

SUPPLEMENTARY INFORMATION

Effect of NiAl alloy microparticles deposited in Flexible SERS Substrates on the limit of detection of Rhodamine B molecules

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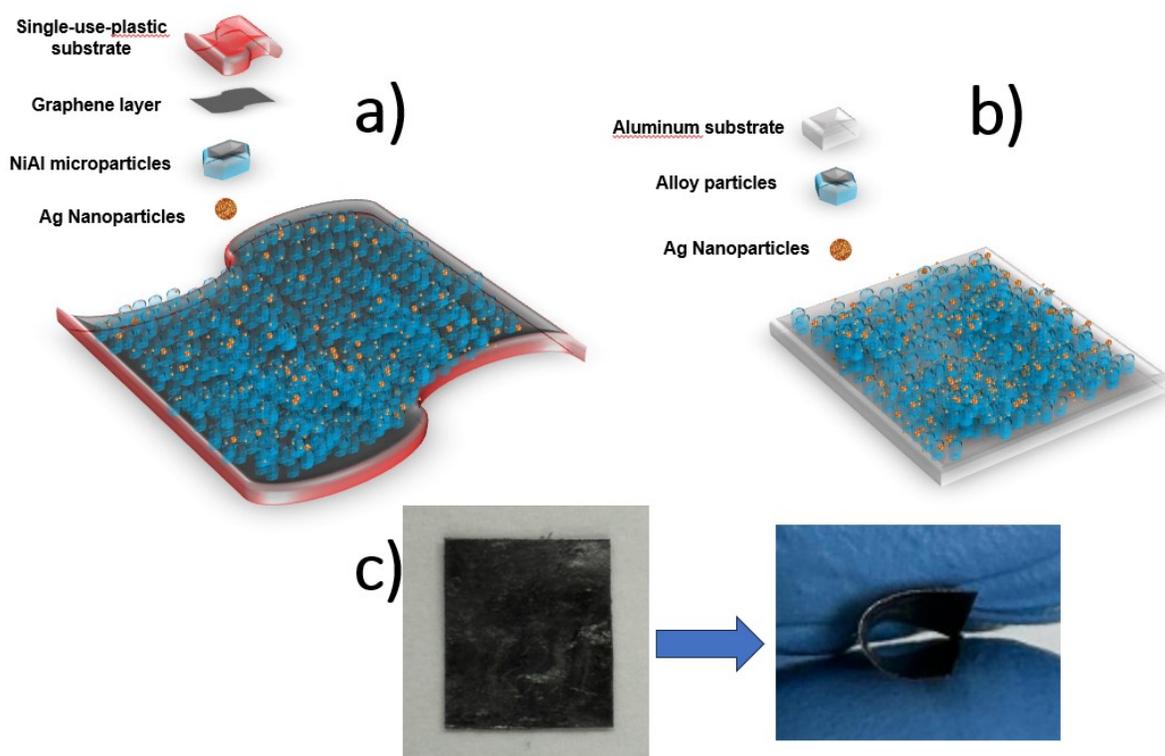


FIGURE S1. Schematic illustration showing the FERS substrate made with: a) graphene and b) Al layer (coating on the single use packets already deposited by the manufacturer). c) digital photographs of the FERS substrates fabricated in this work.

