From the death of an icon to the birth of the world's most sensitive photonic biosensor

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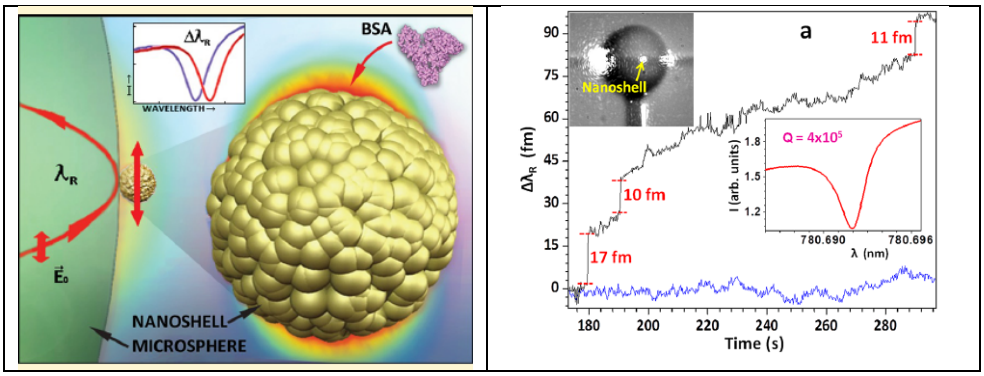
The announcement (in 2002) that the death of my favorite source of knowledge and inspiration, and arguably the world's most prolific science fact and fiction writer (Asimov, >500 books) had been from an HIV infection (contracted during open heart surgery) redirected my laboratory's efforts to design a means for immediate detection of individual virions in blood [1]. This effort led to the creation of the *Whispering Gallery Mode biosensor* (WGM) [2]. This photonic device was born by an analog with an electronic atom, and its sensitivity is accounted for by a heuristic principle, the *Reactive Sensing Principle* (RSP) [3].

My lecture will trace the evolution of the so-called *Whispering Gallery Mode Biosensor* from a discovery made in 1995 in my laboratory at the then *Polytechnic University (currently NYU-Tandon School of Engineering),* [4] and show how the addition of a nano-plasmonic epitope, has pushed its sensitivity beyond individual virions to individual cancer marker molecules, [5] and even single atomic ions. Surprisingly, although the hybrid mode includes a plasmonic nanoshell with an intrinsic loss rate more than 5,000x that of the bare WGM, the hybrid mode produced by coupling the two has a linewidth increased by only ~10% over that of the bare WGM. This is described by a model that combines *Coupled Mode Theory* (CMT) and the *Reactive Sensing Principle* (RSP). [6,3]



Left: *WGM nanoplasmonic resonator configuration for label-free detection of single molecule from the shift of its hybrid mode.* Right: *Detection of thyroid cancer marker protein,* [4].

References

[1] S. Arnold, R. Ramjit, D. Keng, V. Kolchenko, and I. Teraoka, "MicroParticle PhotoPhysics illuminates viral biosensing", Faraday Discuss. **137**, 65–83 (2008).
[2] F. Vollmer and S. Arnold, "Whispering Gallery Mode Biosensing: Label-free detection down to single molecules", Nature Methods **5**, 591-596 (2008).
[3[S. Arnold. M. Khoshsima. I. Teraoka, S. Holler, and F. Vollmer, "Shift of whispering gallery modes in microspheres by protein adsorption", Opt.Lett. **28**, 272-274 (2003).
[4] A. Serpenguzel, S. Arnold, and G. Griffel, "Excitation of Resonances of microspheres on an optical fiber", Opt. Lett. **20**, 654-656 (1995).
[5] V.R. Dantham, S. Holler, C. Barbre, D. Keng, V. Kolchenko, and S. Arnold, "Label-free detection of Single Protein using a Nanoplasmonic-Photonic Hybrid Microcavity", Nano Lett. **13**, 3347-3351 (2013).
[6] Stephen Arnold, Jiachen Wan, and Mohammad-Ali Miri (in preparation).