Integrated Bio-Fluorescence sensor

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As biological analysis systems scale to smaller dimensions, the realization of small and portable biosensors becomes increasingly important. The innovation of integrated fluorescence sensors is now possible due to the development of optoelectronics over the past decade. We propose the monolithic integration of vertical cavity surface emitting lasers (VCSELs), PIN photo-detectors and optical emission filters to be used as a fluorescence sensor. The integration will drastically reduce cost and size of fluorescence detection systems. Also, parallel sensing architectures of more than one hundred channels will be possible. The sensor will be utilized for near-infrared fluorescence detection. This spectral range is compatible with standard AlGaAs optoelectronic technology and will also reduce background fluorescence from complex bio-fluids such as blood. Fabrication processes have been developed to realize these sensors. Figure 1 shows a proximity sensing architecture with a VCSEL located in the center of an annular photodetector. Optical simulations have been preformed to evaluate the performance of a proximity sensing architecture. These simulations predict a detection sensitivity lower than 10000 fluorescent molecules in a detection area of 10^4 μm^2. High quality photodetectors and VCSELs have been realized. The IL characteristics of the VCSEL, Figure 2, show 4mW multimode operation at 770nm. The VCSEL should be an excellent source to excite the fluorescent molecules. Currently, we are moving towards testing the sensor sensitivity and, specifically, working on reducing the laser background at the photodetector to increase sensor sensitivity.

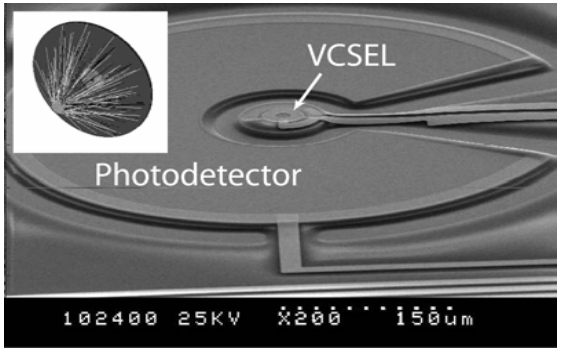

Fig. 1: SEM image of fabricated sensor. VCSEL and Photodiode regions are marked inside figure. Emission filter is monolithically integrated above the photodetector top surface. *Insert, top left*: Optical simulations are used to simulate sensor performance

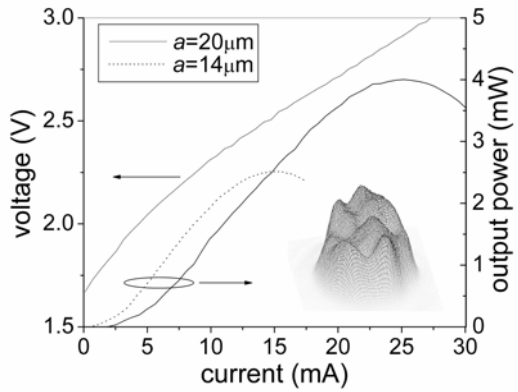

Fig. 2: CW power-current and voltage-current characteristics of 773nm VCSELs with apertures of 14 and 20µm. The current-voltage curve is shown for VCSEL with aperture of 20 µm. *Insert, bottom right*: Near-field intensity image of VCSEL aperture shows multiple transverse mode operation.