Size-tuned Silver Nanocubes as Optimized Two-Dimensional SERS Effective Superlattices

Zhaoxi Yang[a], Ning Yu[a], Boqun Liang[b], Katie Lao[c], Kimberly Perez[a], Jesse Ortega[a], Charlie Ding[e], Ming Liu[d], Ruoxue Yan[a]

[a]*Department of Chemical and Environmental Engineering, University of California, Riverside, CA 92521, USA*

[b]*Department of Material Science Engineering, University of California, Riverside, CA 92521, USA*

[c]*Department of Bioengineering, University of California, Riverside, CA, 92521, USA*

[d]*Department of Electrical and Computer Engineering, University of California, Riverside, CA, 92521, USA*

[e]*Stuyvesant High School, 345 Chambers Street, NY, 10282, USA*

zyang128@ucr.edu

The morphology and size of metallic nanoparticles play a critical role in enhancing the sensitivity of Raman spectroscopy through surface-enhanced Raman scattering (SERS). Among these, silver nanocube (AgNC) superlattices are particularly effective due to their strong localized surface plasmon resonance (LSPR). This study focuses on the precise synthesis of monodispersed AgNCs and their assembly into close-packed superlattices via the Langmuir-Blodgett (LB) method to optimize SERS performance.

Silver nanocubes with sizes ranging from 65 nm to 180 nm were synthesized using a one-pot, precipitation-based double-jet process, guided by real-time UV-Vis monitoring for precise size control. The nanocubes were subsequently assembled into single layer superlattices using the LB technique to ensure uniform packing and consistent plasmonic behavior. These superlattices were evaluated for their ability to enhance the Raman signal of typical Raman dyes, including 4-MBA and 4-ATP.

To provide insight into the size-dependent plasmonic behavior, numerical simulations using COMSOL were performed on 5×5 AgNC superlattices, predicting that optimal LSPR occurs when AgNC sizes range between 110 nm and 130 nm. Experimental results strongly supported the simulations, demonstrating that AgNCs with sizes of 110–130 nm consistently yielded the highest SERS enhancement, with the optimal size centered at approximately 120 nm.

This study highlights the critical role of precise nanoparticle synthesis and controlled LB assembly in achieving optimal SERS performance. By tuning the size of AgNCs, we demonstrate that the assembly of uniform superlattices can be engineered to maximize plasmonic enhancement, with experimental results corroborated by theoretical simulations.

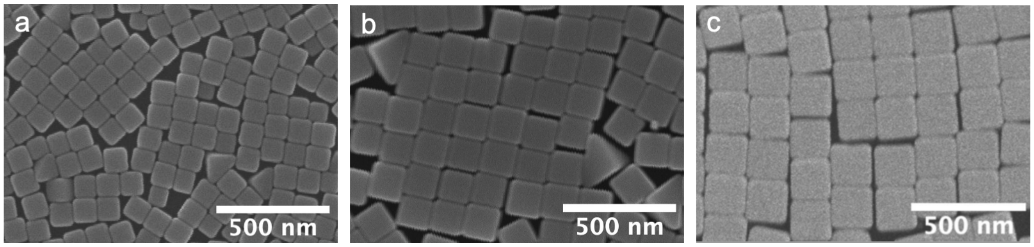

Figure 1: SEM images of close-packed 2D AgNC superlattices with cube sizes of (a) 100nm, (b) 140nm, (c) 180nm