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Research Scholarship for International Graduate Students

Nitride-based Surface-Enhanced Raman Spectroscopy for DNA sensing

氮化 物表面增益拉曼光譜 於 DNA感測的應用

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Abstract

Detecting mutated DNA fragments is the key in screening and finding precise therapies to cancer patients. Surface-Enhanced Raman spectroscopy (SERS) is merging as a powerful analytical tools to detect the DNA molecules. However, SERS DNA biosensors are still rarely found in practical applications due to its insufficient active area and unstable signal intensities. In our research, III-nitride compound semiconductor especially InGaN QWs grown by MOCVD system is proposed as a unique SERS substrate to address the aforementioned issues. The sensitivity of our substrate is further boosted by adjusting MOCVD conditions towards the clinical SERS DNA biosensor.

Our substrate preparation steps

1. The InGaN QWs/ GaN is fabricated by MOCVD system, then decorated with Gold and Aluminum NPs .
2. R6G and DNA were used as the analyte and excited by the 532nm-laser and 488nm.

Si-doped GaN CAP LAYER
InGaN
(InGaN QW/GaN QB)*(n-1)
Si-DOPED GaN
Si-DOPED GaN
Si-DOPED GaN
NUCLEATION (BUFFER) LAYER
C-SAPPHIRE

Figure 1. *InGaN/GaN substrate by MOCVD*

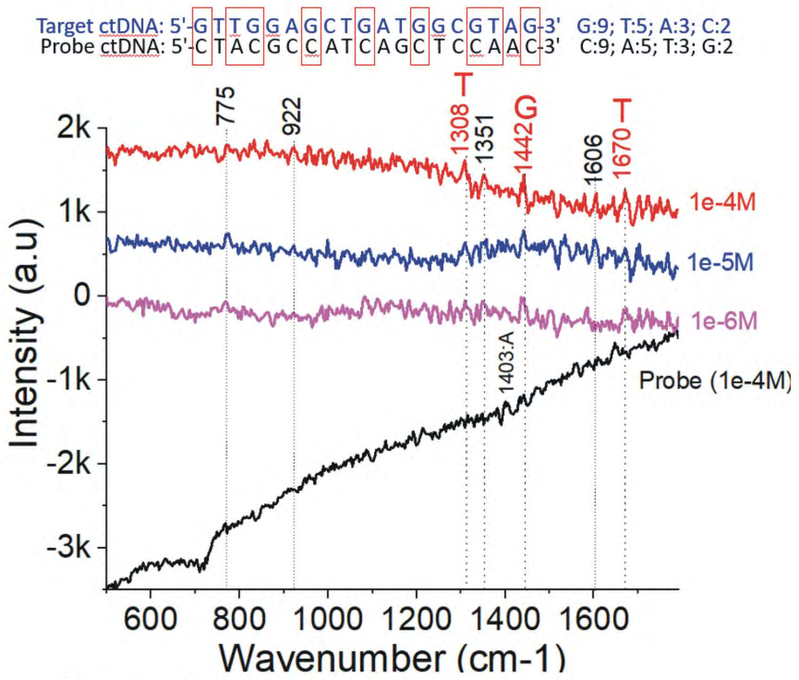

Figure 4.
SERS spectra of ctDNA before and after the DNA hybridization process with the concentration of 1e-4M of probe ctDNA and the concentration from 1e-6M to 1e-4M of target ctDNA. The sequences of ctDNA were also shown in the figure.

