Nanoantennas are key optical elements in the conversion of light from free-space to ultra-small volume. Since they can provide highly-enhanced fields, strong confinement (to sub-wavelength scale) and high bulk and surface sensitivities, they are of interest in photodetection and biosensing applications. A Schottky barrier photodetector formed at the interface between a metal and a lightly doped semiconductor can be used to detect infrared radiation below the bandgap energy of the semiconductor via the internal photoelectric effect [1].

In this paper we report on electrically-contacted metal nanodipole antennas on Si for photodetection and biosensing. To this end, we introduce a Au nanodipole array on Si, forming a Schottky contact thereon, covered by water, supporting short-range surface plasmon polaritons. Fig. 1 (left) shows a sketch of the concept, where the Au nanodipoles are interconnected via Au lines running perpendicularly to the dipole axes through the middle of each arm to a common circular contact pad used to collect the photocurrent. We use a hot-carrier thin-film model to calculate the internal quantum efficiency [1]. Fig. 1 (right) shows the computed responsivity ($R_{\text{exp}}$) and minimum detectable power ($S_{\text{min}}$) vs. free space wavelength ($\lambda_0$).

The rectenna can monitor changes in the refractive index of bulk solutions and in the thickness of (bio)chemical adlayers on its surface. High sensitivities are predicted for the dipoles: 250 nm/RIU (bulk) and 8 nm/nm (surface), determined using FDTD methods [1]. We also model the gap between the arms of nanodipoles as a capacitor and the two arms as two open-circuited transmission lines and find an implicit expression yielding the resonant wavelength from modal results. Using this model we obtain expressions for the bulk and surface sensitivities which are in a good agreement with the FDTD results, and optimal designs that maximize the sensitivities [2].

The fabrication and experimental characterization of rectennas have been initiated. Electrically-contacted nanodipole arrays are made via E-beam lithography and Au lift-off on p-Si. Two scanning electron microscope (SEM) images of a realized structure are shown in Fig.2. The top SEM shows an array connected to a circular pad and the bottom one shows a close-up of the array.

In addition to biosensing applications, the broad infrared sensitivity of this device could enable low-cost silicon imaging detectors.