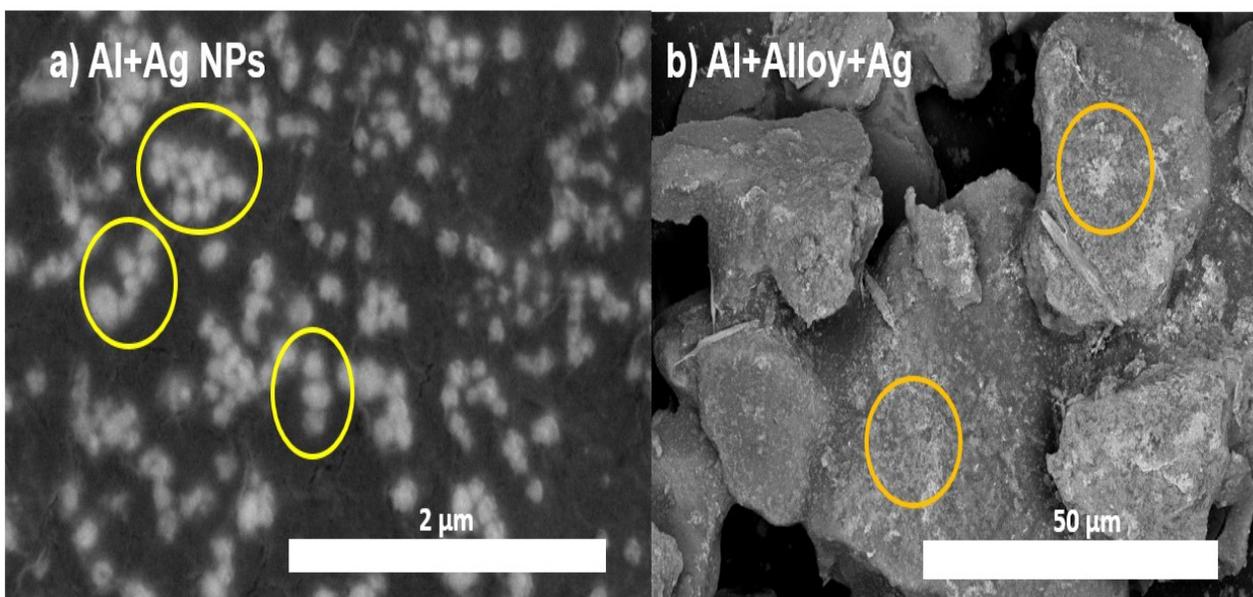


FIGURE S2. SEM images for: FERS substrates made of: a) Al+Ag-NPs and b) Al+NiAl-alloy+Ag-NPs.

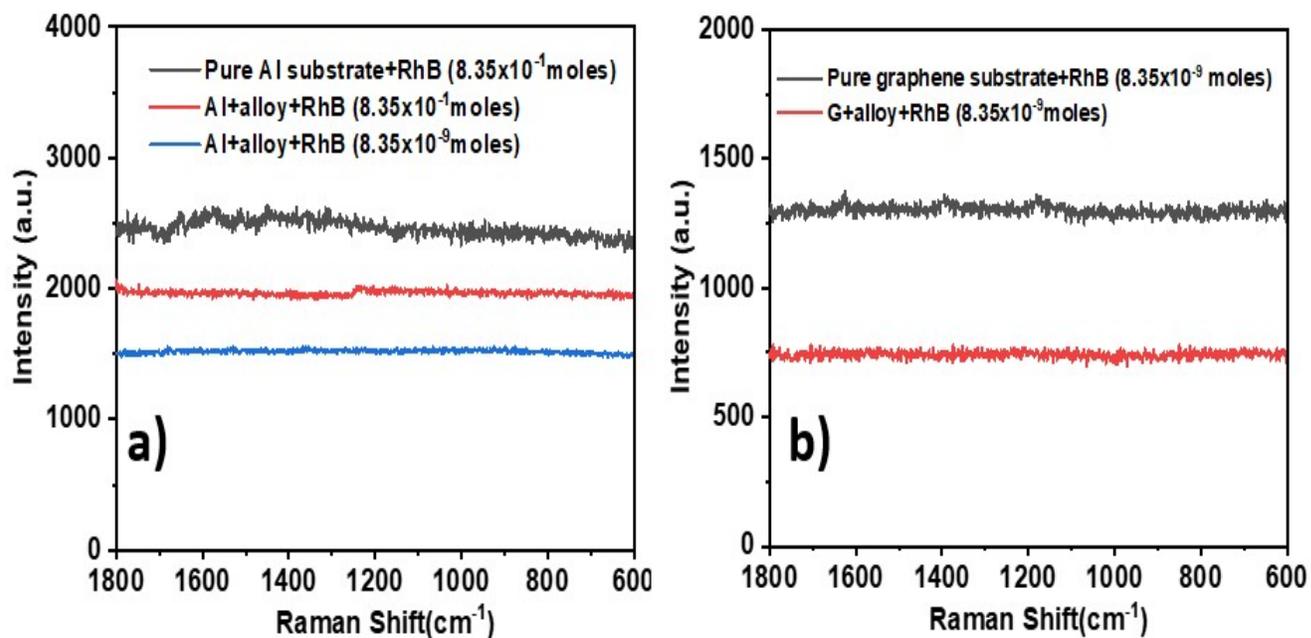


FIGURE S3. Raman signals for different FERS substrates made with different concentration of RhB and NiAl alloy (without Ag NPs).

