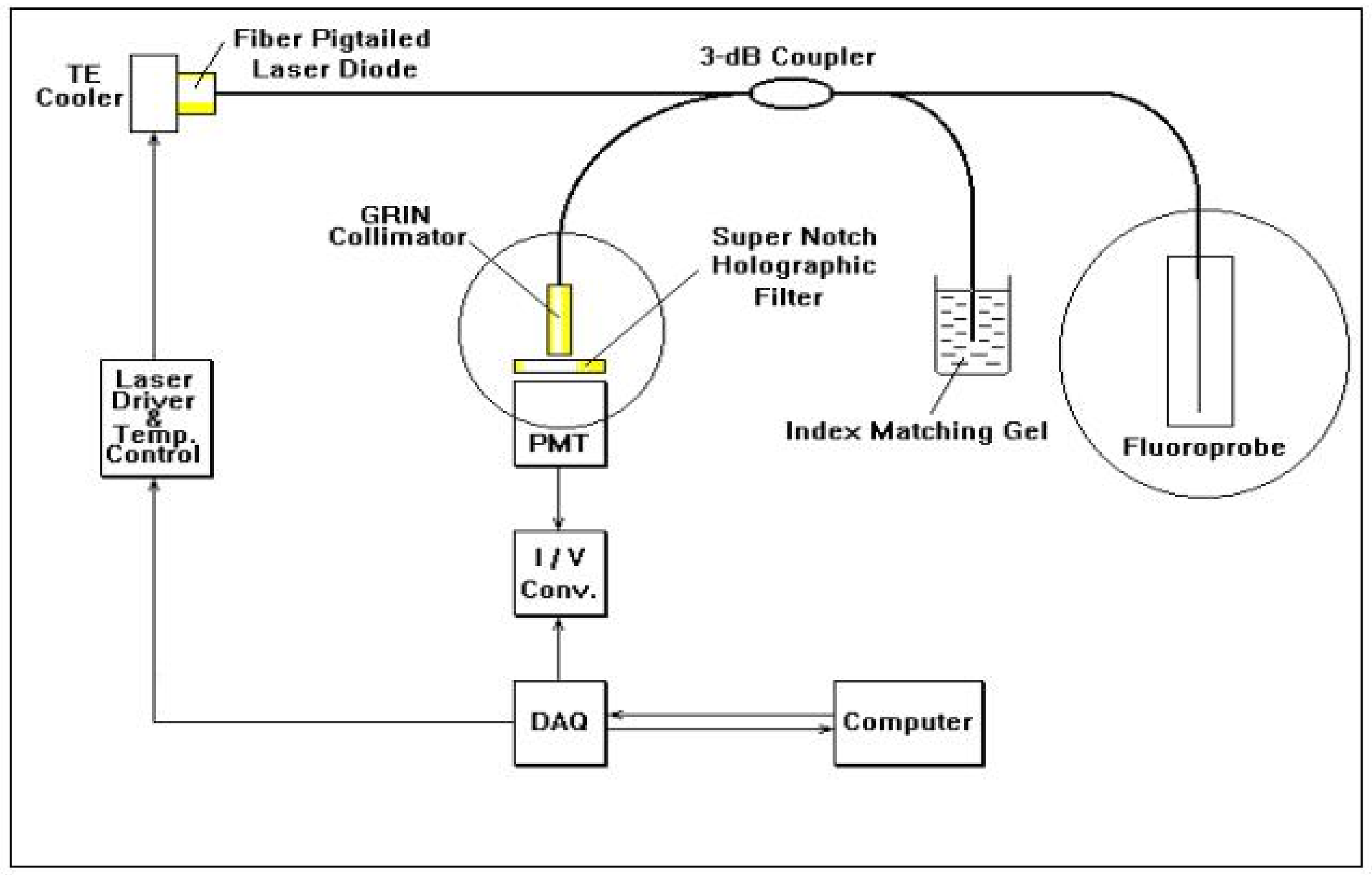
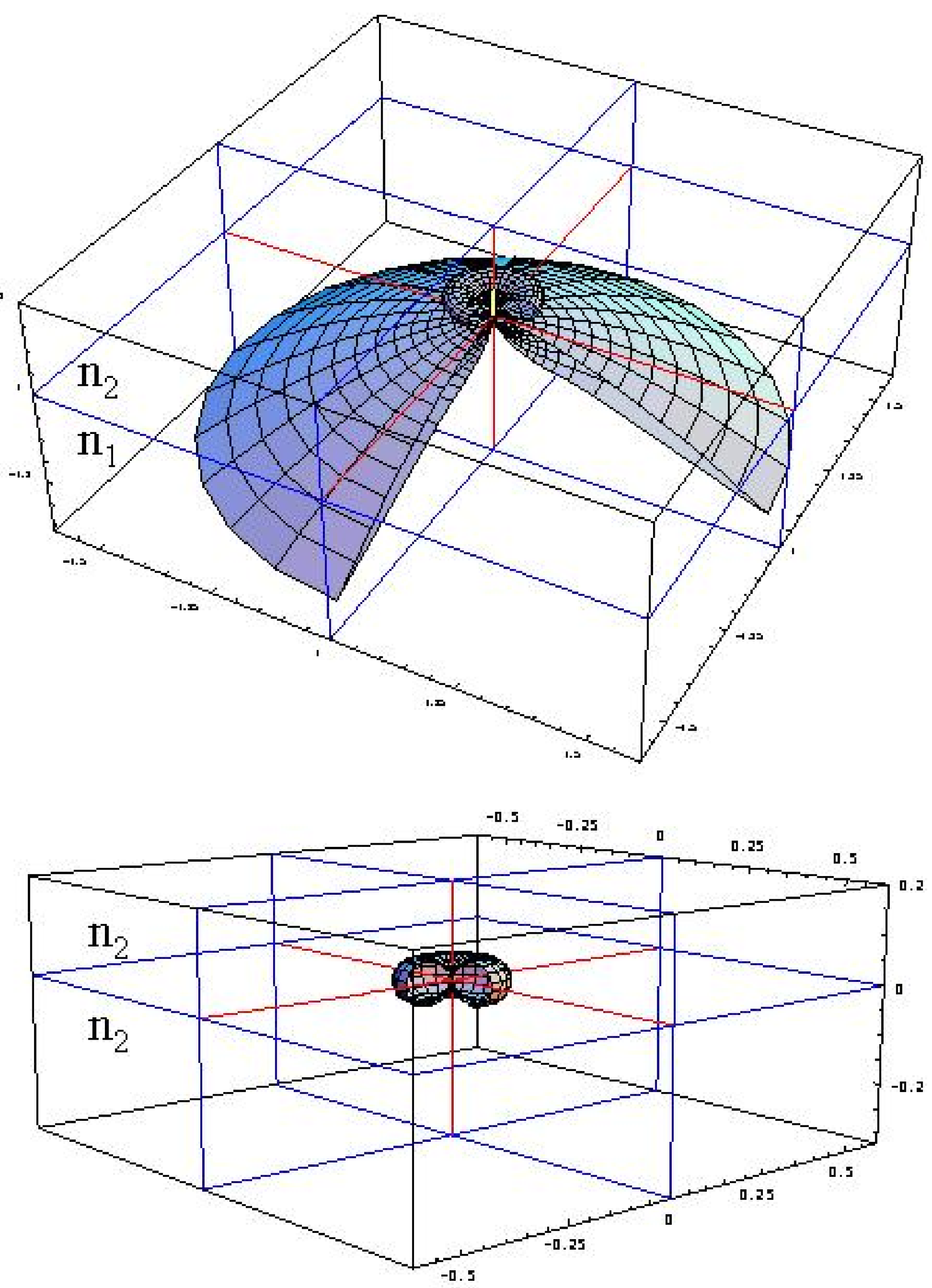
Optical Fiber Biosensors: Strong Anisotropy of Dipole Radiation at an Interface

