



Novel two-dimensional materials for biosensing and electrochemical catalysis

Xiaoqiang Cui

EasyChair preprints are intended for rapid dissemination of research results and are integrated with the rest of EasyChair.

July 3, 2019

Novel two-dimensional materials for biosensing and electrochemical catalysis

Xiaoqiang Cui^{1,a}

¹ Jilin University, State Key Laboratory of Automotive Simulation and Control, Department of Materials Science, Key Laboratory of Automobile Materials of MOE, Changchun 130012, China

^axqcui@jlu.edu.cn

Keywords: Two-dimensional nanomaterials, SPR biosensor, MoS₂ phase transformation, hydrogen evolution.

Abstract.

Two-dimensional materials are attracting dramatically increasing interest due to their unexpected physico-chemical property and broad of potential applications. We focus on the surface and interface engineering of two-dimensional materials to modify the electronic structures and in turn to enhance the catalytic performance.

We developed a surface plasmon resonance sensor based on two-dimensional nanomaterial of graphene and antimonene for the specific label-free detection of clinically relevant biomarkers such as miRNA-21 and miRNA-155. ^[1-3] The strong interaction between target probes and 2D materials results an variation of the refractive index of graphene and antimonene, which highly enhanced the performances of SPR biosensor. First-principles energetic calculations reveal that antimonene has substantially stronger interaction with ssDNA than the graphene. The detection limit can reach 10 aM, which is 2.3–10,000 times higher than those of existing miRNA sensors.

We also report a spontaneous phase transformation of MoS₂ from the 2H to the 1T phase, which is induced by the strong interactions between Ir nanoparticles, Co nanosheets, Ni nanosheets, Fe₂O₃ nanoplates or Pd-Au hybrid nanosheets and MoS₂. ^[4, 5] Particularly, the Co/Ni/Fe nanoplates/MoS₂ hydrides become an array of Co/Ni/Fe single atoms covalently bound onto distorted 1T MoS₂ nanosheets after electrochemical leaching. These resulting metal/1T MoS₂ heterostructures show outstanding catalytic activity for hydrogen evolution reaction, which is much better than that of commercial Pt/C.

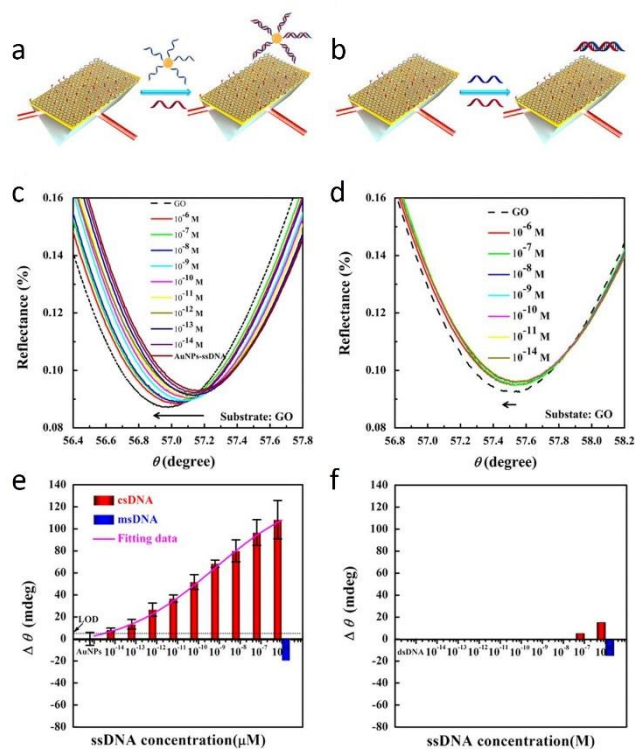


Fig 1. Schematic illustration of different concentrations of target csDNA mixing with AuNPs–ssDNA (a) and ssDNA (b) as competitive acceptors. SPR angular reflectivity spectra for a GO-based SPR chip surface incubated with the mixing solution of AuNPs–ssDNA (c) and ssDNA (d) with 10^{-14} – 10^{-16} M target csDNA. The left-shift of SPR angles versus a series of concentrations of target csDNA (red) and msDNA mixing with AuNPs–ssDNA (e) and ssDNA (f) as competitive acceptor. ^[2]

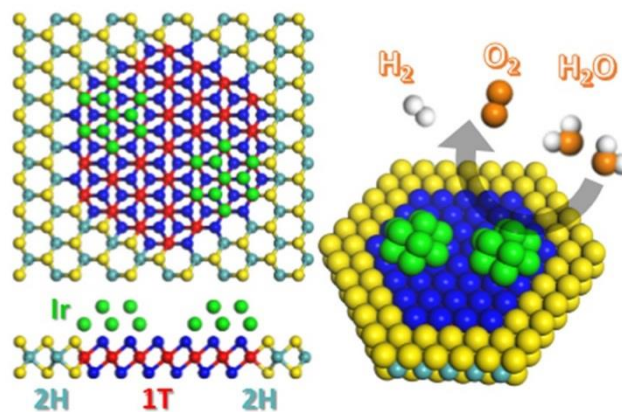


Fig 2. Schematic illustration of the spontaneous phase transformation of MoS₂ from the 2H to the 1T phase, caused by the strong metal–support interaction during iridium adsorption. ^[4]

References

1. T. Xue, W. Liang, Y. Li, Y. Sun, Y. Xiang, Y. Zhang, Z. Dai, Y. Duo, L. Wu, K. Qi, B. N. Shivananju, L. Zhang*, X. Cui*, H. Zhang*, Q. Bao*, *Nature Communications* **2019**, *10*, 28.
2. T. Xue, X. Cui*, W. Guan, Q. Wang, C. Liu, H. Wang, K. Qi, D.J. Singh, W. Zheng*, *Biosensors and Bioelectronics* **2014**, *58*, 374-379.
3. T. Xue, X. Cui*, J. Chen, C. Liu, Q. Wang, H. Wang, W. Zheng*, *ACS Applied Materials&Interfaces* **2013**, *5*, 2096–2103.
4. S. Wei, X. Cui*, Y. Xu, B. Shang, Q. Zhang, L. Gu*, X. Fan, L. Zheng, C. Hou, H. Huang, S. Wen, W. Zheng*, *ACS Energy Letters* **2019**, *4*, 368-374.
5. B. Shang, X. Cui*, L. Jiao, K. Qi, Y. Wang, J. Fan, Y. Yue, H. Wang, Q. Bao, X. Fan, S. Wei, W. Song, Z. Cheng, S. Guo, W. Zheng*, *Nano Letters* **2019**, *19*, 2758-2764.

Biography:

Xiaoqiang Cui has achieved his PhD from Changchun Institute of Applied Chemistry, Chinese Academy of Sciences (2002) under the supervision of Academician Xiurong Yang. He subsequently joined Prof. Changming Li's group (2005) as a postdoctoral research fellow at Nanyang Technological University, Singapore and then worked as a research staff (2008) at National Institute of Advanced Industrial Science and Technology (AIST), Japan. Now he is a Changbai Mountain Scholars Professor and Deputy Dean at School of Materials Science and Engineering, Jilin University. His current research interests focus on the design of 2D nanomaterials for efficient electrocatalysis, photocatalysis, and beyond.