Fundamental Study on Thermally Robust Molecular Recognition Surface of Nanoscale Metal Oxides for Electrical Molecular Sensing and Discrimination

劉, 江洋

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氏　　名 ：リウ　ジャンヤン

Name：　　LIU JIANGYANG

論 文 名　: Fundamental Study on Thermally Robust Molecular Recognition Surface of Nanoscale Metal Oxides for Electrical Molecular Sensing and Discrimination

（電気的分子センシングおよび分子識別へ向けたナノスケール金属酸化物の堅牢な分子認識表面に関する基礎的研究）

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論 文 内 容 の 要 旨

Thesis Summary

This thesis is organized by a fundamental study for molecular recognition surface of nanoscale metal oxides, consequently aiming at improving the molecular detection performance of electronic devices whose directly molecular contact section is based on semiconductor metal oxide, mainly focus on deeply understanding molecule-to-surface reaction behavior and novel sensing device integration, in order to make breakthrough for molecule detection.

On account of the unique chemical/property which are quite adaptive for benefiting the molecule sensing performance, we investigated the impurity metal ions doping approach for controlling the morphology of hydrothermal zinc oxide nanowires. The inhomogeneous W dopant distribution in an individual ZnO nanowire is unveiled for the first time, but such ion dopant nanowire failed to design the surface because most ion is doping at core part. Therefore we employ a metal modified nanowire surface and mixed the cations by a simple thermal treatment, molecule adsorption and transformation behavior on a gradual modulation of cation composition in heterostructured $(Cu_x,Zn_{1-x})O$ nanowires was investigated for a better understanding of molecule-to-surface reaction. We also discovered a facile methodology to create zinc titanate nanotubes via reaction-byproduct etching, it created a mix cations surface on nanotube with lower thermal annealing temperature than solid-phase diffusion method. In addition to surface cation modification, we revealed a simple surface treatment using strong acids to elicit surface water on WO_3 nanowire to enhance the electrical molecular sensing of nonanal. The directly molecule-to-atom connection contributes to both sensitivity and recovery time enhancement. Those surface modification/treatment surface show their potential to be utilizing onto sensing devices merit from enhanced sensing properties such as recovery time and duration, but they can't contribute towards the tiny, selectively molecule detection, other surface functionalized method is in demand. For achieving the aiming molecule detection from mixture volatiles, a “molecular fingerprinted” concept was designed. Prior to the device application, its molecular discrimination ability was optimized by control its formation temperature. Molecular fingerprinted nanowire formation mechanism was revealed by investigate the atomic-diffusion of zinc into the

titanium oxide cross-link layer because the stronger bonding its provided for stabilizing template molecule during formation procedure. The excellent thermal robustness confirmed they can be fabricated onto sensing device operated at relative high temperature. A nanowire-sensor hybrid devises is carried out, nanowire play as pre-selector with its surface functionalized by as mentioned molecular fingerprinted strategy. The selectively detected of benzaldehyde, even from imbalanced molecular ratio of tiny benzaldehyde ratio show the potential of molecule detection from complex realistic application. Furthermore, such molecular fingerprinted nanowire as preconcerted platform integrated with sensor can reach ultralow detection by concentrated nonanal on the surface and thermally desorb into a small chamber. Obviously sensing response can be observed even to sub-ppb level nonanal (500 ppt), which could be detected by currently sensing device. Except the effort for promoting the discrimination adsorption of nanowire surface, we devoted to manipulating molecules discrimination at desorption procedure utilizing nanowire-sensor hybrid device, which could separate molecule sensing by controlling the desorption temperature and heating time. The successful discriminated sensing signal from co-adsorbed nonanal and its condensation product demonstrated its feasibility. We believe simultaneously utilizing molecular discriminate adsorption and desorption, more accuracy detection can be achieved in the near future.