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Immobilization of heterogeneous polydiacetylene supramolecules on SiC substrate for cyclodextrin sensors

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Self-assembled Polydiacetylenes (PDAs) with two different functional groups were successfully immobilized and chemisorbed on the surface of SiC substrates coated with thermally grown SiO_2. Patterned PDAs on the surface of SiC with thermally grown SiO_2 have shown selective response only to α-CDs (cyclodextrins) and not to γ-CDs through the manipulation of the outer structures of these PDAs. This shows the potential of integrating PDA-based chemosensors with high temperature SiC microelectronics and MEMS systems.

1 Introduction SiC has shown tremendous promise in high power rectifiers, high frequency electronics and sensors in harsh environments such as toxic solutions, high temperature, space and nuclear energy reactors [1–6]. SiC is well-suited to these applications because of its exceptional chemical, wide-energy bandgap and excellent electrical transport properties such as higher breakdown field (3×10^6 V/cm), higher thermal conductivity (3.2–4.9 W/cm K), higher saturation velocity (2×10^7 cm/s) and higher Young's modulus (700 GPa) than silicon [7]. In addition, SiC is not etched by most acids. It can, however, be etched by alkaline hydroxide bases such as KOH over 600 °C [7]. These properties also make SiC very promising for applications in Micro Electro Mechanical System (MEMS) technology and in various sensors and actuators systems [8–11].

Polydiacetylenes (PDAs) are unique in terms of their output fluorescence emission signals, which range from no fluorescence emission to red fluorescence emission in response to environmental perturbations such as heating, pH or ligand–acceptor interactions [12–14]. After Charych et al. [15] first used PDAs to detect influenza virus, there have been intensive research efforts to develop PDA-based chemosensor systems. However, most efforts have focused on developing solution-based chemo-sensor systems, which are less sensitive against smaller amount of analytes than PDA vesicle sensors immobilized on solid state substrates [16]. Recently, we have reported immobilization of PDAs on glass substrates [16], but the immobilization of PDAs on semiconductor substrates will be more advantageous because of their higher sensitivity for detection and they can be readily integrated with advanced microelectronics and MEMS for Lab-on-Chip applications. Since the immobilization requires a high quality oxide for the chemisorption of self-assembled monolayer (SAM), it was difficult to demonstrate the chemisorption of PDAs on semiconductor substrate. Unlike silicon, III–V compound semiconductors do not generally have high-quality native oxides. For example, gallium oxide grown by oxygen plasma exposure is very unstable in humid environments and generally not uniform. Therefore, a novel approach is necessary to functionalize the surface of III–V compound semiconductors. Baur et al. [17] successfully functionalized the surface of GaN and AlN using H_2SO_4/H_2O_2. Another alternative is thermally grown SiO_2 which has higher quality than SiO_2 grown by the PECVD (plasma-enhanced chemical vapor deposition) technique. It is relatively straightforward to thermally grow SiO_2 on single-crystal