Nanoparticle Based Sensors and Organic Nanospintronic transistors

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Abstract

The work presented in this doctoral thesis is mainly divided into two main parts: nanoparticle swelling based sensors and organic nanospintronics.

In the swelling based sensors work, three novel experimental methods for enhancing the sensitivity of gold core shell nanoparticle (Au-CSNP) films are presented. The first method utilises a long ligand of alkane-thiols, e.g. dodecanethiols and a significant response was obtained for alkanes with long carbon chain such as decane ($C_{10}H_{22}$) which is found in petrol. The sensitivity of swelling- based gold core- shell nanoparticle vapour sensors can be enhanced considerably by cooling sensors below ambient temperature. We found that the sensitivity to a particular analyte scales with temperature like that of the analyte's saturated vapour pressure and the sensitivity is linked to the analyte's enthalpy of vaporisation. This allows for quantitative prediction of sensitivity enhancement for vapours not yet tested. We demonstrated the detection of low level of a biogenic odour that is released by E.coli bacteria (1-decanol odour) at a partial pressure in the order 100 ppb using Au-CSNPs decorated with a long –OH terminated ligand. This is an exceptionally low limit of detection for swelling- based sensors, and relies firstly, in the careful matching of the CSNPs ligands to the targeted odour, and secondly, in the very low volatility of this odour.

In the spintronic part, the organic spin field effect transistor was demonstrated for the first time and about –1400% giant magnetoresistance at was estimated at room temperature using such transistor. This probable GMR effect is exceptionally high and could have a strong impact on the field of organic spintronics. Also, we developed a platform (in-plane spin valve structure based on $Ni_{80}Fe_{20}$ nanostructures) for studying spin transport in organic semiconductors. Using such platform, about –0.4% magnetoresistance was obtained with the electron transporter organic semiconductor PTCDI-C_{13}. Unlike vertical spin valve structures, our in-plane structure does not suffer from the ill-defined organic/ferromagnetic interface as the organic semiconductor will always be deposited on the top of the ferromagnetic contacts. This allows for the depositing of different organic layers on the same device multiple times as long as the organic materials can be washed out by a suitable solvent.

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List of Publications and Conferences

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2. **AlQahtani, H.**, Alduraibi, M., Richardson, and T., Grell, M. (2012). Manifold sensitivity improvement of swelling-based sensors. Phys. Chem. Chem. Phys., 14, 5558-5560.

3. **AlQahtani, H.**, Sugden, M., Puzzovio, D., Hague, L., Mullin, N., Richardson, T., and Grell, M. (2011). Highly sensitive alkane odour sensors based on functionalised gold nanoparticles. Sensors and Actuators B-Chemical, 160, 399-404.

4. Stansfield, G. L., Vanitha, P. V., Johnston, H. M., Fan, D., **AlQahtani, H.**, Hague, L., Grell, M., and Thomas, P. J. (2010). Growth of nanocrystals and thin films at the water-oil interface. Philosophical Transactions of the Royal Society a-Mathematical Physical and Engineering Sciences, 368, 4313-4330.

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