MORPHOLOGY AND OPTICAL PROPERTIES OF GOLD ISLAND FILMS FORMED BY ANNEALING OF PERCOLATED GOLD LAYERS

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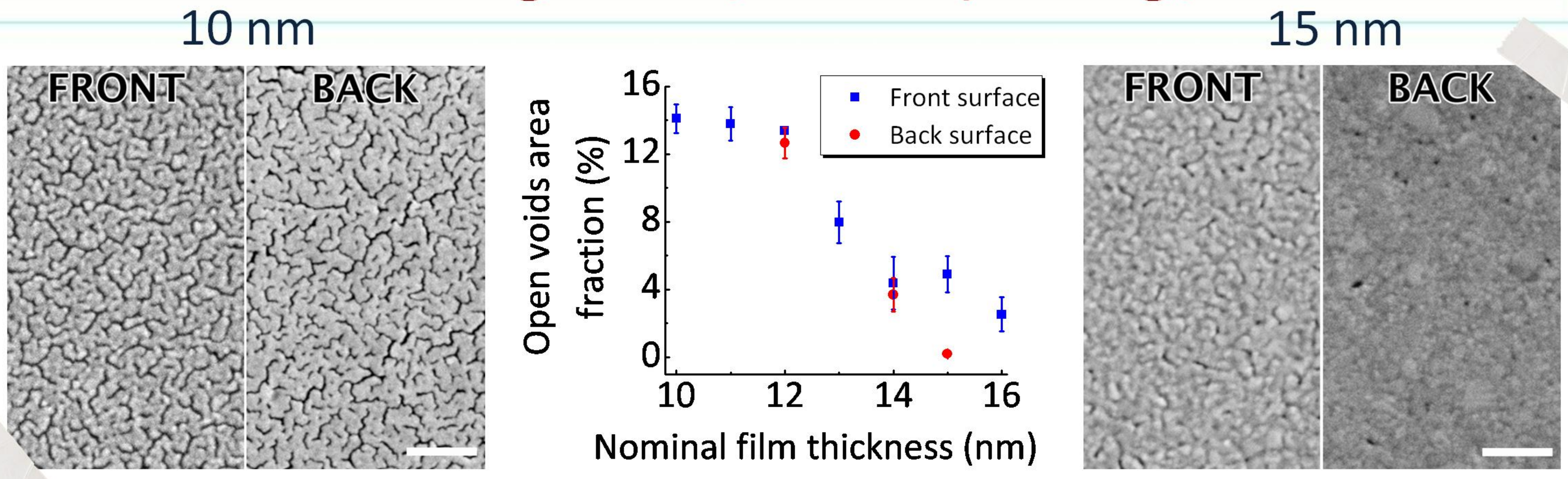
Introduction

