Waveguide – Sensor - Task P1 (VT2015)

a) Determine the wavelength range for single-mode guidance of the planar waveguide (WG1) sketched in the figure to the right, consisting of a sample with a thin film of thickness $d = 450$ nm and refractive index $n_t = 2.21$, deposited on a substrate of index $n_s = 1.44$, with a cladding of index $n_c=1.33$.

b) Calculate the penetration depths of the guided modes in the substrate and the cladding at an operational wavelength $\lambda = 1.55$ $\mu$m. Sketch and comment on the transverse distributions of their electric fields.

c) A second waveguide (WG2) – originally identical to the previous – is used as a substrate for bacterial population growth. After two days, the bacteria have grown to form a thick ($>5\mu$m) cladding, which covers uniformly a length $L = 775$ $\mu$m (along the propagation direction $z$) of the guiding film ($n_t$), while the rest of the waveguide has still the same cladding as WG1. WG2 and WG1 are then put in the two arms of a Mach-Zehnder interferometer (as sketched in the picture here on the left), which measures the relative phase delay between light propagating in WG2 and in WG1: $\Delta \varphi = \varphi_2 - \varphi_1$. The measurement, performed at $1.55$ $\mu$m for light polarized as shown in the figure (E-field), yields a phase lag $\Delta \varphi = \pi$. Calculate the average refractive index of the bacterial layer grown on WG2.