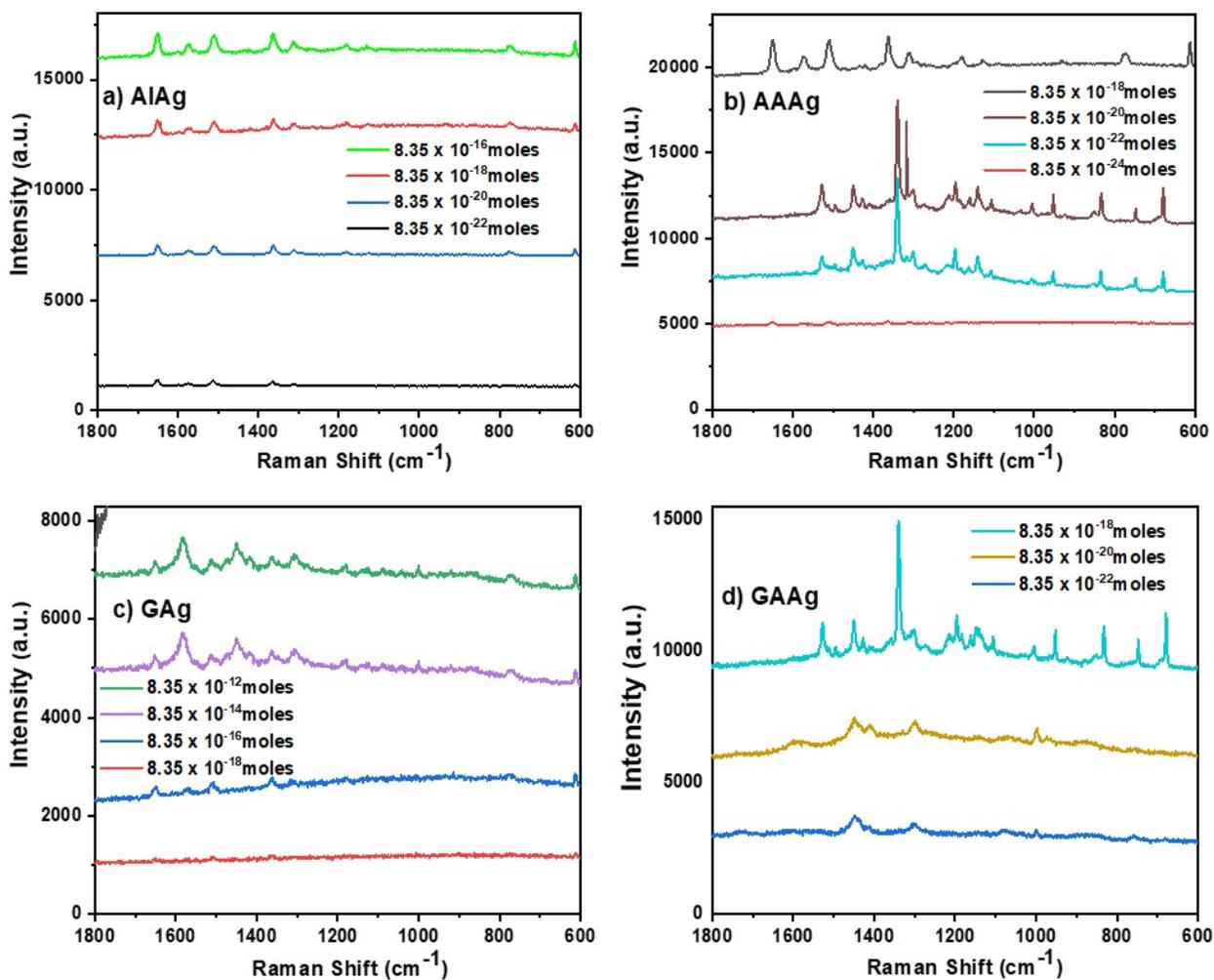


FIGURE S4. Zoomed view of the Raman signals depicted in Figures 5a-5d.