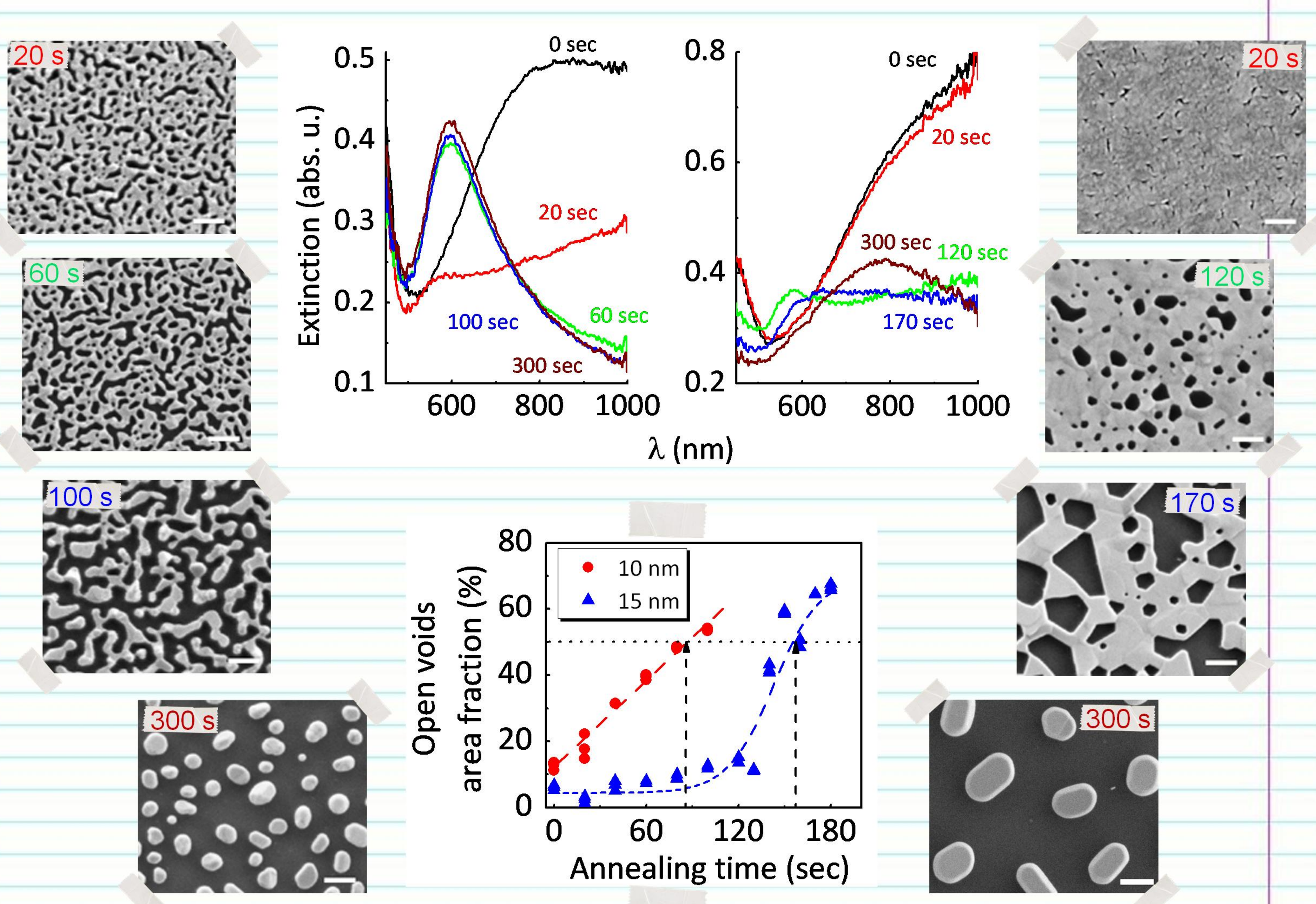
Noble metal nano-island films supporting localized surface plasmon resonance (LSPR) are of interest as optical transducers in a variety of sensing applications. The refractive index sensitivity (RIS) and decay length of LSPR transducers, crucial for determining the transducer sensitivity to specific analytes, vary with the island film morphology. Therefore, development of an effective and applicable technology allowing tuning of the surface plasmon (SP) band is critical for optimization of LSPR transducers.