Results and discussion

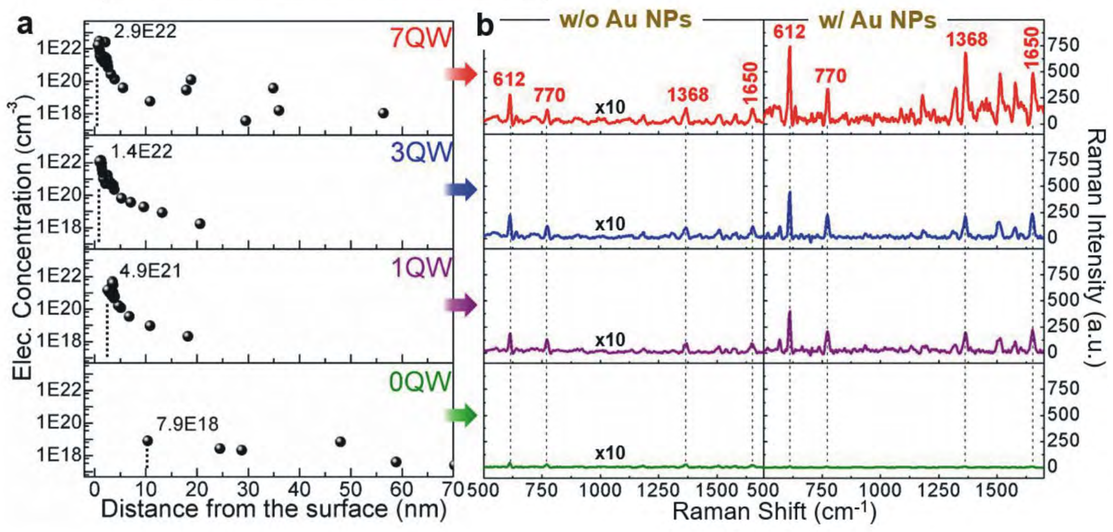

Figure 2. *(a) Depth profiles of electron concentration attained by CV measurements with the four samples: 0QW, 1QW, 3QW, and 7QW. (b) SERS spectra of R6G recorded on the four samples without (left column) and with (right column) Au nanoparticles (NPs), showing increased Raman intensities with QW number on the two surface conditions [6]*

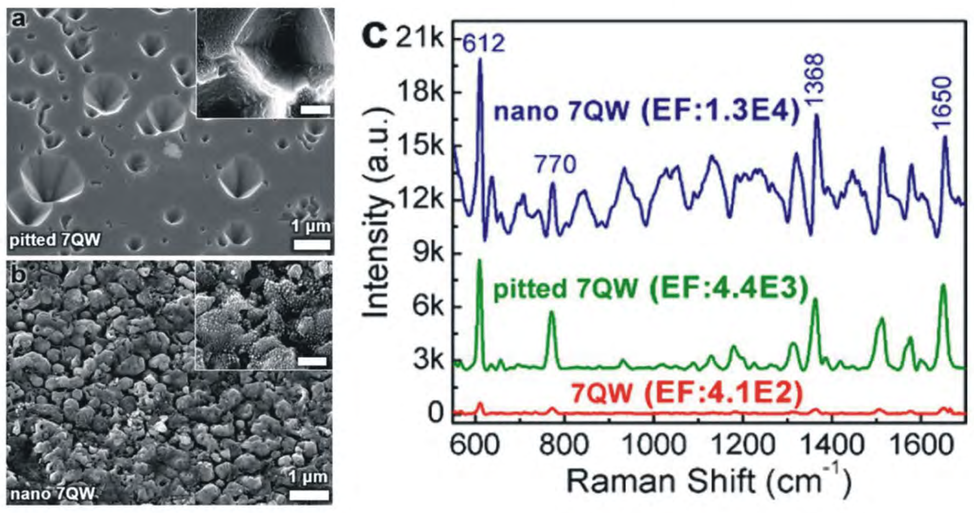

Figure 3. *(a) SEM image of the pitted 7QW surface. A zoom-in image (scale bar: 300nm) is shown in the inset, where one can see Au nanoparticles. (b) SERS spectra of R6G (10^{-5} M) were recorded on the flat, pitted and nanostructure 7QW samples [6].*

Summary

Using the optimized indium gallium nitride quantum wells (InGaN QWs) grown by MOCVD, we can firstly systematically observe the relationship between the substrate surface electron concentration, morphology and its performance, which results in the detection of the hybridization mutated DNA molecules with low concentration of 10-6M. The sensitivity of hybridization SERS substrate is going to be increased by MOCVD adjustments.

Selected Journal Publications

1.Chien, F.-C.; Zhang, T. F.; Chen, C.; **Nguyen, T. A. N.;** Wang, S.-Y.; Lai, S. M.; Lin, C.-H.; Huang, C.-K.; Liu, C.-Y.; Lai, K.-Y. Nanostructured InGaN Quantum Wells as a Surface-Enhanced Raman Scattering Substrate with Expanded Hot Spots. ACS Appl. Nano Mater. ASAP Article 2021.

2.Nguyen, T. A. N.*; Yu, Y.L.; Chang, Y. C.; Wang, Y. H.; Woon, W. Y.; Wu, C.T.; Lin, K. L.; Liu, C. Y.; Chien, F. C.; and Lai, K. Y. Controlling the Electron Concentration for Surface-Enhanced Raman Spectroscopy. ACS Photonics 2021, 8, 24102416. (2021).

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