SUPPLEMENTARY INFORMATION

Multi-layer graphene as a selective detector

for future lung cancer biosensing platforms

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Supporting Information Contains:

S1.   Calculation of the contact resistance.

S2.   Sheet resistance analysis.

S3.   The variation of sheet resistance as a function of concentration.

S1. Calculation of the contact resistance

In order to measure sheet resistance (ρ_g) of graphene samples as a function of concentration (C) of "cancer markers" we used standard two probe method. This method gives value of two probes resistance: $R_{2p} = 2R_c + R_g$, where R_g (equal to $\rho_g L/W$, L – length, W – with of sample) is the resistance of the graphene layers and R_c is the contact resistance. The calculation of contact resistance was provided[1] followed by the analysing the sheet resistance of graphene samples (see **SFig. 1**) using the formula: $\rho_g = (R^1_{2p} - R^2_{2p})(L^1/W^1 - L^2/W^2)$.

Calculation of contact resistance for another sample (shear exfoliated graphite on PP fibre)

Dev	R_{2p} avg (Ω)	W (mm)	L (mm)
A	297028.8	2.4	5
B	500838.9	2.4	10
C	668553.4	2.4	15
D	932502.2	2.4	20
E	1.19E+06	2.4	25
F	1.41E+06	2.4	30

$$\rho_G = (R_{2p}^{Dev1} - R_{2p}^{Dev2})(L^{Dev1}/W^{Dev1} - L^{Dev2}/W^{Dev2})^{-1}$$
$$R_c = (R_{2p}^{Dev1} - \rho_G(L^{Dev1}/W^{Dev1}))/2$$
$$R_{2p} = R_G + 2R_c$$

Dev1	Dev2	ρ_G (Ω/sq)	R_c(Ω)	Abs Rc
A	B	97828.88	46609.3	46609.3
B	C	80502.93	82705.03	82705.03
C	D	126695.5	-61646.7	61646.65
D	E	122797.3	-45404.4	45404.41
E	F	105120	46665	46665
A	C	89165.9	55633.23	55633.23
A	D	101675.8	42602.13	42602.13
A	E	106956.1	37101.73	37101.73
A	F	106588.9	37484.26	37484.26
B	D	103599.2	34587.8	34587.8
B	E	109998.6	21255.77	21255.77
B	F	108778.9	23796.69	23796.69
C	E	124746.4	-55555.8	55555.81
C	F	118204.3	-35111.6	35111.65
D	F	113958.7	-8576.65	8576.646

42315.74 average   this is the contact resistance in Ohm

Contacts at L distance:

A	B	C	D	E	F
5 mm	10 mm	15 mm	20 mm	25 mm	30 mm

SFig. 1. Calculation of the contact resistance (Excel).

S2. Sheet resistance analysis

Multiple I_{ds}-V_{gs} measurements (based on two probe method) required to be recalculated to the sheet resistance value using Ohm's law for each step and then average it. To simplify the sheet resistance analysis the Matlab code (**SFig. 2**) was created. The code's interface is user-friendly and allows convenient way of sheet resistance evaluation.

