Development of AI-Derived, Non-Invasive, Label-Free 3D-Printed Microfluidic SERS Biosensor Platform Utilizing Cu@Ag/Carbon Nanofibers for Detection of Salivary Biomarkers in Mass Screening of Oral Cancer

*Navami Sunil[1], Rajesh Unnathpadi[1], Rajkumar Kottayasamy Seenivasagam[2], T Abhijith[1], R. Latha[3], Shina Sheen[3] and Biji Pullithadathil[1,]**

[1]Nanosensors and Clean Energy Laboratory, Department of Chemistry & Nanoscience and Technology, PSG Institute of Advanced Studies, Coimbatore-641004, India

[2]Department of Surgical Oncology, PSG Institute of Medical Sciences and Research, Coimbatore-641004, India

[3]Department of Applied Mathematics and Computational Sciences, PSG College of Technology, Coimbatore-641004, India

*Corresponding author Email: bijuja123@yahoo.co.in; pbm@psgias.ac.in

SUPPORTING INFORMATION

SEM Analysis:

The surface morphology of core@shell Cu@Ag nanoparticles anchored on the surface of carbon nanofibers were examined using scanning electron microscopy. The SEM images of CNFs, Cu/CNFs, and Cu@Ag/CNFs are shown in Figure S1. The SEM images of the

nanofibers obtained indicate clearly smooth and long, continuous cylindrical morphologies with diameters in the range of 200-300 nm. The long cylindrical morphology of the CNFs with high surface area to volume ratio can significantly improve the active sites for the distribution of core-shell Cu@Ag nanoparticles enhancing the SERS properties.

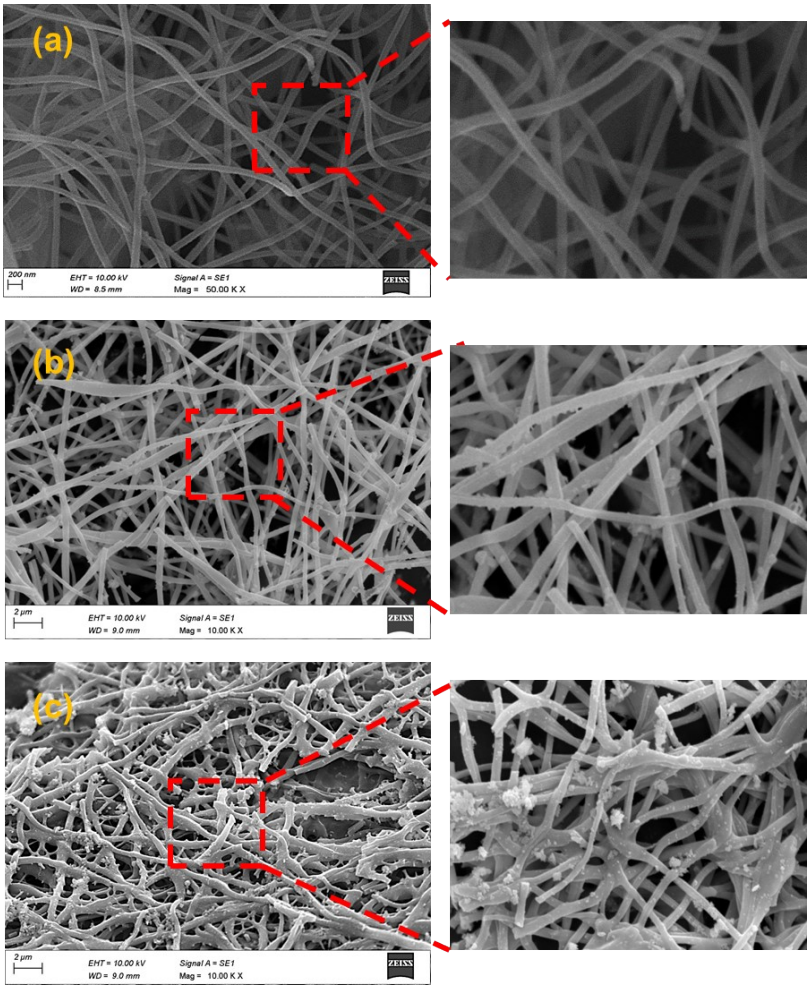

Figure S1 : SEM image of (a) CNFs, (b) Cu/CNFs and Cu@Ag/CNFs

As can be seen in Figure S1 (a), the SEM images of the nanofibers indicate clearly smooth and long, continuous cylindrical morphologies. The images illustrate the elevated surface area-to-volume ratio of carbon nanofibers (CNFs), which renders them ideal as solid support materials for the uniform deposition of plasmonic nanoparticles. The long cylindrical morphology and high surface area of the CNFs can greatly improve the active sites for the distribution of core-shell Cu@Ag nanoparticles enhancing the SERS properties. Figure S1 (b) shows the SEM

image of Cu/CNFs which indicates the uniform deposition of copper nanoparticles on the surface of the carbon nanofibers.

