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# Sensor applications of graphene quantum capacitance varactor

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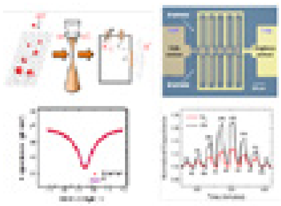
Graphene has tremendous potential to form the basis of a powerful platform for bio sensing due to its unique combination of properties, including high surface sensitivity, chemical stability, mechanical strength, and biocompatibility. However, to date, nearly all sensor concepts based upon graphene involve direct measurement of the electrical current in graphene. The need for direct electrical connections can limit the range of applications suitable for these devices, including many biological sensing functions, where wire leads can be cumbersome or impractical. In this talk, I will describe a novel sensor concept that utilizes a unique property of graphene, the quantum capacitance effect. The quantum capacitance effect in graphene allows the formation of a variable capacitor (or varactor) which, when integrated with an inductor, can form a passive LC resonator that can be interrogated through near-field inductive coupling. When the varactor is exposed to an external analytes (chemical, biological, etc.), the surface interaction of the analytes with the graphene shifts the charge concentration in the graphene, thus changing the capacitance and the resonant frequency of oscillation. With appropriate functionalization, this interaction can occur selectively to capture a specific chemical or biological target. We have developed a stable, high-yield fabrication process for graphene varactor utilizing a graphene grown by chemical vapor deposition and demonstrated devices with capacitance tuning ratios as high as 1.6-to-1. The varactor performance can be modeled very accurately utilizing a simple analytical model that takes into account disorder and charge trapping effects. We have demonstrated the operation of these devices for a variety of sensing applications, particularly for detection of glucose and acetone, important analytes for the treatment of diabetes. Finally, we have extensively analyzed the parasitic effect of water on the sensor performance and this work provides important insight into how the sensor robustness can be further improved.



## Biography

Steven J Koester has received his PhD in 1995 from the University of California, Santa Barbara. From 1997 to 2010, he was a Research Staff Member at the IBM T J Watson Research Center and performed research on a wide variety of electronic and optoelectronic devices, with an emphasis on group-IV electronics. Since 2010, he has been a Professor of Electrical and Computer Engineering at the University of Minnesota where his research focuses on novel electronic, photonic and sensing device concepts with an emphasis on graphene and other 2D materials. He has authored or co-authored over 200 technical publications and conference presentations, seven volumes, four book chapters, and holds 66 United States patents. He is an Associate Editor for IEEE Electron Device Letters and an IEEE Fellow.

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