Interference amplified SERS

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Outline

• Principles of IESERS
• Experimental details:
  Au Island film (633 nm)
  Au Island film (514.5 nm)
  Au continuous/rough film (633 nm)
• High $\alpha$ or high $R$?
• Conclusion
Sructurisation of gold layer (SERS, photoemission)

Porous aluminium oxide
(anodization)

(COOH)$_2$, $U_a=40\, \text{B}$, $T=20^\circ\text{C}$

H$_3$PO$_4$, $U_a=60\, \text{B}$, $T=20^\circ\text{C}$

High SERS signal; Nanotructrurisation of gold + interference?
Interference enhanced Raman Scattering (IERS)

IERS: structure consisting of three layers
1. sample layer
2. resonator layer (dielectric cavity)
3. reflecting layer (metallic mirror)

total optical thickness of the layers (1) and (2) = \( \lambda/4 \)
(taking into account \( n \))

Materials with high \( \alpha \)

- Absorption in dielectric layer is very low
- base layer is a good reflector

light is absorbed wholly in the sample layer

Raman Scattering efficiency enhances the signal to noise ratio by a factor 10 to 1000

Interference enhanced SERS

Sample

e-beam evaporation:
Al and Au (3·10^{-6} mbar, rate Al - 3 nm/s, Au – 0.3 nm/s)
SiO₂ (10^{-4} mbar, rate 0.3 nm/s)

Island film = «effective» medium

<table>
<thead>
<tr>
<th>Au mass thickness, nm</th>
<th>α_{eff} 514, cm⁻¹</th>
<th>α_{eff} 633, cm⁻¹</th>
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<tbody>
<tr>
<td>5</td>
<td>6·10⁵</td>
<td>1.3·10⁶</td>
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<th>Au mass thickness, nm</th>
<th>R514 (I/I₀)</th>
<th>R633 (I/I₀)</th>
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<td>5</td>
<td>0.18</td>
<td>0.24</td>
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Wavelength (nm)

lg(lo/I)

514.5
632.8
SERS intensity vs Reflectivity

$R_{ws}$ should be low

excitation
Stokes 1200 cm$^{-1}$
Au 5 nm, 632.8 nm

backscattering geometry.
angle of incidence 0°.
SERS: He-Ne laser, output power 6 mW
Objective x10, NA=0.25
Au 5 nm, 514.5 nm

backscattering geometry.
angle of incidence 0°.
SERS: Ar+ laser, output power 2.5 mW
Objective x10, NA=0.25

No LSPR
High $\alpha$ or high $R$?
Au 15 nm, 632.8 nm

backscattering geometry.
age of incidence 0°.
SERS: He-Ne laser, output power 6 mW
Reflectance: white light lamp

[Graph showing the relationship between resonator layer thickness and SERS intensity]
Fabri-Perot

$R_{\text{eff}} = 0.3$

Au, 5 nm

$R_{\text{eff}} = 0.75$

Au, 15 nm
Conclusion

• Enhancement of signal from 10 to 40 times (depending on Au layer properties)
• Thin layer (islands) – LSPR + amplification of Stokes scattering and excitation light
• Thick layer (rough) – Fabri-Perot resonator (narrow absorption)

THANK YOU FOR THE ATTENTION!