**Fabrication of nanorod structure:** The Au nanorods were electrochemically grown in a substrate-supported, porous, anodized aluminum oxide (AAO) template [S1]. The substrate is a multilayered structure comprising a 1 mm thick glass slide, a 10 nm thick Ta₂O₅ base layer, and a 5 nm thick Au film acting as the working electrode for the electrochemical reaction. An aluminum film of up to 500 nm thick is then planar magnetron sputter deposited onto the electrode. This Al film is subsequently anodized to produce the porous alumina template. The diameter, separation, as well as ordering of Au rods in the assembly are determined by the geometry of the AAO template, i.e. the anodization conditions. The geometry of the AAO template determines the rod diameter and spacing. These parameters, in addition to the rod length, can be tuned to control the optical properties of the nanorods throughout the visible and near-infrared spectrum [S1].

**Optical measurements** were performed using collimated white light from a tungsten halogen lamp which was incident onto the sample from the substrate side and, after passing through the sample, was collected using an objective lens and coupled to the spectrometer equipped with a liquid nitrogen cooled CCD via a multimode optical fibre. Angular and polarisation resolved transmission spectra were measured. For ATR measurements, the sample was placed in immersion contact with a glass prism and illuminated through the prism. Angular and spectral dependences of the reflected light were examined in this case. For high precision sensing measurements in ATR geometry the prism with the nanorod structure was placed onto a rotary block of a variable angle spectroscopic ellipsometer (Woollam VASE® ellipsometer, J.A. Woollam, Lincoln, NE) to allow a very fine variation of the angular prism position with respect to the optical path of the ellipsometer. The nanorod structure was brought into a contact with a flow cell, filled with aqueous solutions. Using a peristatic pump, we introduced solutions of water with different concentrations of Glycerine to the cell. Knowing the difference of refractive indices of Glycerine and water, we could calibrate and determine the detection limit of our system. The system was illuminated by monochromatic light.
with variable wavelength, obtained by the passing of a white-light source through a monochromator. The experiments were performed with a configuration of either fixed wavelength or incident angle. Passive thermal stabilisation was used providing temperature stability better than $10^{-2}$ K. Numerical estimations indicate that the temperature stability of the G-mode resonance is about 0.01 nm/K against thermal expansion effects and about 0.3 nm/K against combined refractive index variations of Au and analyte with temperature.

**Numerical simulations of optical response of nanorod assemblies:** In our simulations we assumed that permittivity of gold is described by Drude model with finite-size corrections as described in Ref. S2. The dispersion of the modes of periodic nanorod arrays was simulated using commercial finite-element PDE solver. For each excitation frequency two lowest-band modes of periodic nanorod array were identified. For frequencies and wavevector-ranges used in the experiments, numerically obtained dispersion relations of these modes were identical to those of ordinary and extraordinary plane waves propagating in uniaxial media. Since the propagation of ordinary waves is not affected by material anisotropy, these simulations allowed to unambiguously extract the values of components of permittivity tensor of the metamaterial. As seen in figure S1, the extracted values showed vanishing spatial dispersion (dependence on the components of the wavevector), and were in perfect agreement with predictions of effective medium theory described in detail in Ref. 22. Once the validity of effective medium theory is established, reflectivity data, as well as properties of waveguide modes supported by the system were calculated using transfer matrix approach.

**Biosensing test:** We strictly followed a commercial biosensing protocol described in Ref. 25 of the manuscript. After several functionalization steps, including the immobilisation of 8-amino-1-octanethiol to make possible the attachment of streptavidin molecules and block unspecific sorption, the nanorods were immobilized by a streptavidin-Melamide complex as a receptor. Before the
injection of biological substances, metamaterial was in contact with PBS buffer solution. Then, biotin of gradually increasing concentration was injected in the flow cell. In the experiments, we controlled the position of the reflectivity minimum corresponding to the excitation of the G-mode. Fig. S2 shows the position of the minimum as a function of biotin concentration. One can see that the response of the G-mode is similar to responses of flow cell-coupled SPR and LSPR-based biosensors. The increase of the biotin concentration leads to a gradual increase of the mode response until the signal comes to saturation corresponding to a complete coverage of streptavidin sites. Under conditions of our experiments, this saturation took place at biotin concentration of about 100 μM. The spectral shift of the resonance can be in principle related to the amount of bound material and the surface coverage index but such analysis is challenging even in the case of a classic planar surface SPR [S3] and requires development of numerical tools, rigorous microscopy and mass analysis that are beyond the scope of this paper.

The detection limit was determined by a standard procedure, implying the comparison of noise and signal levels under the injection of a defined concentration of analyte (biotin). That is, the injection of 10 μM of biotin leads to the shift of the G-mode position by about 2 nm as determined from 10 tests. Taking into account that after averaging the level of noise is lower than 0.05 nm, we can conclude that the detection limit is at least 40 times lower than the above-stated signal. Therefore, even without the application of additional signal treatments (e.g., temporal or other signal modulation, as it is necessary in many cases with other sensing approaches), the detection limit is below 300 nM level. The application of additional treatments can further lower the detection limit.
REFERENCES


Fig. S1. Components of the effective permittivity tensor of the nanorod array in water environment calculated using effective-medium theory (lines) and via finite-element-based numerical solutions of Maxwell equations (shaded areas): dashed and dash-dotted lines correspond to the components of the permittivity along the nanorods ($\varepsilon_x$) and perpendicular to nanorods ($\varepsilon_{y,z}$), respectively; red and blue lines represent real parts of permittivity, black lines represent imaginary parts; imaginary part of $\varepsilon_{y,z}$ is vanishingly small. The thickness of shaded areas represents a weak effect of spatial dispersion (i.e., variation of the permittivity due to the changes in the direction of light propagation). Experimentally achievable range of angles $0<\theta<90^\circ$ is assumed. The insert is the zoom into the main graph.
Fig. S2. The dependence of the G-mode wavelength in the functionalized nanorod-based metamaterial on different concentrations of biotin under biotin-streptavidin binding reaction. The data are presented for a single, unaveraged test. The line is the guide for eyes only.