Posters Session II – B
Nanoelectronics

Nanoscale Photonic Humidity Sensor Based on the Fluorescence Lifetime of BODIPY Dye Molecules

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Abstract: Radiative decay rate of the Boradiazaindacene (BODIPY) dye molecules in the presence of a gold thin film is analyzed using a conventional time correlated single photon counting technique. The metal thin film and the spacer thickness effects on the fluorescence lifetime of BODIPY molecules are investigated. When the thickness of the gold layer is reduced, the reflectivity of the thin film decreases; thus, the emission field penetrates the gold and this causes further quenching. As compared to free BODIPY dye molecules, time-resolved experiments show that the fluorescence lifetime of BODIPY which is brought into the proximity of the metal surface exhibit an oscillatory behavior as a function of the thickness spacer between fluorescent dye and the metal surface. This interference effect is employed to build a humidity sensor based on time resolved fluorescence lifetime measurements using a relative humidity sensitive polyethylene glycol (PEG) polymer coating as a spacer material. The swelling characteristic of PEG coating provides nanometer accuracy to control the emitter-metal surface distance. Humidity induced change in the thickness of the PEG coating is investigated for a range from 13 to 87% using a single wavelength ellipsometry. It is envisaged that humidity induced changes in the fluorescence lifetime of the dye molecules represent a clear example of the Drexhage interference model. The experimental results presented in this work suggest a practical motivation to investigate fluorescence lifetime enhanced sensor (FLES) with a simple production mechanism and a simple principle of operation for relative humidity control.

Keywords: BODIPY, gold, PEG, fluorescence lifetime, humidity, sensor.

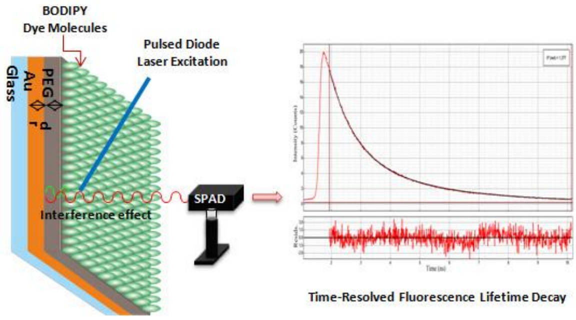

Figure 1: Figure illustrates humidity sensing mechanism based on the fluorescence lifetime of BODIPY dye molecules. The thickness of polymer layer changes the radiative decay rate of the dye molecules due to interference effect between emitted and reflected light waves.

Silicon Carbide Tunable MEMS Resonator with Wide Operation Range

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Abstract: Electrically tunable filters with a wide operational range are crucial elements in both multi-band communication systems and wideband tracking receivers because they have the ability to replace filter banks (Mansour *et al.*; 2014). Micro-electro-mechanical system (MEMS) resonators have emerged as a potential candidate technology for implementation of high-Q tunable filters that are able to solve power consumption and miniaturization issues (Van Beek *et al.,* 2012). One of the most promising materials for high efficiency MEMS resonators is silicon carbide because of its excellent electrical, mechanical and chemical properties (Sarro; 2000).
Integration of MEMS resonators with electronic circuits requires the ability for electrical actuation and and sensing of the mechanical vibration. Electrothermal actuation technique has been attracting increasing attention as a means of allowing simple fabrication process, low actuation voltages, impedance matching and effective frequency tuning. Recently, we have demonstrated a silicon carbide MEMS resonant device with electrothermal actuation and piezoelectric sensing (Sviličić *et al.*; 2012). For the electrical sensing, piezoelectric transduction has been used because it enables stronger electromechanical coupling and relatively simpler fabrication process compared to the alternative electrostatic transduction.
In this paper, we present a two-port 3C-SiC MEMS resonator actuated with u-shaped designed electrothermal actuator (input port) in order to provide tunable filter function with wide operation range (Figure 1). The electrothermal actuator is formed of thin platinum (Pt) layer, while piezoelectric sensor (output port) is formed of lead-zirconium-titanate layer sandwiched between two Pt layers. Two-port transmission frequency response measurements performed in atmospheric conditions have shown that the resonator's operating frequency can be adjusted up to 33% of the un-tuned resonant frequency by applying DC bias voltage in the range 1 V – 7 V (Figure 2). Details of the design, fabrication processes and measurement setup will be presented. The electrothermal actuation technique will be studied with an emphasis on the influence of DC tuning voltage on the resonant frequency, Q factor and motional resistance.

