MASS SENSING WITH GRAPHENE AND CARBON NANOTUBE RESONATORS

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In recent years nanoelectromechanical resonators made out of carbon nanotube and graphene have attracted much attention thanks to their great potential for high resolution mass sensing of atoms and molecules as well as for the study of surface science such as diffusion effects [1, 2] and phase transitions [3, 4]. Carbon systems have a low mass density and a very high Young's modulus, which makes them very sensitive mass and force sensors vibrating at high frequencies. The record of mass resolution of 1.7 yg was recently demonstrated by our group with a carbon nanotube mechanical resonator [5]. A nanoelectromechanical resonator allows us to extract the mass of molecules by measuring the shift in the resonance frequency when molecules get adsorbed onto the resonator.

In this work we aim to achieve single molecule mass resolution with carbon based nanomechanical resonators. Our goal is to detect single fullerene molecule adsorption and to study the diffusion of fullerenes on the surface of graphene flakes. We have studied ultra-clean carbon nanotube resonators as well as double clamped graphene resonators. The carbon nanotubes were grown by chemical vapor deposition over prefabricated trenches of 1 μm width. The graphene nanomechanical resonators were fabricated by transferring a graphene flake onto the same type of trenches with a wet transfer technique [6]. The mechanical motion is actuated and detected by the frequency-modulation mixing technique [7]. We measure the mass resolution of a graphene resonator at 4 K and in ultra-high vacuum conditions (10^{-11} mbar) with a computer controlled feedback loop. The estimated mass resolution is about 4.4 zg. With this resolution we are close to the mass of one fullerene molecule (m=1.2 zg). We measured the adsorption of many fullerene molecules onto carbon nanotube and graphene resonators. In order to detect a single fullerene molecule adsorption with graphene resonators, we aim a higher mass resolution. We will tackle this goal by fabricating graphene resonators of smaller dimensions. Another goal is to contribute to the understanding of the sources of frequency fluctuations of mechanical resonators that are limiting sensing applications with nanomechanical resonators.

References

[1] Y. T. Yang, et al., *Nano Letters, 11*(4) (2011) 1753–9

[2] C. Edblom et al., *Physical Review B. 90* (2014) 155425

[3] Z. Wang et al. *Science,* 327(5965) (2010) 552–5

[4] A. Tavernarakis et al., *Physical Review Letters, 112*(19) (2014) 196103

[5] J. Chaste et al., *Nature Nanotechnology, 7*(5) (2012) 301–4

[6] C. R. Dean et al., *Nature Nanotechnology, 5*(10) (2010) 722-6

[7] V. Gouttenoire et al., *Small, 6*(9) (2010) 1060–5