

pH-Sensors based on amino-terminated carbon nanomembrane (CNM)/graphene heterostructures

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Here we employ 1 nm thick molecular amino-terminated carbon nanomembranes (NH₂-CNMs) [1] for the stable non-covalent functionalization of graphene [2] and use the engineered heterostructure in an electrolyte-gated field effect transistor (FET) for pH-sensing [3] (Fig. 1). By analyzing the transfer characteristic of the devices and supportive DFT calculations, we show that doping induced by NH₂-CNM in graphene is caused by pH-dependent protonation of the amino-groups. We describe the electrochemical transduction by simulating the charge-potential relationship at the graphene/CNM/liquid interface employing an earlier developed model [4]. The FETs show a shift of the minimum conductivity point of up to 25 mV/pH in the pH-range from 5 to 8 and chemical stability in the pH-range from 2 to 12 at physiological conditions (Fig. 2). While this sensitivity is sufficient for the application in commercial pH-sensor devices, the fact that the electrochemical response is significantly sub-Nernstian is advantageous for application of the heterostructure for biosensing after respective functionalization of the amino groups with probe molecules.

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Figures

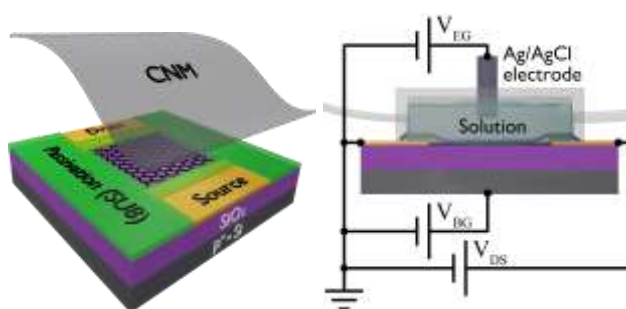


Figure 1: Schematic 3D view of the device (left) and electrical wiring diagram in cross section view including the microfluidic channel (right).

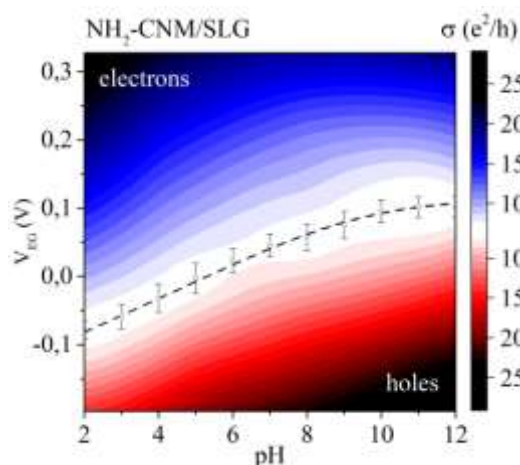


Figure 2: Shift of graphene transfer characteristic as a function of pH for a NH₂-CNM/graphene FET. The dashed line shows the model result for the minimum conductivity point.

References