Keywords: MEMS resonator, tunable filter, electrothermal actuation, piezoelectric sensing.

B. Sviličić acknowledges financial support of Croatian Science Foundation and University of Rijeka.

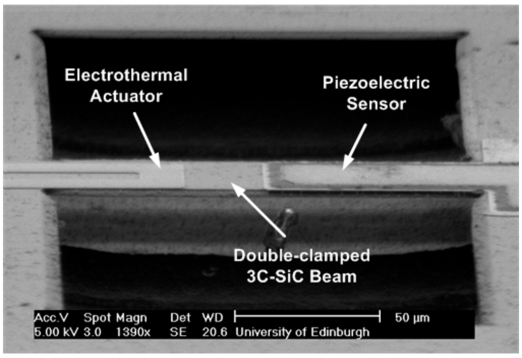

Figure 1: SEM of the fabricated resonator with the u-shape layout of the electrothermal actuator (input port) and piezoelectric sensor (output port) placed on the top of 3C-SiC double-clamped beam.

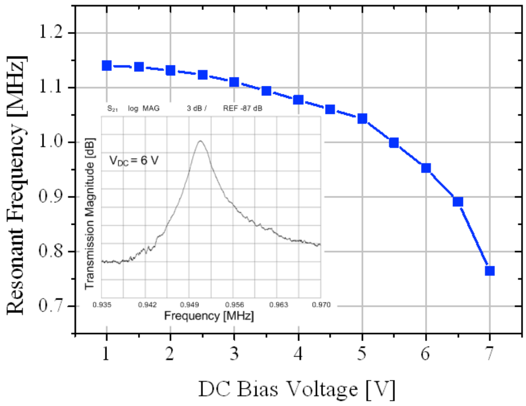

Figure 2: Measured resonant frequency versus DC tuning voltage. The inset shows two-port transmission frequency response magnitude plot.

References:

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Lithium cobalt oxide thin films towards resistive memories

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Abstract:

Resistive switching phenomena have recently been observed in Li_xCoO_2 thin films [1]. It is widely accepted that such a material, used today in rechargeable lithium batteries, exhibits a bulk-type electrical conductivity. It involves cobalt redox reactions coupled to lithium intercalation/de-intercalation processes. In the field of non-volatile memories, this material may represent a possible alternative to present oxides involving filamentary conduction.
Li_xCoO_2-based devices [2] may thus lead to further downscaling possibilities. On such devices (Figure 1), we report preliminary promising results regarding the influence of electrode surface on several resistive switching properties, such as the ratio between the low resistance state (R_{ON}) and the high resistance state (R_{OFF}) (see an example of observed curve in Figure 2).

Keywords: thin films, cobalt oxides, non volatile memories, resistive memories, electrical filamentary conduction, redox reactions, resistance states, switching kinetics.

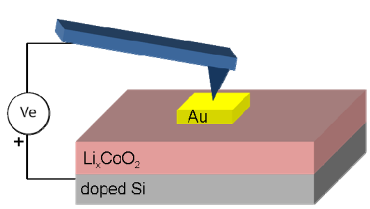

Figure1: Schematic view of an electrode /Li_xCoO_2/electrode device. A conducting AFM probe is in contact with the upper electrode. The bias is applied between the bottom electrode and the AFM tip.