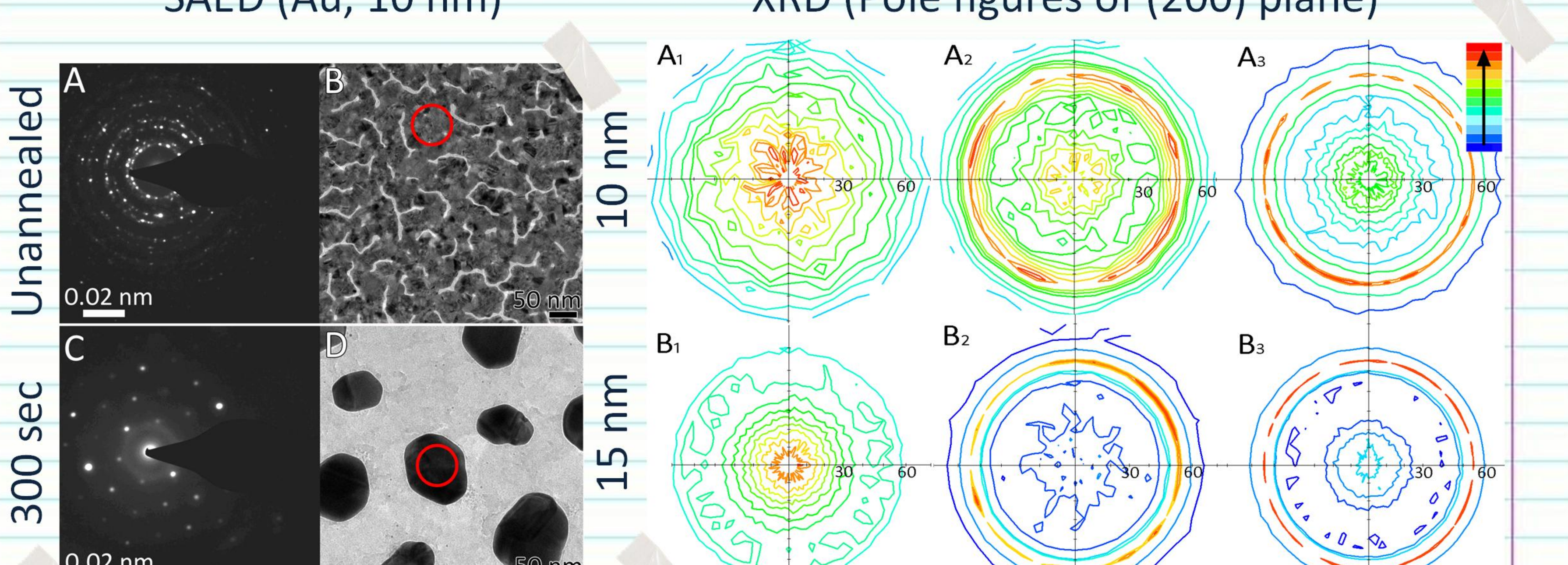
Initial gold layer morphology



A 10-nm-thick evaporated Au layer shows open voids penetrating to the glass; a 15-nm-thick layer is asymmetric, showing continuous Au at the bottom.

