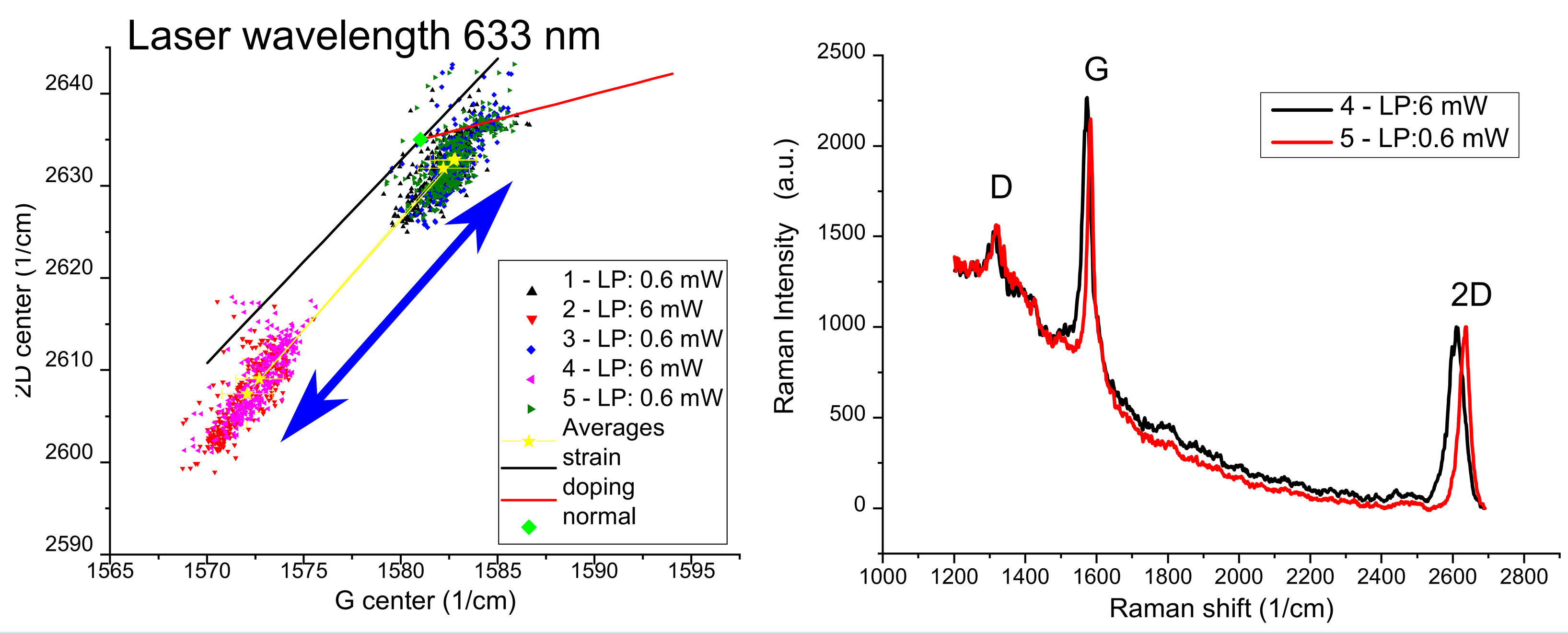
A significant increase in the p-type doping was found after the high laser power irradiation. The shift of the averages follow the pure p-doping slope of 0.55 very well. The doping increased from −18 ± 13 meV ; to −238 ± 19 meV while the compressive hydrostatic strain remained unaltered.



Graphene on Au NPs:

No change in doping or defect concentration was observed on Au NP supported graphene, even after several irradiation cycles. Moreover, the laser irradiation induced dynamic hydrostatic strain in the graphene on Au NPs, which turned out to be completely reversible.

+0.4% tensile strain emerged in graphene during the high laser power irradiation. The induced tension was completely relaxed after the laser spot moved away and the previously irradiated spots cooled down back to room temperature.



Conclusions

We demonstrated that completely reversible dynamic strain could be induced in the Au NP supported graphene by high power (6 mW) laser irradiation.

We also showed that – while similar laser irradiation induced increased doping and damage in SiO_2/Si supported graphene – no change in doping or defect concentration was observed on Au NP supported graphene, even after several irradiation cycles.

Outlook

Since the high temperature associated with high power laser irradiation increases the strain in graphene, which in turn enhances its sensing properties, these results can have implications in the development of graphene/plasmonic nanoparticle based high temperature sensors operating in dynamic regimes.

Acknowledgements

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