GO was synthesized chemically by oxidation of graphite using modified Hummer’s and Offeman’s method. 0.5g graphite powder (Bay carbon, SP1), 0.55g Sodium Nitrate (Sigma Aldrich, >99.999%) and 23ml Sulfuric acid (Sigma Aldrich, 99.999%) were mixed and stirred for 10 minutes. Then, 3g Potassium Permanganate (Sigma Aldrich, >99.0%) was added slowly and temperature maintained below 20°C. DI water added slowly and the temperature raised to 90°C. The solution turned bright yellow when 3ml of Hydrogen peroxide (30%) was added. The mixture was filtered while warm and washed with warm DI water. Purification was done by centrifugation. Highly doped silicon with 50nm SiO₂ were used as substrate. The substrate was plasma cleaned and modified using Aminopropyl-Trichloroethoxysilane (APTES, Sigma Aldrich, 99%) to create predefined areas for GO localization. The substrate was immersed in GO aqueous solution washed with DI water.

Electron beam resist (PMMA – Microchem corp, A3) was spin coated on the substrate before performing e-beam lithography to define the electrodes. The channel dimensions were defined as 2μm by 15μm.
Decoration of gold was obtained by using 1ml of 10mM Chloroauric acid (HAuCl₄) (Strem Chemical, 99.9%) diluted with 9ml DI water. The mixture was heated to 80°C together with the graphene oxide deposited substrate. Next, 77mM sodium citrate (Sigma Aldrich, ACS reagent) was added. The substrate was then washed with DI water and kept under N₂ to avoid contamination. Briefly for silver decoration, AgNO₃ (Sigma Aldrich, 99.9999%) solution was injected into closed cells with GO substrate while continuously flushed with N₂. After 20 minutes, the substrate was taken out and rinsed with DI water. Graphene oxide and the hybrid devices then underwent chemical reduction using Hydrazine Monohydrate vapor for 18 hours at 140°C in a closed flow cell. The chip is then flushed with N₂ for 6 hours to remove the excess hydrazine, baked for 1 hour to clean the PMMA residue, and stored in N₂ before measurement.

Field emission scanning electron microscopy (FE-SEM, JEOL JSM7600F) at 1kV and transmission electron microscopy (TEM JEOL2100F) at 200kV were used to characterize various specimens in this experiment. Electrical measurements were done with Keithley 4200 on a probe station (TTP-6, Desert Cryogenic) under ambient temperature and vacuum in both transistor and resistor configurations. Raman measurements were performed using a Witec system at 488 nm. Gas sensing measurement was done in a home-made setup using manual air flow controller in a closed chamber at room temperature and atmospheric pressure.
Supporting figures

**SI 1.** a) APTES functionalization gives amine termination that attract GO to stick on the substrate thus securing the single layer. b) Octadecyltrichlorosilane (OTS) treated substrate which gives hydrophobic surface repels GO from sticking on the substrate. Surface appears clean from GO. c) Plasma cleaned substrate which gives hydrophilic surface allows some GO to stick on the substrate. d) Localized single GO layer on desired position. Inset showed big piece of GO layer (around 15μm) is deposited through this method. Scale bar is 2μm.
SI. 2. AFM measurement of rGO. Average thickness of the layer is around 0.65nm, which may be contributed to un-removed oxygen functionalities on the layers.
SI 3. a) SEM image of Au-rGO, b) SEM image shows selective decoration of Au nanoparticle on single GO sheet. The free standing particles on the substrate (appear lighter in color) are easily removed by mild sonication.
SI 4. AgrGO gas detection; a) SEM images for Ag decorated GO by chemical synthesis. The particle size is found to be 7.05 ± 2.10 nm with particle density of 949 particles / μm², b) Transient measurement in NO₂ (black) and H₂S (gray) respectively, c) Transfer characteristic in NO₂ – 2 ppm, threshold voltage is positive shifted as result of p-type doping and mobility increases by 46% with relative to mobility calculated in N₂; d) Transfer characteristic in H₂S – 8 ppm, threshold voltage is negative shifted as result of n-type doping and mobility decreases by 37% with relative to mobility calculated in N₂. Limit of detection in NO₂ is 39 ppb and in H₂S is 900 ppb.
SI 5. SEM images for Au-rGO taken directly from the device used in figure 4d, showing different Au nanoparticle density (decreasing density from sample A, B, C to D). For samples A, B, C and D respectively, mean size of the nanoparticle was found to be around 13nm, 20nm, 28nm and 40nm; the density of nanoparticles are 335 particle/μm², 120 particle/μm², 50 particle/μm² and 10 particle/μm².