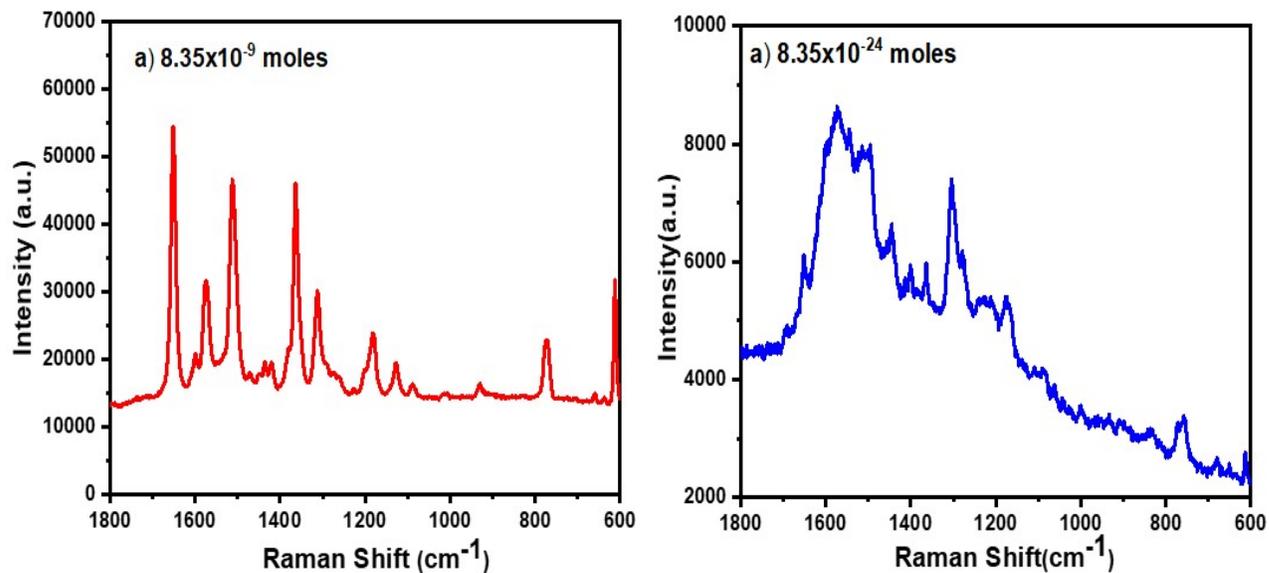


FIGURE S5. a) and b) show the Raman spectra for two SERS substrates (Al+NiAl+Ag-NPs) that were stored for 10 months, but they had on their surface fresh (recent) concentrations of RhB (8.35×10^{-9} and 8.35×10^{-24} moles).

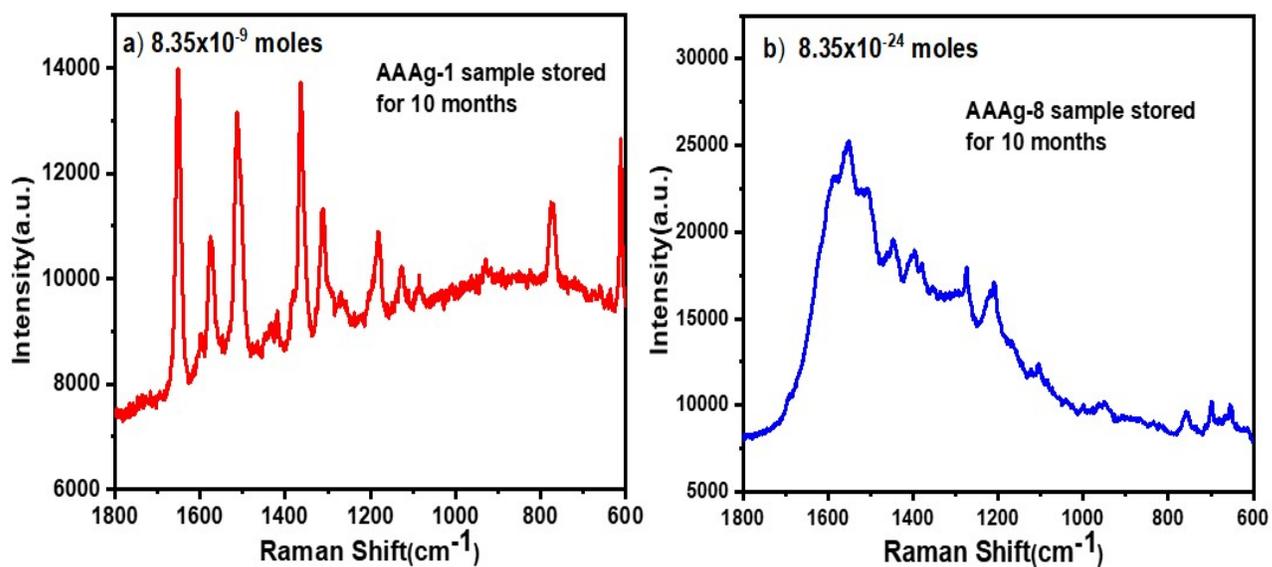


FIGURE S6. Raman spectra for old AAAG-1 and AAAG-8 SERS substrates stored for 10 months. Those substrates had RhB molecules on their surface.

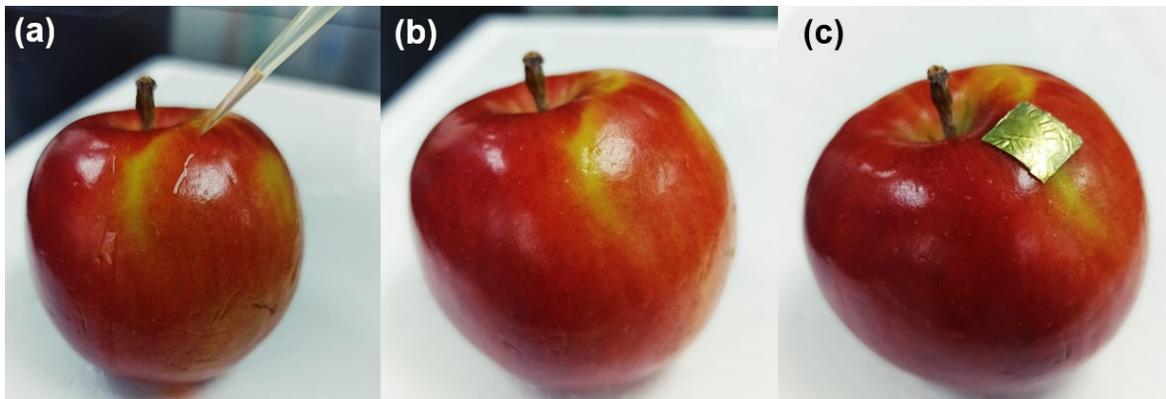


FIGURE S7. a) and b) show the deposition of RhB on the red apple. c) shows the SERS substrate (Al+NiAl+Ag-NPs) on the apple to take the sample of RhB.

