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CARBON NANOTUBE MECHANICAL MASS SENSOR WITH SINGLE MOLECULE RESOLUTION AT ROOM TEMPERATURE

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Carbon nanotubes (CNTs) are outstanding materials with very particular mechanical, thermal and electrical properties due to their sp^2-hybridization resulting in nearly perfect atomic structures. Two other properties of CNTs are their lightness since their mass are in the range of the attogram (1 ag = 10-18 g) and their defect-free surfaces. CNTs are synthesized using bottom-up methods which were demonstrated to give materials with less defects than their top-down analogues NEMS which are usually etched from silicon or nitride substrates[1]. Interesting sensitivity of 1.4 yg[2] was demonstrated in a cryogenic environment (1 yg = 10-24 g). However, at room temperature, this sensitivity was reported to be much worse 25 zg[3] (1 zg = 10-21 g). This has impeded the use of SWCNTs as sensors in real-life applications.

In this work, we expose that carbon nanotubes used as mechanical resonators exhibit mass sensitivity down to 70 yg, the mass of a single molecule as small as pentane. Noise mechanisms that could limit the sensitivity were attentively inspected. Residual molecules in the gas phase, electrical fluctuations, temperature drifts and Brownian motion could be the origin of those limitations. It was found that our set-up works intimately close to the Brownian noise limit and that it is not bounded to external sources of noise. Moreover, the sensitivity does not seem to get worse when increasing the pressure meaning this sensitivity might be preserved up to ambient pressure. Importantly, the high sensitivity observed here is similar for several SWCNTs, making it a reliable and reproducible set-up.

Our work drive the possibility to carry out single-molecule sensing, in a wide variety of situations like biological applications, metrology, mass spectrometry or surface sciences[1,4].

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