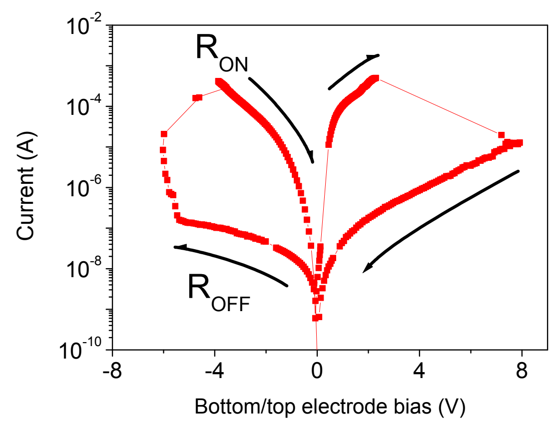

Figure 2: Typical *I–V* characteristics of a device presented in Figure 1 (with a 30x30 µm² upper electrode), exhibiting a resistive-switching behavior (sweeping rate of 100 mV s^{-1} from 0 to –6V, back to +8V, and ultimately to 0V). In this example, the R_{OFF}/R_{ON} ratio reaches $3x10^3$ (measured at +1V).

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[2] V.H. Mai, A. Moradpour, P. Auban Senzier, C. Pasquier, K. Wang, M.J. Rozenberg, J. Giapintzakis, C.N. Mihailescu, C.M. Orfanidou, E. Svoukis, A. Breza, Ch. B. Lioutas, S. Franger, A. Revcolevschi, T. Maroutian, P. Lecoeur, P. Aubert, G. Agnus, R. Salot, P.A. Albouy, R. Weil, D. Alamarguy, K. March, F. Jomard, P. Chrétien, O. Schneegans, *Sci. Rep.*, Accepted

Tunable Luminescence Carbon nanoparticles From Carbohydrate Foodstuff

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Abstract: Tunable luminescence carbon nanoparticles CNPs were prepared through microwave-assisted and low temperature thermal pyrolysis of aqueous suspension of starch extracted from different carbohydrate foodstuffs (rice, potato, and cassava). The carbonization was mediated by inorganic acids (sulfuric and phosphoric acid) (Li et al., 2011). Functionality of the CNPs were elucidated from Fourier transform infrared spectroscopy FTIR, while the optical properties were investigated using UV-Vis spectroscopy, and also under visible and 365nm UV light. The as-prepared CNPs showed various luminescence of green, blue and yellow (Zhang et al., 2010) (Fig. 1) without adding any surface-passivating agents. FTIR studies revealed characteristic bands at 3460 cm^{-1} (OH), 2978cm^{-1} and1397cm^{-1}(C-H), 1707cm^{-1} (C=O), 1187 and 1039cm^{-1} (C–O–C/C-O) indicative of the graphitic nature of the carbon and the presence of hydrophilic groups on the surface of the CNPs. The band gap determined from UV-Vis spectra revealed that the C-dots are in the semiconductor range. The results indicate that the CNPs can be explored as potential luminescent materials for bio imaging applications.

Keywords: carbon nanoparticles, carbohydrate, luminescence, microwave assisted, tunable

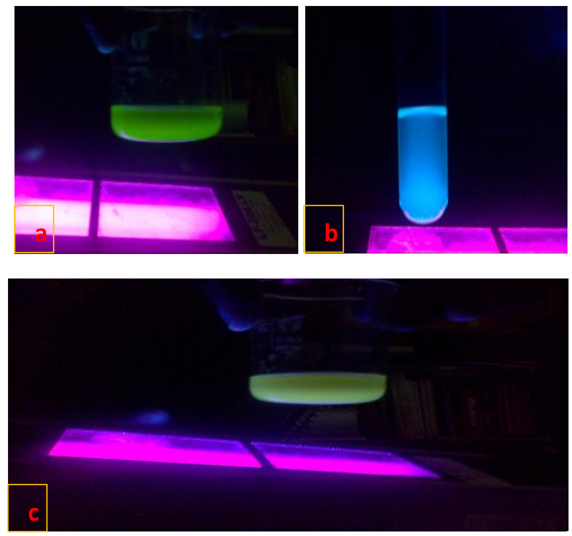

Fig. 1. Shows CNPs (a) Green, (b) Blue and (c) Yellow Carbon nanoparticles under 365nm UV light

References:

Li, H., He, X., Liu, Y., Huang, H., Lian, S., Lee, S., and Kang, Z. (2011) One-step ultrasonic synthesis of water-soluble carbon nanoparticles with excellent photoluminescent properties. *Carbon* 49, 605 – 609.