Vildana Hodzic, *Hyunmin Yi, †James Sumner, † James B. Gillespie, *William Bentley, and Christopher C. Davis. Department of Electrical and Computer Engineering, *Department of Chemical Engineering, †Army Research Laboratory, Adelphi, MD



Schematic diagram of the optical fiber biosensor

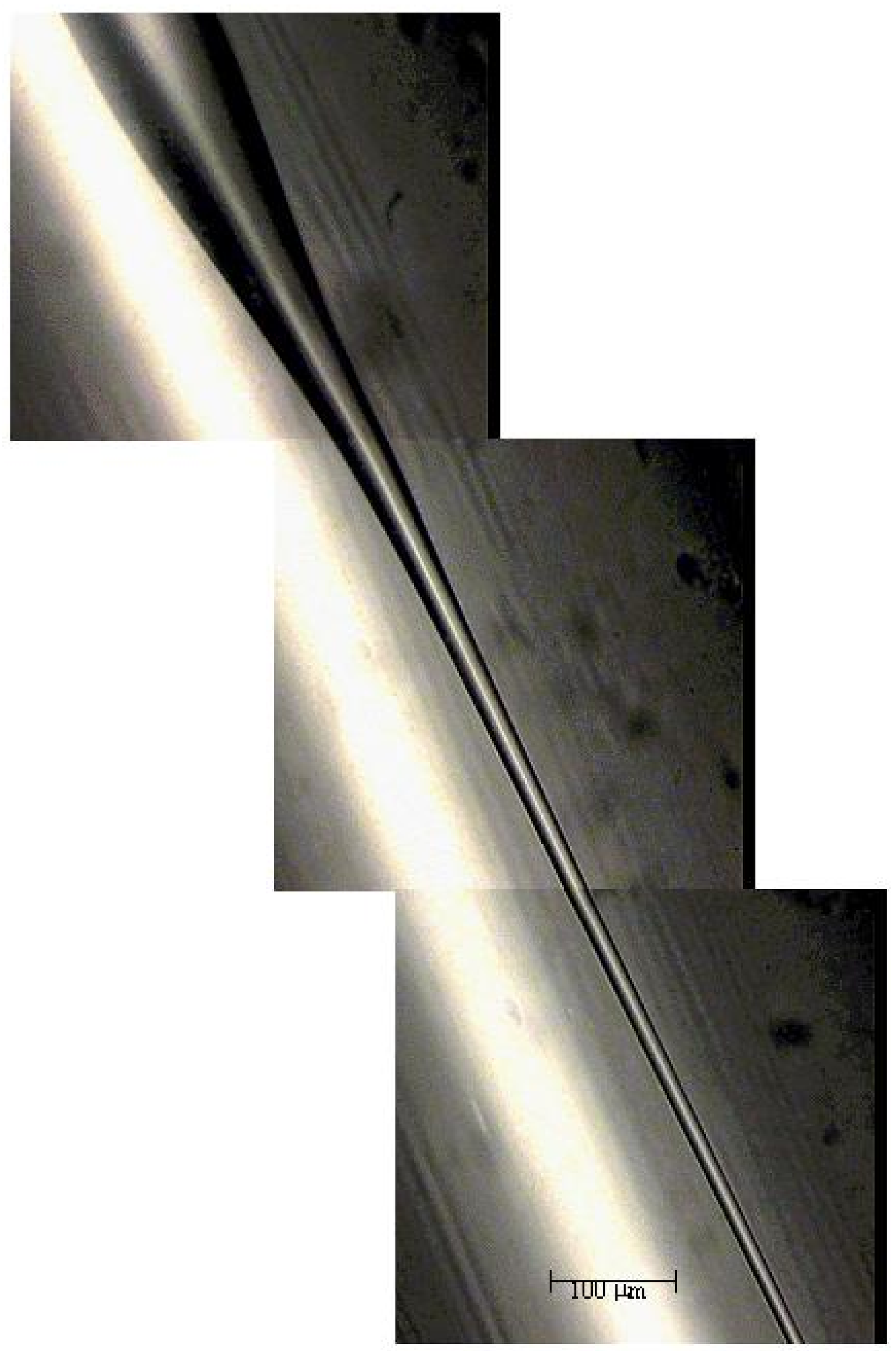


a)

