Highly Sensitive Microfiber-Based Surface Plasmon Resonance Sensor

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Abstract: A novel refractive index (RI) sensor based on microfiber (MF) coated with gold nanowires has been proposed and theoretically investigated. Comparing with gold film, the gold nanowires can significantly improve the performance of the MF sensor. The influences of the diameters of gold nanowire and microfiber on the sensing properties are investigated. For analyte RI $n_s = 1.33$, the maximum sensitivity of 5200nm/RIU ($D_{MF} = 3\mu m$, $D_{wire} = 120nm$) and the maximum figure of merit (FOM) of 150.38RIU⁻¹ ($D_{MF} = 9\mu m$, $D_{wire} = 30nm$) can be achieved. And both the sensitivity and FOM will increase when the RI increases from 1.33 to 1.40. For $n_s = 1.40$, an extremely high RI sensitivity of 12314nm/RIU ($D_{MF} = 10\mu m$, $D_{wire} = 50nm$) can be obtained.

KeyWords: Sensitivity; microfiber; gold nanowires.





Fig. 1. Schematic of gold nanowires based fiber sensor. (a) Three-dimensional schematic; (b) Cross-section of the proposed sensor; (c) A quarter of the cross-section and the boundary conditions; (d) is the zoom in of (c); (e) The geometry diagram of gold nanowires and microfiber.

The structure of the GNC-MF SPR sensor is illustrated in Fig. 1. Gold nanowires are arranged tightly around the surface of MF, where these nanowires are parallel to MF. The finite element method (FEM) is employed to simulate the model, where perfect electric conductor (PEC), perfect magnetic conductor (PMC), and perfect matched layer (PML) are used as the boundary conditions, as shown in Fig. 1(c). By doing so, only TE mode can be excited although both TE and TM modes can be supported by our model. For the microfiber, the refractive index of fused silica is 1.45. And the dielectric constant of the gold nanowire is described by the Drude model [3].



Fig. 2. The calculated real part of the effective index as a function of wavelength respectively for the MF-guided mode (black line) and plasmon mode (red line); Here, the diameters of gold nanowire and microfiber are 40nm and $6.0 \,\mu$ m, respectively. Insets are distributions of optical field respectively for plasmon mode (a), MF-guided mode (b), and SPR mode (c).