Zhang, J., Shen, W., Pan, D., Zhang, Z., Fang, Y., and Wu, M. (2010) Controlled synthesis of green and blue luminescent carbon nanoparticles with high yields by the carbonization of sucrose. *New J. of Chem.* 34, 591-593

Modal parameter identification of perforated microplates from output data only

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Abstract:

The design of micro electromechanical systems includes oscillating elements and components which are often perforated microplates supported by elastic suspension as shown in Figure 1. The main purpose of perforations is to reduce the damping and spring forces acting in the MEMS due to the fluid flow inside and around the micro structure. The study of the damping caused by surrounding fluid and by the dissipations in the material is very important to predict the dynamic response of the microsystem and to estimate some important parameters such as the quality factor, the switching time and the release time. G. De Pasquale and T. Veijola used numerical strategies for the estimation of the damping force acting on a perforate movable MEMS (De Pasquale *et al* 2008). Results from the 2D Perforated Profile Reynolds method and the simplied 2D ANSYS method are compared in the case of uniform perforation and perpendicular motion of the fluid. It was shown that ANSYS results contained a systematic error at small perforations and were not usable for large perforations. Very small damping forces are obtained by ANSYS and a correction equation for ANSYS was proposed.

In this paper, the model used to study the microplate behavior is constituted by the following parameters : the plate mass concentrated in the central plate, the damping coefficient and the stiffness coefficient which are constituted of fluidic and non fluidic components. Our purpose is to identify the modal parameters of the microplate : the eigenfrequency, the damping ratio and the stiffness from the displacement response only of the microstructure given in Figure 2. The dynamic measurements are conducted in the time domain by means of a laser vibrometer, details are given in the communication. With our approach, called subspace method (J. Lardiès *et al* 2011), it is not necessary to use the excitation force, only output measurements in the time domain are used.

The fundamental problem in modal parameter identification by the subspace method is the determination of the state space matrix (or transition matrix) which characterizes the dynamics of the system. In the communication we present a comparison of two subspace methods to estimate the transition matrix and the modal parameters of the perforated microplate. The first method uses properties of the shifted block controllability matrix and the second method uses properties of shifted columns of the block Hankel matrix. The procedures presented in the paper can identify closely eigenfrequencies that cannot be identified by the traditional Fourier transform. Numerical examples and an experimental example of a perforated microplate are presented. Figure 3 shows in red the identified displacement response of the perforated microplate, using a subspace method presented in the communication.

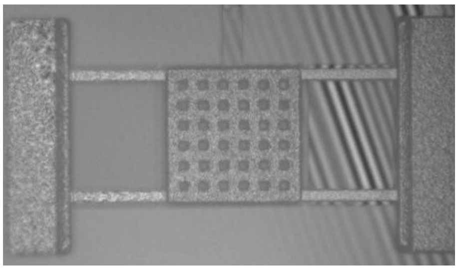

Figure 1. Optical image of the perforated microplate with four lateral elastic suspensions

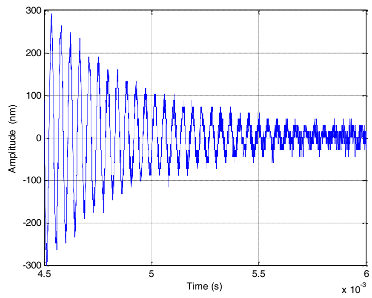

Figure 2. Displacement response of the perforated microplate

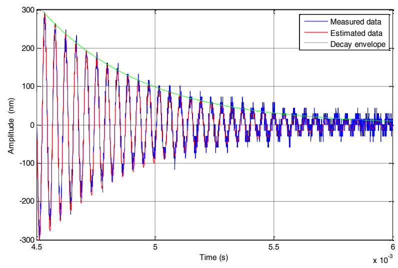

Figure 3. Comparison between the measured (in blue) and the reconstituted (in red) displacement response of the perforated microplate

Keywords: MEMS, microplate, oscillating system, dynamic response, time domain, modal parameters, subspace methods,experimental identification.