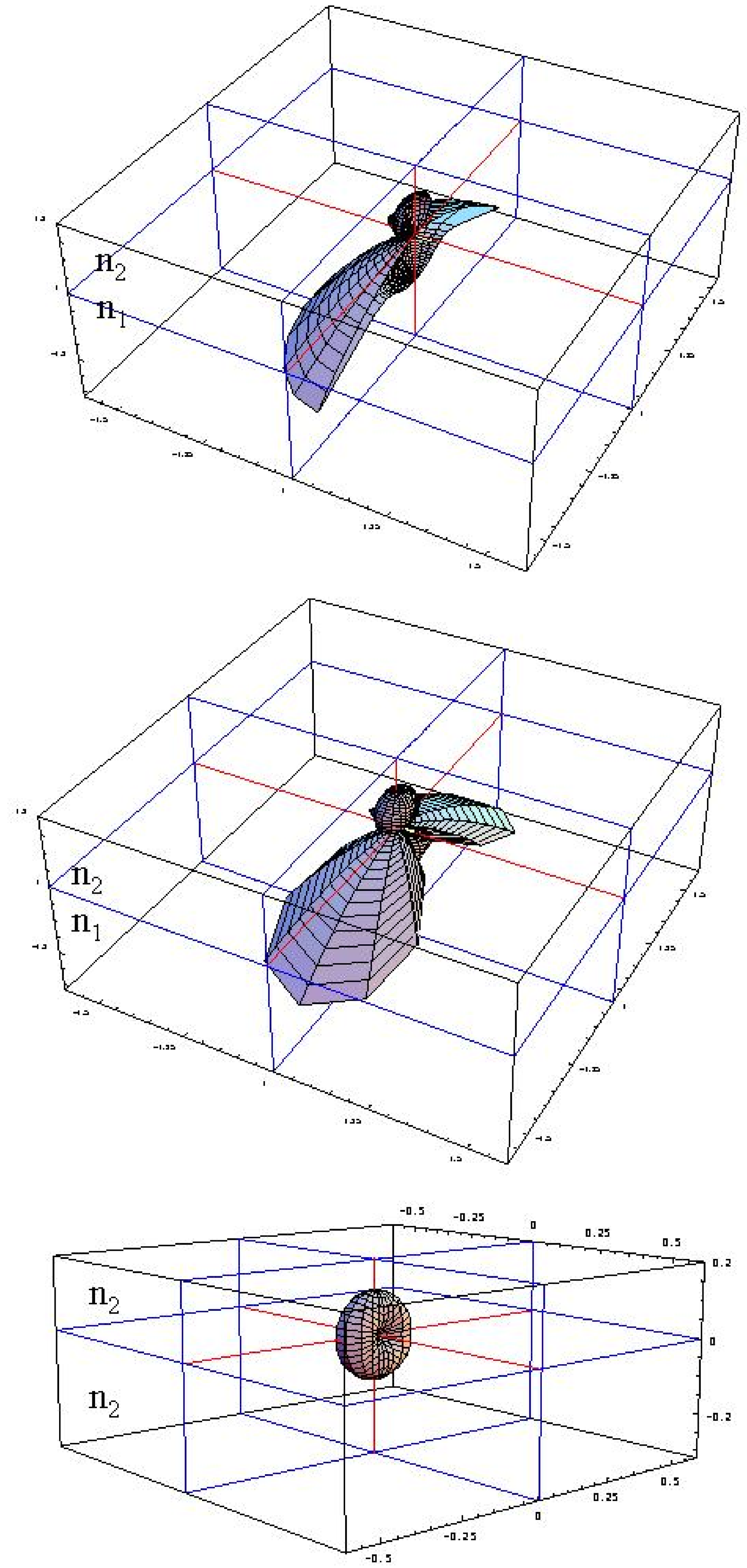
b)

a) Angular distribution of radiated power of an electric dipole perpendicular (e, ⊥) to the fused-silica/water interface ($n = n_1/n_2 = 1.0929$). Dipole is in water at a distance $z_0 = 0$ from the interface. b) Angular power distribution of a free dipole (e, ⊥) in unbounded medium 2 (water).

The presence of an interface near a fluorescing molecule introduces important changes into its radiation. A very important effect of the interface, which is relevant to optical fiber biosensor design, is a strong anisotropy of radiated intensity when the distance of the radiating dipole is small compared to the wavelength of dipole radiation. For molecules situated at a refractive-index discontinuity the emission maximum lies at the critical angle of the two media, and a significant part of the radiation is emitted at angles above the critical angle. A significant amount of the radiation emitted into a denser medium comes from modes that are evanescent on the rarer-medium side. The integrated radiation of a dipole at the interface is greater than that of a free dipole in unbounded medium 2 (with no interface). The physics behind this is shortening of the fluorescence lifetime of surface-bound fluorescent molecules, which is another important effect of the interface.



Composite microscope picture of part of a tapered optical probe in a microcapillary tube. On this scale, the surrounding microcapillary is outside the field of view.



a)

b)

c)

a) Angular distribution of radiated power of an electric dipole parallel (e, ||) to the fused-silica/water interface ($n = n_1/n_2 = 1.0929$). Dipole is in water at a distance $z_0 = 0$ from the interface. Only one half of the space is shown. b) Same as a) but the whole space is shown. c) Angular power distribution for a free dipole (e, ||) in unbounded medium 2 (water).