The code is using a loop which is applied for each folder with concentration data followed by an import of the data of each measure. Then sheet resistance for each value of current (±1V) was measured and averaged. After all, we have an average sheet resistance value (ΔR_s) for each concentration. Results of all measurements are stored in the list, thus we can obtain a graph by plotting the variation of sheet resistance as a function of the concentration. The code also calculates the initial sheet resistance value (the file has to be stored in the root folder) that will appear on the graph afterwards.

```matlab
function [C_Rs_vector]=fonction_calcul_resistance(adresse,W,L,Rc)

    rep = strcat(adresse, '\');

    %Data

    Concentration=[0 1/7 1/6 1/5 1/4 1/3]*10e5

    %Calculation of the initiale resistance
    ext = '*.dat';
    path = fullfile(rep,ext);
    list=dir(path);
    G = {list.name};
    InitialValue =importdata(char(strcat(rep,G(1))));
    Vi= InitialValue.data(:,1);
    Ii= InitialValue.data(:,2);
    Rinitiale=mean(Vi./Ii)-2*Rc;

    %This loop will start to calculate resistance of the 1:2
    %conccentration, to finish with the 1:6

    for k  = 1:5
        folder=strcat(rep,strcat('1-',int2str(k+1)),'\');
        ext = '*.dat';
        chemin = fullfile(folder,ext);
        liste = dir(chemin);
        N={liste.name}; %List of all the .dat file for the 1:k concentration
        DeltaResistanceK = [];

        %Calculate the variation of resistance for each measure of the same
concentration
        for i = 1:length(N)

            nameFile = strcat(folder,N(i));
            File =importdata(char(nameFile););
            V= File.data(:,1);
            I= File.data(:,2);
            R=V./I;
            Ravg=mean(R);
            DeltaResistanceK(i) = Ravg-2*Rc-Rinitiale;

        end
        DeltaResistance1(k)=mean(DeltaResistanceK); %Calculate the average of all
the previous measurement

    end


    DeltaResistance1=[DeltaResistance1 0];
    Resistance=flip(DeltaResistance1)

    Sheet_Resistance=Resistance*W/L;

    C_Rs_vector=[Concentration; Sheet_Resistance]


end
```
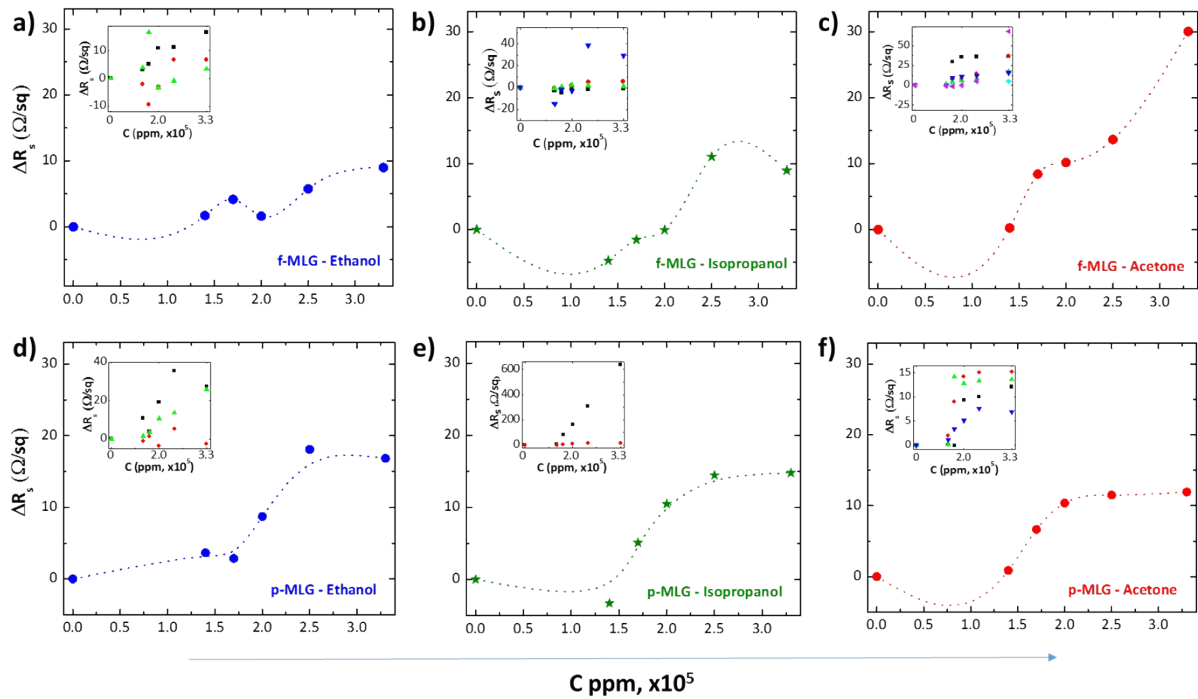
SFig. 2. Matlab code for sheet resistance estimation.

S3. The variation of sheet resistance as a function of concentration

SFig. 3. Sensitivity analysis of f-MLG and p-MLG electrodes at various concentrations of cancer marker solutions (ethanol – ●, isopropanol – ★, acetone – ◆). Changes in the value of sheet resistance (ΔR_s, small graph insertions) averaged for f-MLG (**a–c**) and p-MLG (**d–f**) as a function of CMs concentration.

1. S. Russo, S. et al. *Physica E* 2010, **42**, 677–679.