References:

De Pasquale G. and Veijola T. (2008) Comparative numerical study of FEM methods solving gas damping in perforated MEMS devices, *Microfluid Nanofluid* 5, 517-528

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The Effect of 2-step Plasma Treatment for Single-walled Carbon Nanotube on Electrochemical Sensors

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Abstract: Carbon nanotubes (CNTs) have been widely used as active electrodes for electrochemical sensors because of their unique electrical, chemical, and mechanical properties such as high electrocatalytic activity (Wang *et al.*, 2002), large surface area (Cahill *et al.*, 1996), and the ability to alleviate surface fouling (Wang *et al.*, 2002). These properties lead to high chemical stability, effective electron transfer, high sensitivity, low detection limits, and an enhanced signal-to-noise ratio. However, the sensor applications by using CNT is limited owing to chemically inactive surface of the CNTs. Several investigators demonstrated that the sensitivity of CNT-based chemical sensors can be significantly improved by introducing defect sites along the sidewall of the CNTs when exposed to oxygen-based plasma. However, plasma-treated CNTs were found to try to revert to their original surface states over time, and to lead to relatively low sensitivity and weak interfacial bonding between biomolecules and CNTs because CNT had too little functional group by 1-step plasma treatment. In this study, we introduce the advantages and experimental procedure of 2-step plasma treatment on single-walled nanotube (SWCNT) films, and show results of increased immobilization efficiency of $CD4^+$ T cells for biosensor.
The integrated three-electrode system that consisted of a modified CNT working electrode (WE), an Ag/AgCl reference electrode, and a Pt counter electrode was fabricated by RF sputter, plasma-enhanced chemical vapor deposition and reactive-ion etching. After SWCNT modifying on WE by spray-coating method, SWCNT functionalization was performed by first O_2 plasma treatment to generate carboxyl groups and clean the SWCNT film. SWCNT film was stored at room temperature to recover the damaged SWCNT, and than was functionalized by second O_2 plasma treatment. $CD4^+$ T cells was immobilized on the 2-step plasma treated SWCNT film.
We measured the analytical performance characteristics of the 1- and 2-step O_2 plasma treated SWCNT electrodes-immobilized with anti-CD4 antibody by squre wave voltammetry (SWV). These peak currents were 0.0763 μA and 0.3263 μA, respectively, demonstrating that the 2-step treated electrode had an approximately 4.28 times larger current flow than the one-step treated electrode. Since the sensor signal can be greatly affected by the quantity and stability of immobilized biomolecules on the surface of the electrode, the high level current associated with the two-step O_2 plasma-treated electrode indicates a larger amount of functional groups and immobilized anti-CD4 mAbs.

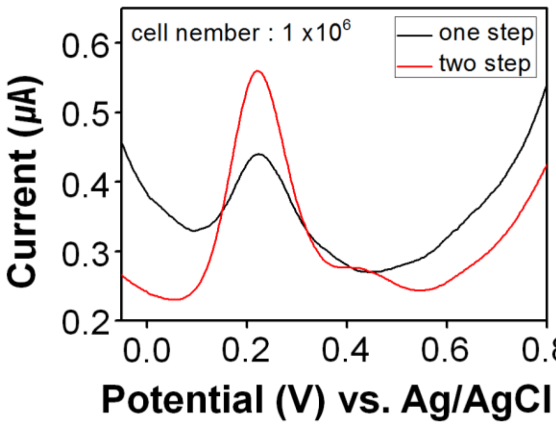

Figure 1: Comparison of sensitivity between 1- and 2-step O_2 plasma-treated SWCNT immunosensor : SWV of peak currents for 1- and 2-step O_2 plasma treated SWCNT electrodes following capture of $CD4^+$ T cells among 1×10^6 splenocytes.

Keywords: SWCNT, electrochemical sensor, CD4+ T Cells, plasma treatment.