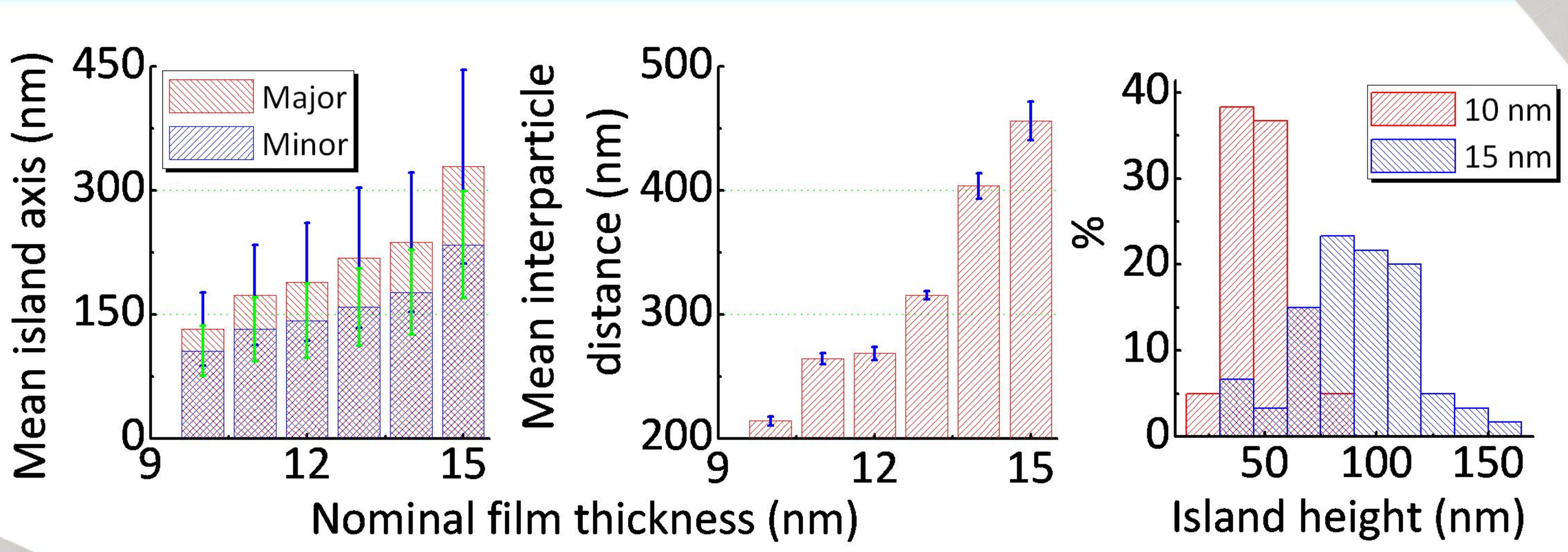
Au layer morphology during annealing



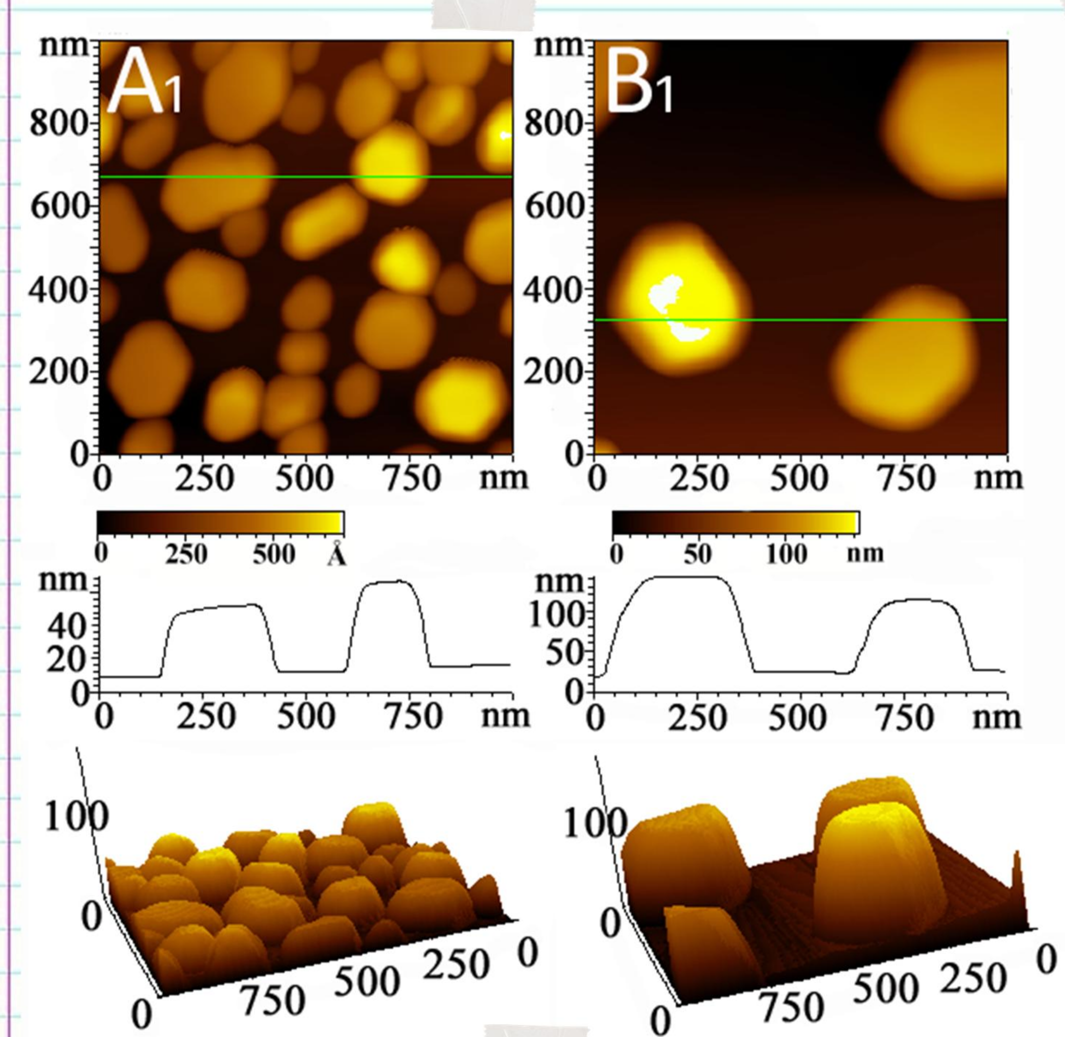


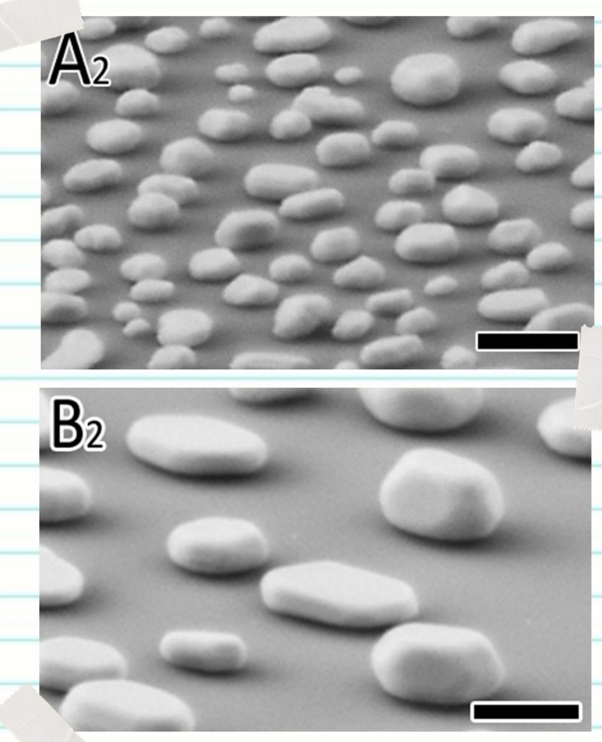
Left: Selected-area electron diffraction (SAED) and corresponding TEM images of a 10 nm Au layer, as-deposited and after 300 sec at 550 °C (red circle indicates the selected area aperture). **Right:** A representative set of pole figures obtained at the Bragg angle of {200} (2θ = 44.4°). (A_1, B_1) as-deposited Au layers on bare glass; (A_2, B_2) 300 sec and (A_3, B_3) 10 h at 550 °C.