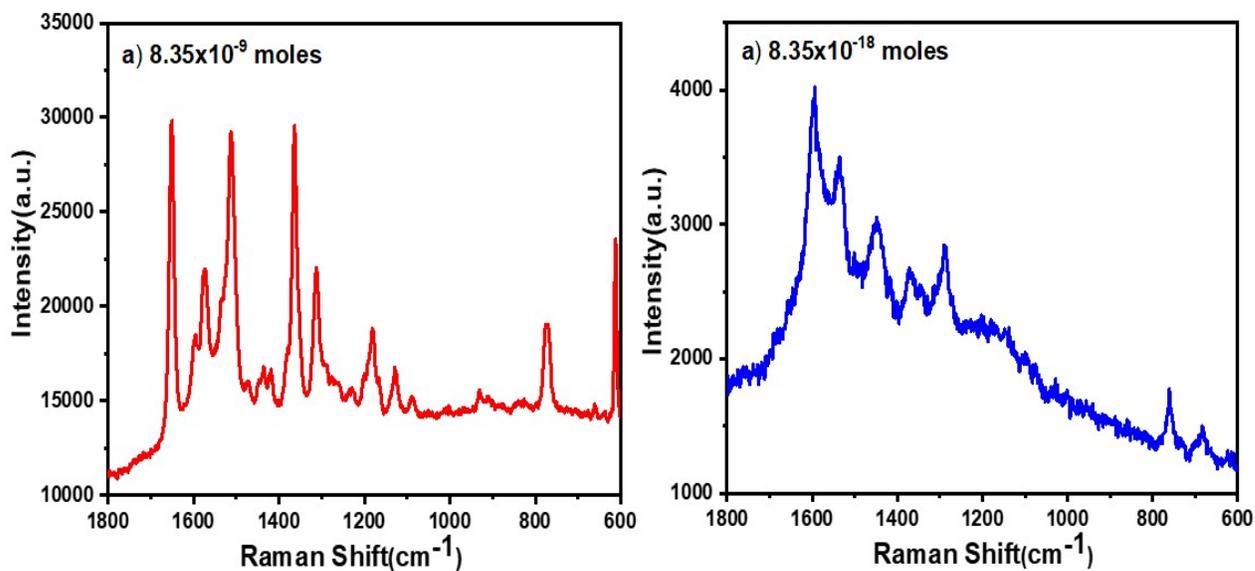


FIGURE S8. Raman spectra obtained from SERS substrates (Al+NiAl+Ag-NPs), which were used to take samples of RhB molecules from red apples.