References:

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Theoretical predictions of luminescence due to cyclosiloxanes in nanostructured Silicon Rich Oxide films employing the Global Reactions Model.

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Abstract:

Silicon Rich Oxide (SRO) thin films have been studied extensively and are very interesting due to their opto-electronic properties, particularly those related with luminescence. In general, lumi-nescent properties can provide significant information regarding the crystalline structure of a ma-terial and, in the case of SRO thin films, electro-luminescence properties are particularly im-portant since these films can be used to fabricate luminescent devices .
Recently we developed a theoretical model to describe a set of chemical reactions that can poten-tially occur during the process of obtaining silicon rich oxide (SRO) films, an outside stoichiome-try material, regardless of the technique used to grow such films. Particularly, chemical reactions that occur during the process of growing of SRO films by LPCVD technique were highlighted in the model presented. We suggest and evaluate either some types of molecules or resulting nanostructures and we predict theoretically, by applying the density functional theory, the con-tribution that they may have to the phenomenon of luminescence which is measured in SRO films. Also, we have calculated the opto-electronic properties of SRO films. The suggested mod-el provides enough information required to propose cyclosiloxanes structures. It is also possible to determine the molecular cyclosiloxanes structures which are modified due to the effect of heat treatment. We evaluated the annealed structures also. The motivation of this work is to apply a new model, which we had called the Global Reactions Model (GRM), for the theoretical study of the optical and electronics properties of Silicon Rich Oxides (SRO) structures regardless of the technique used to fabricate such structures.

Keywords:

GRM, luminescence, Silicon Rich-Oxide, Cyclosiloxanes, LPCVD, DFT..

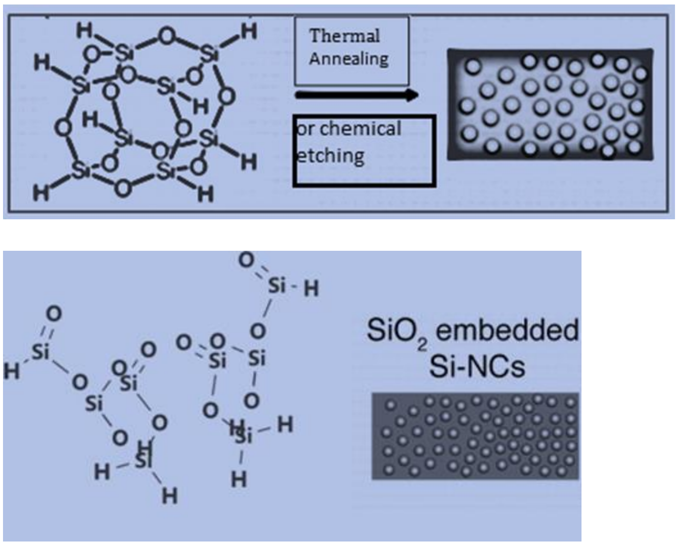

Figure 1:
Siloxane derivatives for n=4. Cage structure of hydrogen silsesquioxane (HSiO1.5)2n (top), and with two branched network structures 2(HSiO1.5)n (bottom).

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http://pubs.acs.org/doi/pdf/10.1021/cm902028q Publication Date (Web): October 22, 2009 Copy-right © 2009 American Chemical Society.

Sensing Low Magnetic Field by Using Planar Hall Effect Sensor

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Abstract: The sensors can detect low magnetic field. The detection of picoTesla of magnetic field at room temperature has been used in many places where required the low magnetic field detection. However, it is hard to miniaturize systems now-a-day such as nano and pico-satelites or IC compass in mobile devices etc.

Therefore, many magnetoresistive (MR) sensors have been developed to decrease the detective field. (for example as tunneling magnetoresistive (TMR), spin-valve, giant magnetoresistive (GMR), and anisotropy magnetoresistive (AMR)) The detective field of these sensors has been stated around 100 pT at the frequency range from hundred Hz to few hundred kHz. However the AMR has more advantages in detection at lower frequency and it can detect 100 pT at around 10 Hz.