Structural parameters of annealed Au island films



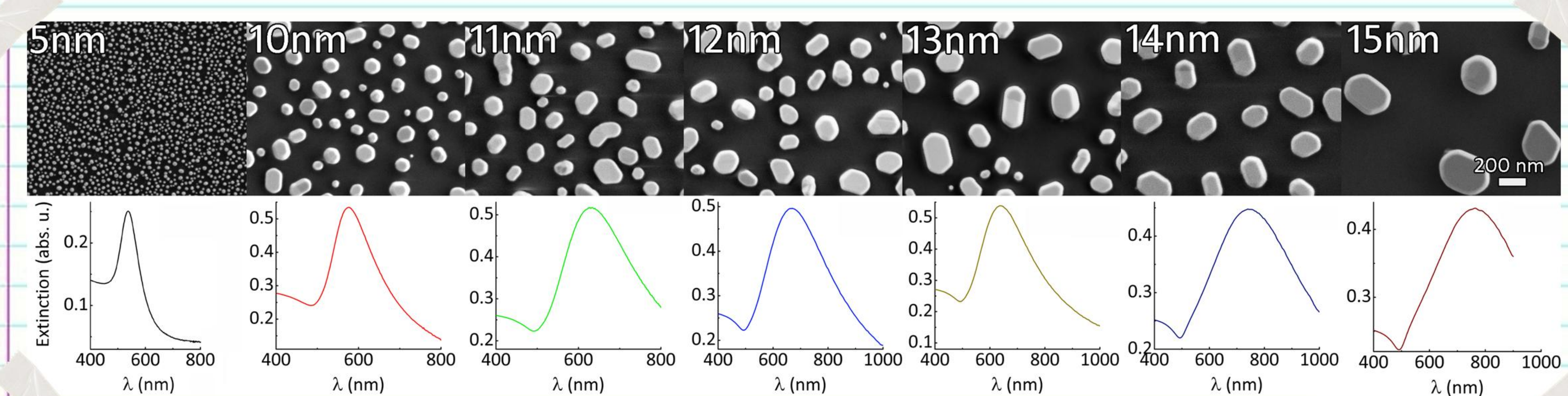
Imaging of island morphology



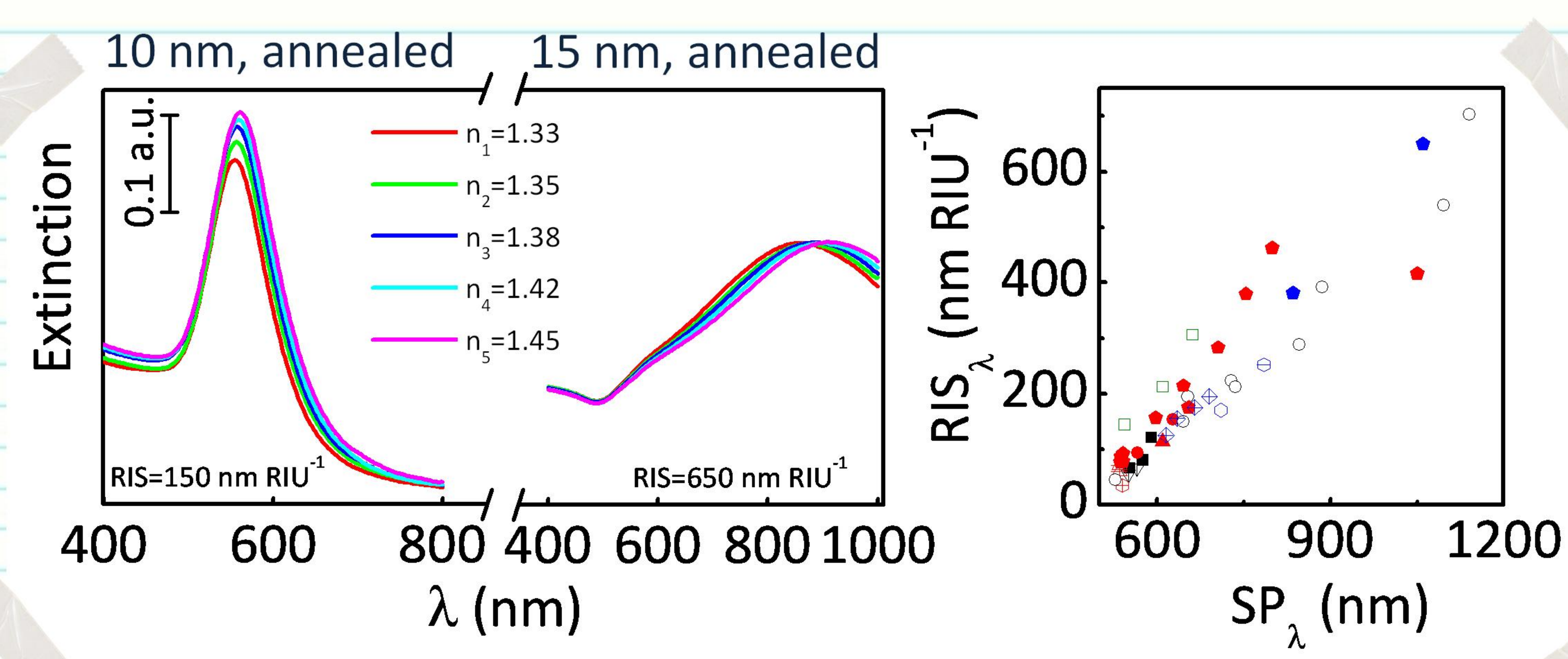


AFM and HRSEM images of Au films, 10 nm (A_i) and 15 nm (B_i) nominal thickness, annealed 10 h at 550 °C.

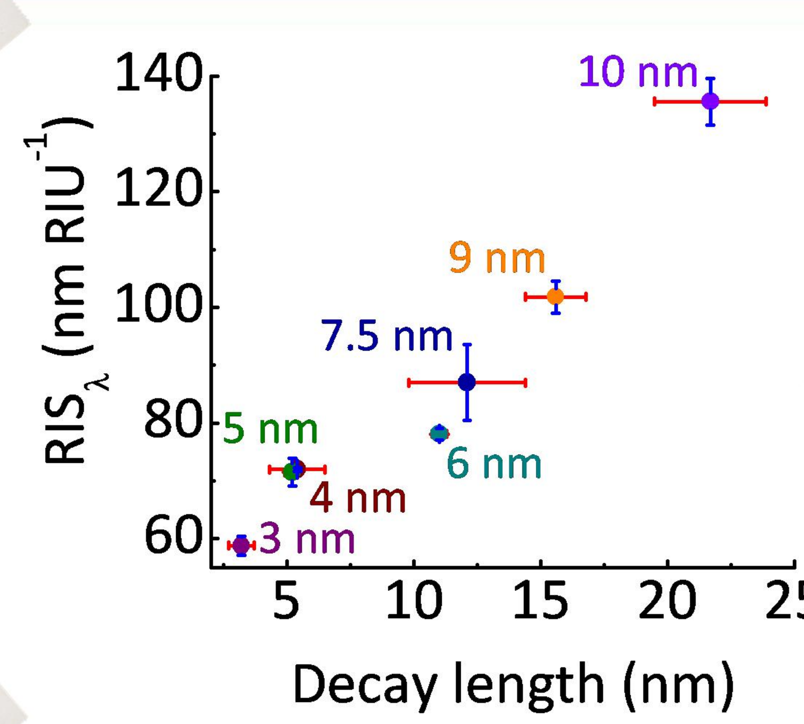
Tuning of the surface plasmon band



Refractive index sensitivity (RIS) of Au island films



Decay length vs. RIS_λ in Au island films



For Au islands of 3 – 10 nm (nominal thickness) the RIS_λ and wavelength decay length are correlated nearly linearly.

Conclusions

A new route to the preparation of Au island films using high-temperature annealing of near-percolated films is shown. Annealing at temperatures higher than ca. 500 °C produces an ensemble of single-crystalline islands with atomically-flat (111) top surfaces. The RIS_λ of such transducers increases with island size. Films formed by thermal depercolation of Au layers show exceptionally high RIS values, up to ca. 650 nm RIU^{-1}. However, their decay length is much larger than the size of common analytes and recognition interfaces. Hence, to optimize LSPR sensing it is imperative to choose a transducer presenting a combination of RIS and decay length which maximizes the response to a specific analyte and recognition layer of given dimensions.