

Nanoporous-Carbon for Chemical Microsensors
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We present the use of nanoporous-carbon (NPC) as an adsorbent coating on surface acoustic wave (SAW) chemical microsensors for a wide-range of analyte gases. Using pulsed-laser deposition (PLD) in a controlled inert gas ambient, NPC grows at room-temperature with negligible residual stress, and hence, can coat most surfaces to nearly any thickness. Mass density is well-controlled by the deposition energetics and can be $< 0.1 \text{ g/cm}^3$, as shown in fig. 1. High-resolution transmission electron microscopy reveals that lower-density NPC has both larger and greater numbers of nanopores than higher-density NPC. The smallest nanopores detected have $\sim 1 \text{ nm}$ diameters. In addition, decreasing NPC density also increases the interplanar spacing between graphene sheet fragments within the ultrathin carbon wall structures. Intercalation of elements and molecules into graphite is well-known; increasing the spacing between graphene sheets should ease diffusion both in and out of the coating.

These physical differences in structure with NPC mass density effectively increase the available graphitic surface area for physi- or chemisorption of analyte gases, with only the structural integrity of the internal NPC wall structures a limiting factor in determining the lowest useful density NPC coating. NPC-coated SAW devices readily detect a variety of volatile organic compounds (e.g. acetone, methanol, benzene) and toxic industrial chemicals (e.g. chlorobenzene, carbon tetrachloride, iso-octane) with strong signals under modest exposures.

The acetone adsorption isotherms plotted in fig. 2 for NPC-coated SAW devices with mass densities ranging from 0.18 to 1.08 g/cm^3 show a direct correlation between NPC mass density and SAW sensor response. The oscillator frequency response increases with decreasing NPC density. Only the lowest density NPC coating does not follow this trend, perhaps due to the development of stress-induced damage during the adsorption of analyte into such a fragile nanostructure. In addition, further data analysis suggests the possibility of detecting acetone below parts-per-billion concentrations.

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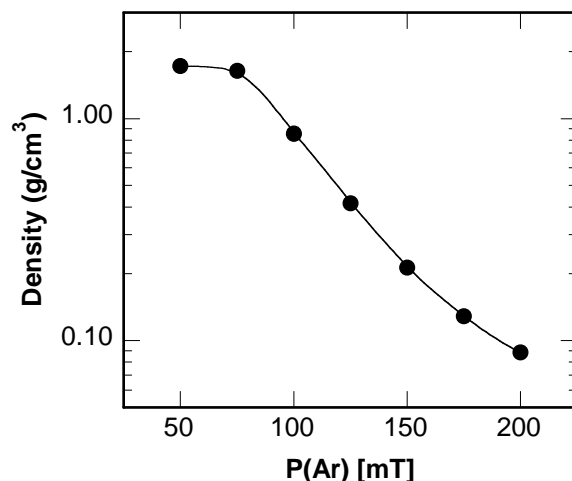


Fig. 1. NPC film density as a function of the background argon pressure used during PLD to attenuate the energy of the ablated carbon species. Note the semi-log scale.

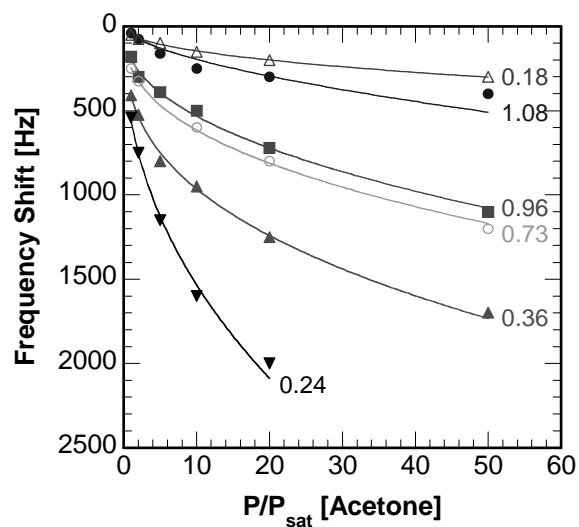


Fig. 2. SAW microsensor response to controlled acetone exposures ranging from 1 – 50 % saturation pressure. Each SAW was coated with the same mass of NPC but with differing densities [g/cm^3] as noted in the figure.