Among MR sensors, the voltage noise of PHE-AMR sensor is lower several order of magnitude compared to others such as TMR sensor or GMR and AMR sensor, because of its off-diagonal geometry.

However, the dectection of the magnetic field by MR sensor is difficult. In order to resolve this problem, we develop a highest sensitivity MR sensor based on the thin film with low magnetic noise. (i) We use the NiFe/Cu/IrMn trilayer structure; NiFe structure (the sensing layer) is amorphous state to minimize its structural noise. (ii) The sensor geometry is designed as a high sensitivity configuration – multi-ring, in which the current and voltage electrodes of the sensor is arranged in the way that the bridge has smallest off-set voltage to minimize the thermal noise. The limitation of the detective field is interpolating from drift voltage as a function of temperature from a set of the sensors where the length of one arm is changed.

Keywords: PHR sensor, Bio-sensor, Magnetic bead, Hall effect, DC sputter, FE-TEM, Helmholtz magnetic measure system.

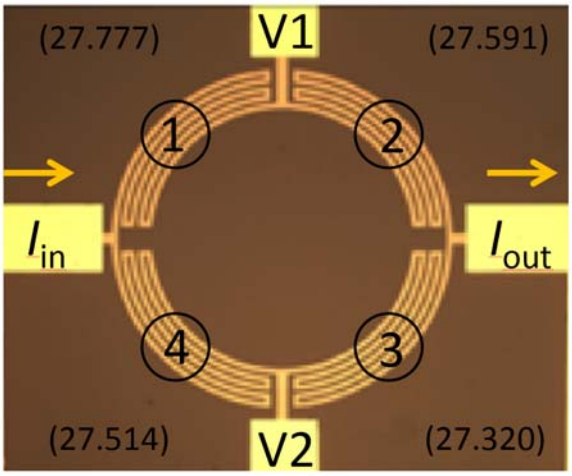

Figure 1: Ring sensor with information of thickness at the middle of the four arms, and the selection of current and voltage electrodes to minimize the voltage off-set

Active plasmonics: Growing Gold Nanoparticles on a Flexible Substrate to enable simple mechanical control of their Plasmonic Coupling

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Abstract: A simple method is presented to control and trigger the coupling between plasmonic particles using both a growing process of gold nanoparticles (GNPs) and a mechanical strain applied to the elastomeric template where these GNPs are anchored. The large scale samples are prepared by first depositing and then further growing gold nanoparticles on a flexible PDMS tape. The growing processes of nanoparticles not only increase the sizes but change also the shape of nanostructures. Upon stretching the tape the particles move further apart in the direction of the stretching and closer together in the direction perpendicular to it. The synergy between the controlled growth of GNPs and the mechanical strain, leads to a drastic shift of the plasmon band and a color change of the sample. Furthermore, the stretching by only a few percent of the amorphous and initially isotropic sample results in a strong polarization-dependent plasmon shift. At smaller gap sizes between neighboring particles, induced by stretching the PDMS tape, the plasmon shift strongly deviates from the behaviour expected considering the plasmon ruler equation. This shows that multipolar coupling effects significantly contribute to the observed shift. Overall, these results indicate that a macroscopic mechanical strain allows one to control the coupling and therefore the electromagnetic field at the nanoscale..

Keywords: Gold nanoparticles, dipolar and multipolar coupling, PDMS, gold nanoparticles seed growth.

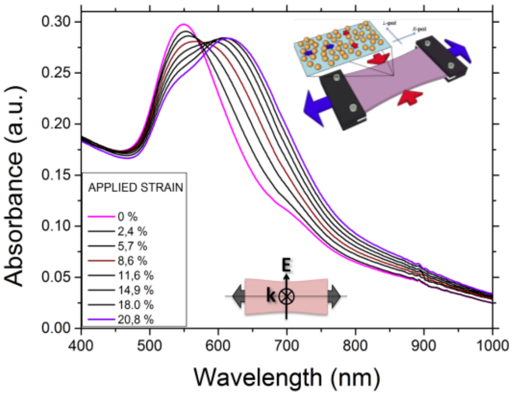

Fig. 1: In the figure is shown the development of plasmonic coupling with the increasing of mechanical strain of sample.