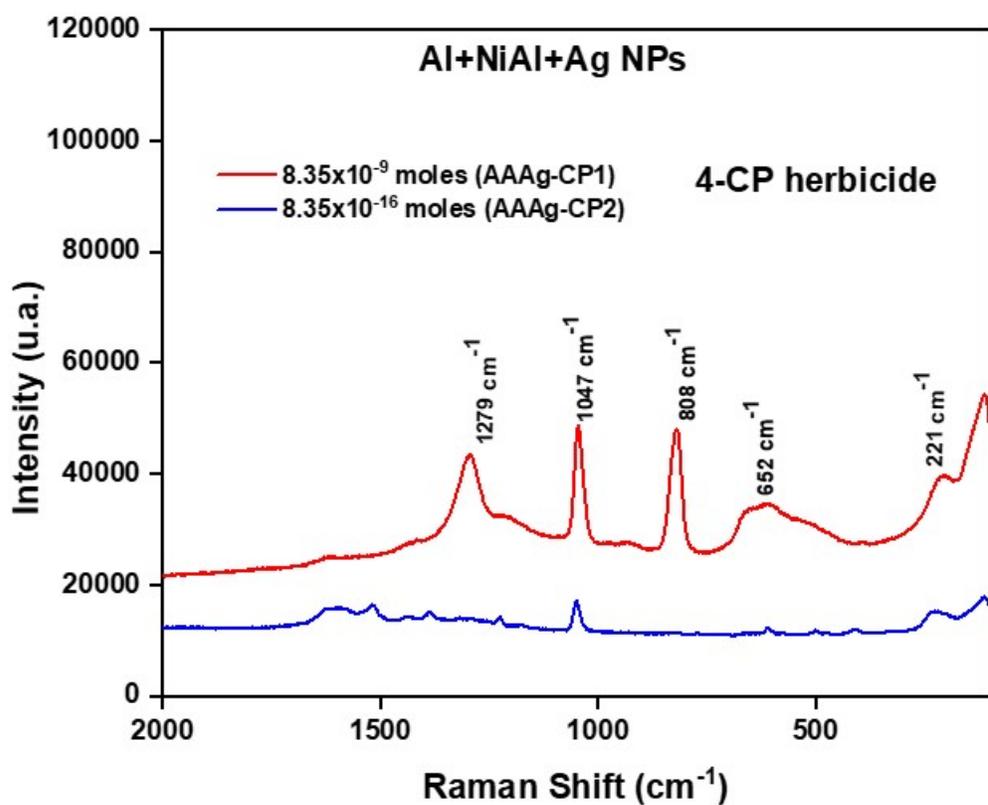


FIGURE S9. Raman spectra for two SERS substrates (made with Al+alloy+Ag-NPs), which had on their surface RhB with concentrations of 8.35×10^{-9} and 8.35×10^{-16} moles.

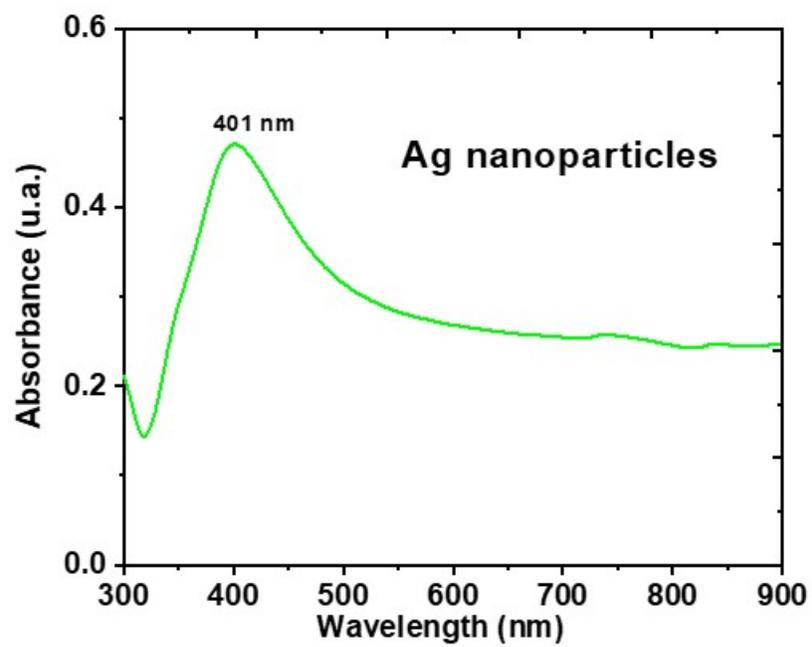


FIGURE S10. Plasmonic (absorption) spectra for the Ag NPs utilized in this research.

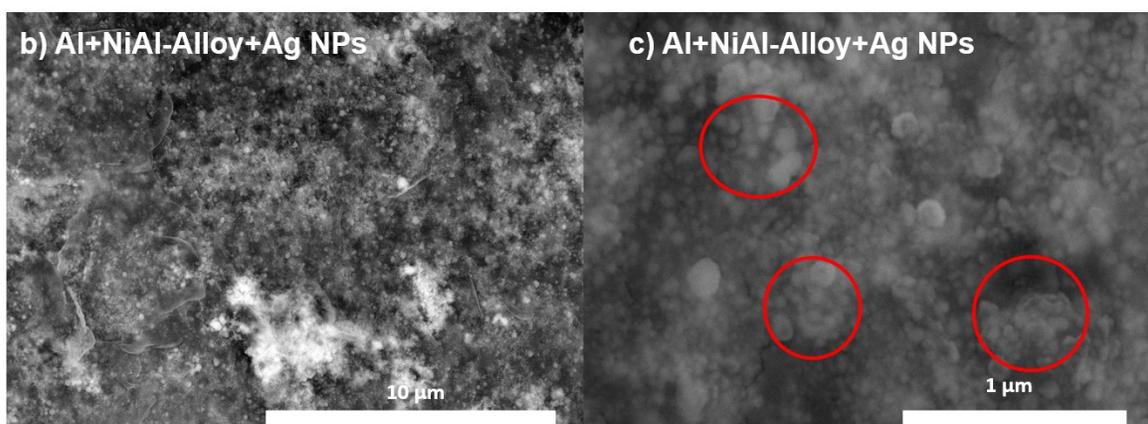
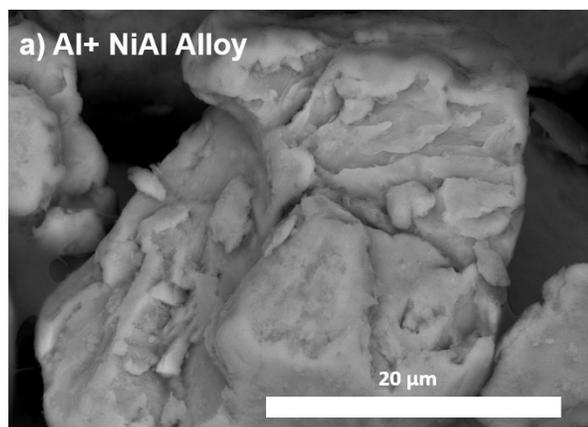


