Evaporated gold island films show a localized surface plasmon (SP) resonance, resulting in enhanced light scattering, the appearance of a characteristic absorption band, and enhancement of local electromagnetic fields. These properties have been used in surface-enhanced spectroscopies as well as in chemical and biological sensing. The latter application is based on the sensitivity of the surface plasmon band to changes in the effective refractive index of the surrounding medium.

In the present work, gold island films (57.5 nm nominal thickness) were evaporated on siliconized glass substrates. The 3D shape of unannealed and annealed (20 min at 200°C) islands was investigated using high-resolution SEM and cross-sectional TEM imaging. The sensitivity of gold island films to the refractive index of the contacting medium was measured for island films of different nominal thicknesses.

Application of Au island films to gas sensing in the transmission localized surface plasmon resonance (T-LSPR) mode was demonstrated by spin-coating of hydrophobic (polystyrene) and hydrophilic (polystyrene sulfonate) polymers onto 5 nm (nominal thickness) Au island films. Changes in the SP band (intensity, wavelength of maximum absorbance) observed upon exposure to various vapors is attributed to vapor absorption and polymer swelling, effecting change in the refractive index of the island’s environment.

Gold island films with unique morphologies were studied as possible substrates for surface-enhanced Raman scattering (SERS) applications using Rhodamine 6G (R6G) as a marker.

**Surface-Enhanced Raman Spectroscopy**

<table>
<thead>
<tr>
<th>Nominal thickness (nm)</th>
<th>a (nm)</th>
<th>b (nm)</th>
<th>c (nm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.5</td>
<td>15±3</td>
<td>13±3</td>
<td>13±2</td>
</tr>
<tr>
<td>5</td>
<td>30±7</td>
<td>24±6</td>
<td>22±6</td>
</tr>
<tr>
<td>7.5</td>
<td>71±2</td>
<td>43±15</td>
<td>39±8</td>
</tr>
</tbody>
</table>

Cross-sectional TEM (left) and HREM (right) images

The reflective index sensitivity of annealed gold island films is determined by extinction measurements in mixtures of methanol and chloroform ($\Delta \lambda / 1.33 \pm 0.45$).

**Gas Sensing**

T-LSPR transducers were fabricated by spin-coating of polymer layers onto Au island films (5 nm nominal thickness, evaporated on siliconized glass and annealed).

**Summary**

- Evaporated Au island films were studied as possible candidates for T-LSPR sensing and SERS substrates. Upon annealing the islands undergo coalescence and attain an oblate spheroid shape, increasing the average island size and separation between islands and decreasing the relative contact area with the substrate. The refractive index sensitivity increases for higher nominal thicknesses.

- The optical response of polymer-coated T-LSPR transducers is sensitive to vapor analytes. Vapors of good solvents induce polymer swelling and thickness increase, manifested as a characteristic change in the reflective index of the island.

- The Raman spectrum of Rhodamine 6G adsorbed on a two-layer hierarchical Au island film was substantially enhanced relative to that obtained with a regular Au island film. Such substrates are therefore promising for surface-enhanced Raman spectroscopy (SERS) and can be optimized by controlling various morphological and interfacial parameters of the hierarchical system.