High Density Ink Jet Printing of Bio-molecules for Photonic Crystal-based Microarray Applications

Wei-Cheng Lai[1,a)], Kathryn Moncivais[2], Swapnajit Chakravarty[3], Xiaolong Wang[3], Che-Yun Lin[1], Zhiwen J. Zhang[2], Ray T. Chen[1,b)]

[1] *Department of Electrical and Computer Engineering, The University of Texas at Austin, 10100 Burnet Road Bldg 160 MER, Austin, TX-78758*
[2]*Division of Medicinal Chemistry, College of Pharmacy, The University of Texas at Austin, 1 University Station Austin, TX -78712*
[3]*Omega Optics Inc, 10306 Sausalito Dr., Austin, TX-78759*
[a)] lai@mail.utexas.edu
[b)] raychen@uts.cc.utexas.edu

Abstract: High density inkjet printing of protein solutions was investigated for photonic crystal based microarray applications. Spacing of 60um has been demonstrated between unique inkjet-printed spots on a silicon substrate.

Photonic crystal (PC) microcavity based biosensors are highly attractive due to their high sensitivity [1] and small size (< 1μm^2), which allows high density integration of microcavity sensing spots on the same substrate. High density integration can be achieved for microarray applications if each microcavity is coated with a unique target protein. This antigen can then binds specifically to a probe protein for which it has unique affinity, resulting in a corresponding wavelength shift. In this way antibody-antigen and protein-protein interactions can be captured with both sensitivity and specificity in a high throughput manner. It is known from simulations and literature that it is sufficient for individual PC microcavities to be separated by about 20 lattice periods for their resonances to be free from any cross-talk. For a device on a silicon platform operating at 1.55μm with a lattice periodicity of ~430nm, this translates to a spacing of ~9μm. However, the density of integration for microarray applications, i.e. the minimum distance between PC microcavities, is limited by the spacing resolution of the process for patterning probe proteins on the PC microcavities.

At present the most popular technique for patterning proteins on silicon substrates is the use of PDMS microchannels [2] and ink-jet printing [3]. Typically, PDMS microchannels 100μm wide with a channel-to-channel spacing of 200μm are ideal to achieve laminar flow. Narrower channels lead to more difficult flow, which will lead to increased cost of device fabrication and complexity of functionalization. Furthermore, in a microarray several spots interact with target antibodies in the same test fluid (blood, serum or saliva), so the microchannels are unnecessary after functionalization and can be removed. In contrast, ink-jet printing removes the microchannel fabrication and removal process and can potentially lead to higher density integration. In this paper we attempt to minimize the spacing between adjacent inkjet-printed spots of different proteins.

As shown in Fig 1, we have achieved 60 μm center-to-center spacing between individual spots of different printed protein solutions. Anitbodies specific for certain proteins were used in this study, and common dyes were used to facilitate visualization in ambient light. The minimum spacing demonstrated to date is >120μm. [3]. Various aspects of the ink-jet biomolecule patterning procedure and their application in the PC microcavity array biosensor will be presented for high throughput densely integrated microarray applications.

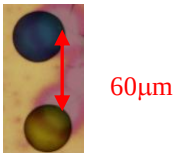

Fig 1: Different bio-molecules were printed with 60 μm center-to-center spacing.

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References:

[1] M. Lee and P.M. Fauchet, "Two-dimensional silicon photonic crystal based biosensing platform for protein detection, Opt. Express 15, 4530-4535 (2007).
[2] J. M. Goddard, S. Mandal, S. R. Nugen, A. J. Baeumner, D. Erickson," Biopatterning for label free detection", Colloids and Surfaces B: Biointerfaces, 76, 375–380 (2010).
[3] C. P. Tan, B. R. Cipriany, D. M. Lin, and H. G. Craighead, "Nanoscale resolution, multicomponent biomolecular arrays generated by aligned printing with parylene peel-off", Nano Lett, 10, 719-725 (2010) .