FIGURE S11. SEM images for: a) Bare NiAl alloy microparticle, b) NiAl alloy microparticle decorated with Ag NPs and c) Zoomed view for the NiAl alloy microparticle decorated with Ag NPs.

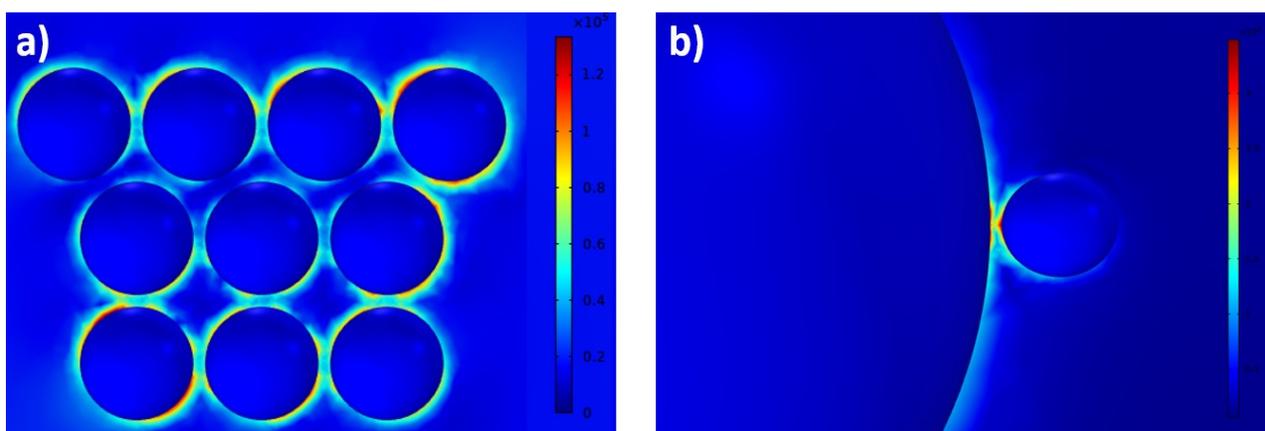


FIGURE S12. Calculation of electric field for the following systems: a) agglomerate of 10 Ag NPs and b) one Ag NP and the bulk NiAl alloy. The separation distance among particles was 2 nm.

TABLE S1. Parameters for the detection of RhB using the FSERS substrates made of Al+Ag-NPs

| Sample | Number of Moles on substrate | Number of Molecules on substrate | Sample Area (μm^2) | Molecules/substrate area (μm^2) | EF | Standard Deviation |
|--------|------------------------------|----------------------------------|---------------------------------|--|---|--------------------|
| AlAg-1 | 8.35×10^{-9} | 5.0296×10^{15} | 1×10^8 | 5.0296×10^7 | 33495 | $\pm 5\%$ |
| AlAg-2 | 8.35×10^{-12} | 5.0296×10^{12} | 1×10^8 | 5.0296×10^4 | 3.898×10^7 | $\pm 5\%$ |
| AlAg-3 | 8.35×10^{-14} | 5.0296×10^{10} | 1×10^8 | 5.0296×10^4 | 2.13×10^9 | $\pm 5\%$ |
| AlAg-4 | 8.35×10^{-16} | 5.0296×10^8 | 1×10^8 | 5.02×10^0 | 1.20×10^{10} | $\pm 5\%$ |
| AlAg-5 | 8.35×10^{-18} | 5.0296×10^6 | 1×10^8 | 5.0296×10^{-2} | 7.08×10^{11} | $\pm 5\%$ |
| AlAg-6 | 8.35×10^{-20} | 5.0296×10^4 | 1×10^8 | 5.0296×10^{-4} | 6.21×10^{13} | $\pm 5\%$ |
| AlAg-7 | 8.35×10^{-22} | 5.0296×10^2 | 1×10^8 | 5.0296×10^{-6} | 3.11×10^{15} (reference= Al+NiAl) 1.07×10^{11} (reference= AlAg-1) | $\pm 5\%$ |