References:

Ugo Cataldi, Roberto Caputo, Yuriy Kurylyak, Gérard Klein, Mahshid Chekini, Cesare Umeton and Thomas Bürgi (2014) , "Growing Gold Nanoparticles on a Flexible Substrate to enable simple mechanical control of their Plasmonic Coupling", *J. Mater. Chem. C*, **2014**,2, 7927-7933

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PU-RGO composites and its properties for thermal conductive adhesive

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Abstract: With the rapid development of electronic technology, the electronic components has been being gradually changed from isolated to highly integrated and modularized, which causes high heat flux for the electronic devices, and a great amount of heat is produced during the running. The stability of the electronic devices will be depressed by 10% as their temperature rises by every 2℃. So, the heat cumulation of electronic components will directly decrease the stability or shorten the life time of the electronic products. Meanwhile, it leads to some serious consequences. Therefore spreading the heat of the electronic devices effectively is very important.

Polyurethane(PU) has been known as a polymeric material that has high mechanical strength and has been widely used as adhesive, film, and etc.. But it has poor thermal or electrical conductivity.

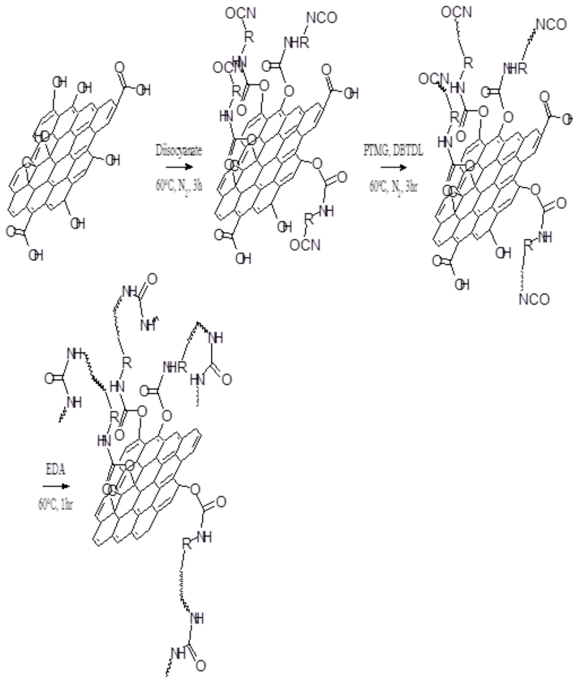
Graphene is a monolayer of sp^2 hybridized carbon atoms arranged ib a two-dimensional honeycomb structure. It has great properties, for example, resistivity (10^{-6}Ω·cm), thermal conductivity(4.84~5.30 x10^3W/mK) and mechanical properties(tensile strength : 130GPa and Young`s modulus : 1TPa).

Recently, Graphene has been further used to fabricate polymer nanocomposites with integrated performance. Cai *et al*. reported a simple method to fabricate fully exfoliated graphene oxides in an organic solvents. With this method in hand, the barrier for well-dispersion of the graphene sheets in polymeric matrix can be easily removed.

Functional groups attached to the graphene oxides(GO) could provide active sites to form chemical bonds, acting as an ideal interface between the graphene and appropriate polymers. Polyurethane(PU) is such a polymer, as it can form chemical bonds with GO by reaction between the isocyanate groups at the end of the PU chains and hydroxyl groups on the graphene oxide.

In this work, we syntheszed several types of reduced ene Oxide(RGO) composite and checked several properties. Structure, morporlogy, thermal properties, and adhesion strength. Schem 1 shows reaction mechanism. Isocyanate reacts GO and urethane reaction

Keywords: Thermal conductivity adhesive, PU composite, Graphene oxide.



schem 1: Graphene oxide react with isocyanate and polyol react with unreated isocyanate function. Ethylene diamine(EDA) play role chain extender and reduct agent.

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