

SUPPORTING INFORMATION

Embedding plasmonic nanostructure-diodes enhances hot electron emission

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Electric field and absorption profiles

The spatial distribution of absorption within plasmonic nanowires varies weakly with embedding depth. To illustrate this, we show both the electric field enhancements and absorption profiles for an idealized Au nanowire at $\lambda = 1300$ nm for the two extremes of embedding depth considered in this Letter (Fig. S1). For all embedding depths ($D = 5$ nm and 25 nm shown), the maximum field enhancement occurs on the two bottom corners. Correspondingly, the absorption maxima are localized at these corners. The remaining absorption occurs near the Au surface, both on the sides and on bottom of the nanowire; absorption within the silica and silicon is negligible.

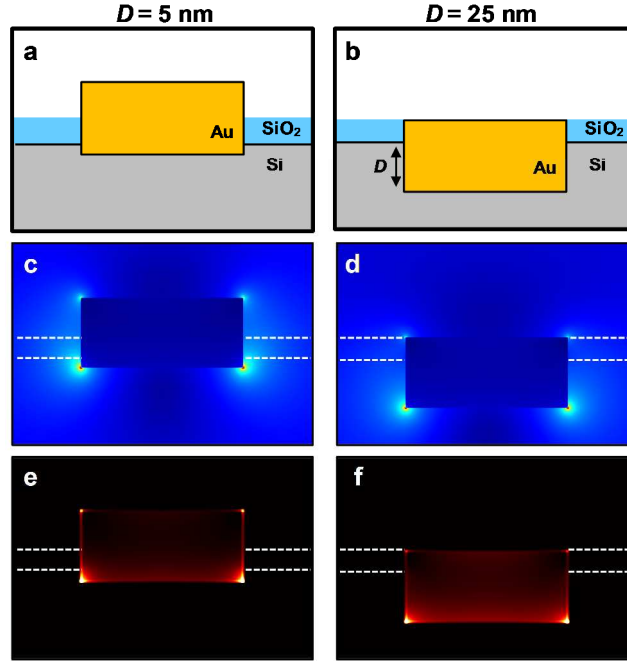


Figure S1. Effect of embedding nanowires in silicon on the near-field and absorption profiles in a representative 80 nm width nanowire, for (a) partial embedding and (b) nearly complete embedding. (c)-(d) The electric field profiles, shown on the same color scale, are minimally affected by increasing the embedding depth, D . (e)-(f) Absorption distributions within the nanowires, which correspond to maps of hot electron production, also are unaffected by varying the embedding depth. Both color scales are identical.

Experimental and calculated enhancements

Experimental photocurrent enhancements, which are the ratio of photocurrent from an embedded device to a minimally embedded device, increase strongly for decreasing nanowire widths (Fig. S2a). This strong enhancement, which approaches 10 for our smallest devices, cannot be explained using either electrodynamic calculations of the absorption or from simple geometric considerations. Using the finite difference time domain method (FDTD, Lumerical) we have calculated the same ratio for the absorption cross sections. These absorption enhancements deviate weakly from unity across the range of sizes considered. The geometric enhancement, calculated as the ratio of the Schottky contact areas between an embedded device

and an unembedded device, shows an increase for smaller devices. This simple geometric approach also fails to account for the large enhancements measured experimentally.

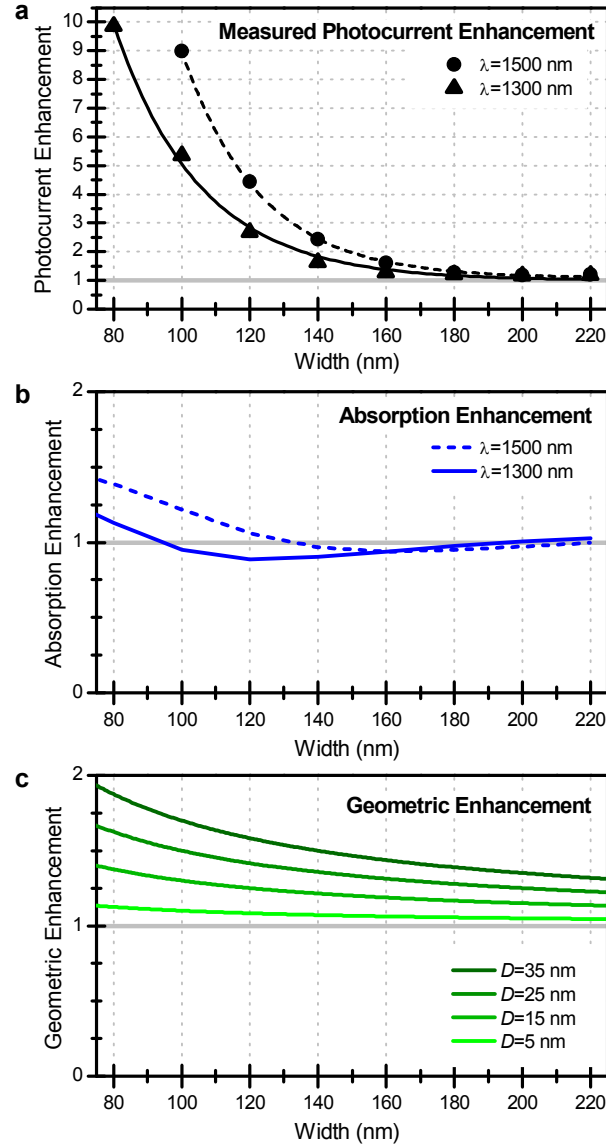


Figure S2. (a) Experimental photocurrent enhancements exceed the enhancements predicted using either (b) calculated enhancements in the absorption cross section or (c) geometric enhancements in the Schottky contact area. The measured enhancements, which significantly exceed predictions based on calculated absorption and geometric factors, suggest that the sidewalls – which provide a Schottky interface normal to the plasmonic oscillations – dominate the photocurrent response.

To explain the discrepancy between simple theory and our measured enhancements, we suggest that the decay of a plasmon creates an anisotropic distribution of hot electrons localized in k -space along the axis of plasmon propagation,¹⁻² rather than the isotropic distribution commonly assumed when explaining transport over a Schottky interface.³ Since emission from the Au across the Schottky interface is only possible for a narrow, near-normal angular distribution of electron wavevectors, the vertical interfaces would dominate the overall response for anisotropic distribution of wavevectors.

References

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