TABLE S2. Parameters for the detection of RhB using the FSERS substrates made of Al+NiAl+Ag-NPs

| Sample | Number of Moles on substrate | Number of Molecules on substrate | Sample Area (μm^2) | Molecules/substrate area (μm^2) | EF | Standard Deviation |
|--------|------------------------------|----------------------------------|---------------------------------|--|--|--------------------|
| AAAg-1 | 8.35×10^{-9} | 5.0296×10^{15} | 1×10^8 | 5.0296×10^7 | 59772 | $\pm 5\%$ |
| AAAg-2 | 8.35×10^{-12} | 5.0296×10^{12} | 1×10^8 | 5.0296×10^4 | 1.74×10^7 | $\pm 5\%$ |
| AAAg-3 | 8.35×10^{-14} | 5.0296×10^{10} | 1×10^8 | 5.0296×10^4 | 3.32×10^8 | $\pm 5\%$ |
| AAAg-4 | 8.35×10^{-16} | 5.0296×10^8 | 1×10^8 | 5.02×10^0 | 4.29×10^{10} | $\pm 5\%$ |
| AAAg-5 | 8.35×10^{-18} | 5.0296×10^6 | 1×10^8 | 5.0296×10^{-2} | 1.94×10^{12} | $\pm 5\%$ |
| AAAg-6 | 8.35×10^{-20} | 5.0296×10^4 | 1×10^8 | 5.0296×10^{-4} | 6.22×10^{14} | $\pm 5\%$ |
| AAAg-7 | 8.35×10^{-22} | 5.0296×10^2 | 1×10^8 | 5.0296×10^{-6} | 5.203×10^{16} | $\pm 5\%$ |
| AAAg-8 | 8.35×10^{-24} | 5.0296×10^0 | 1×10^8 | 5.0296×10^{-8} | 2.05×10^{17} (reference= Al+NiAl) 3.42×10^{12} (reference= AAG-1) | $\pm 5\%$ |

TABLE S3. Parameters for the detection of RhB using the FSERS substrates made of G+Ag-NPs

| Sample | Number of Moles on substrate | Number of Molecules on substrate | Sample Area (μm^2) | Molecules/substrate area (μm^2) | EF | Error |
|--------|------------------------------|----------------------------------|---------------------------------|--|--------------------------|-----------|
| GAg-1 | 8.35×10^{-9} | 5.0296×10^{15} | 1×10^8 | 5.0296×10^7 | 12891 | $\pm 5\%$ |
| GAg-2 | 8.35×10^{-12} | 5.0296×10^{12} | 1×10^8 | 5.0296×10^4 | 7.7×10^6 | $\pm 5\%$ |
| GAg-3 | 8.35×10^{-14} | 5.0296×10^{10} | 1×10^8 | 5.0296×10^4 | 6.86×10^7 | $\pm 5\%$ |
| GAg-4 | 8.35×10^{-16} | 5.0296×10^8 | 1×10^8 | 5.02×10^0 | 2.7×10^9 | $\pm 5\%$ |
| GAg-5 | 8.35×10^{-18} | 5.0296×10^6 | 1×10^8 | 5.0296×10^{-2} | No Raman signal observed | $\pm 5\%$ |

TABLE S4. Parameters for the detection of RhB using the FSERS substrates made of G+NiAl+Ag-NPs

| Sample | Number of Moles on substrate | Number of Molecules on substrate | Sample Area (μm^2) | Molecules/substrate area (μm^2) | EF | Error |
|--------|------------------------------|----------------------------------|---------------------------------|--|-----------------------|-----------|
| GAAg-1 | 8.35×10^{-9} | 5.0296×10^{15} | 1×10^8 | 5.0296×10^7 | 37137 | $\pm 5\%$ |
| GAAg-2 | 8.35×10^{-12} | 5.0296×10^{12} | 1×10^8 | 5.0296×10^4 | 1.6×10^7 | $\pm 5\%$ |
| GAAg-3 | 8.35×10^{-14} | 5.0296×10^{10} | 1×10^8 | 5.0296×10^4 | 1.1×10^9 | $\pm 5\%$ |
| GAAg-4 | 8.35×10^{-16} | 5.0296×10^8 | 1×10^8 | 5.02×10^0 | 1.1×10^{11} | $\pm 5\%$ |
| GAAg-5 | 8.35×10^{-18} | 5.0296×10^6 | 1×10^8 | 5.0296×10^{-2} | 5.02×10^{12} | $\pm 5\%$ |
| GAAg-6 | 8.35×10^{-20} | 5.0296×10^4 | 1×10^8 | 5.0296×10^{-4} | 4.83×10^{13} | $\pm 5\%$ |
| GAAg-7 | 8.35×10^{-22} | 5.0296×10^2 | 1×10^8 | 5.0296×10^{-6} | 6.89×10^{15} | $\pm 5\%$ |