In the SEM images shown in Figure S1(c), the Cu@Ag nanoparticles got uniformly decorated on the surface of the carbon nanofibers and seemed to have a monodisperse size distribution and nearly spherical morphology. From the SEM image analysis, it can be concluded that Cu@Ag nanoparticles are uniformly deposited on the surface of CNFs, increasing the number of hotspots for enhancing the SERS properties.

TEM Analysis:

The TEM analysis of the Cu@Ag/CNFs at different ratios of Cu:Ag = 1:1. 1:3 and 1:5 are shown in the Figure S2. In case of Cu:Ag = 1:1, the silver precursor is not sufficient to completely cover the surface of the core copper and Ag partially appears on the surface of Cu nanoparticles, and is therefore exposed to oxidation. This hinders the SERS performance leading to lower enhancement. For the molar ratio of Cu:Ag is 1:3, the surface of Cu is uniformly coated with Ag which results in the formation of proper copper core silver shell uniformly decorated on the surface of the carbon Nano fibres (Figure S2 a). When the molar ratio of Cu:Ag was 1:5, excess of Ag contributed to the agglomeration between as-prepared Cu@Ag core–shell nanoparticles and the agglomerated silver nanoparticles get deposited away without getting attached to the carbon Nano fibres.

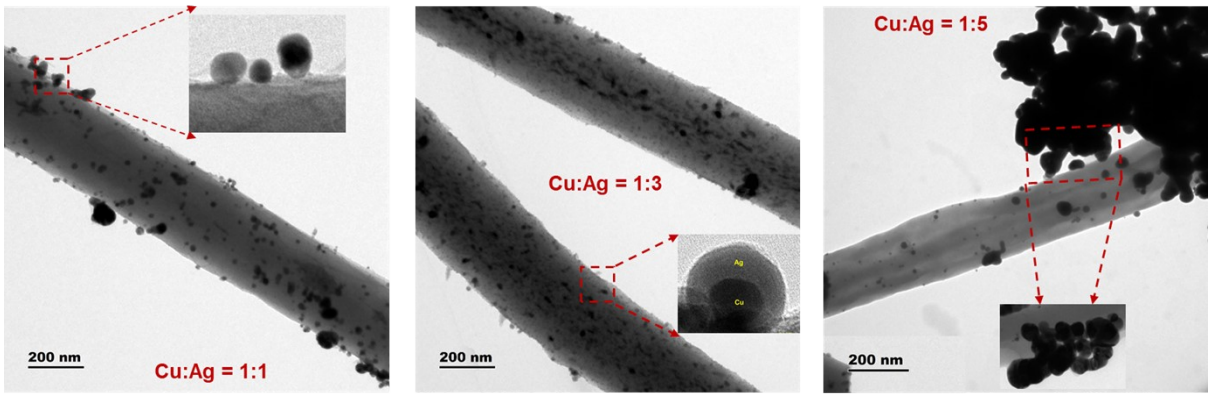

Figure S2: TEM analysis of Cu@Ag/CNFs at different ratios of (a) Cu:Ag = 1:1, 1:3 and 1:5 and the inset images shows the core shell structure atdifferent molar ratios.

Saliva sample analysis using the microfluidic chip:

The microfluidic platform consist of a main well connected to 12 sub wells using channels. The entire device is designed in such a way that when the saliva is dropped on the main well, it will flow (laminar flow) through the channels to the sensor array where the saliva can be collected in the 12 wells, which will be analysed as shown in the Supporting Information S3. Figure S3 shows the flow of saliva from the main well to the sub wells through channels. This device can be used to evaluate the reproducibility of the SERS spectra in which a single saliva samples can give rise to 12 spectra and hence the number of data acquired will be more.

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