Published in final edited form as:

SPIE Newsroom. 2010 March 16; 2(1): 1–2. doi:10.1117/2.1201002.002568.

Smart technology for global access to healthcare

Aydogan Ozcan

University of California, Los Angeles (UCLA) Los Angeles, CA,
<http://innovate.ee.ucla.edu/prof.-ozcan-brief-biosketch.html>

Lensfree on-chip holography can improve point-of-care diagnostics, even in the developing world.

Effective treatments already exist for many global health problems, yet access to diagnostic equipment often limits the speed and quality of diagnosis and treatment. This is true in developed countries but more so in the developing world, where medical facilities are extremely limited or even nonexistent. Therefore, it would be exceedingly valuable for doctors to have immediate access to advanced laboratory results even in resource-limited settings.

The cost of wireless phone technology has reduced significantly over the last decade. As a result, today cellphones are in use even in the developing world including the deserts of Africa.¹ Furthermore, the technical capabilities of existing cellphones are rapidly improving. They can already run a wide variety of different applications and offer enormous computational power on a very compact platform. This impressive advancement is one of the central building blocks of the emerging fields of ‘telemedicine’ and ‘wireless health.’ We are working to develop lensfree on-chip imaging systems that can be miniaturized to a self-contained unit equipped with or connected to a wireless transmitter. To maximize affordability, such systems should be fully compatible with existing cellphone designs.

We recently introduced a novel on-chip design for optical cytometry (cell measurement), termed LUCAS (Lensless Ultra-wide field-of-view Cell-monitoring Array platform based on Shadow imaging).^{2–5} This can rapidly characterize thousands of cells in parallel without the need for mechanical scanning or any fluid flow (see Figure 1). The LUCAS platform samples the shadow images or holographic diffraction ‘signatures’ of target cells. It can detect and count major blood cell types, such as red and white blood cells, platelets, or even CD4+ and CD8+ T-cells (types of white blood cells, whose counts are important for accurate diagnosis of AIDS) when combined with surface-chemistry-based selective approaches.

These images are formed by the interference of light waves that have interacted with each cell with background light directly emanating from an incoherent source such as a LED. To record these for all cells in parallel, the sample solution (either within a microfluidic channel or simply between two cover slips) is placed on the top of an optoelectronic sensor array that has a controlled sample-to-sensor distance, typically less than 1–2mm (see Figure 1). The source-to-sample distance is adjusted to approximately 2–10cm. This free-space propagation between source and sample also creates partial spatial coherence in the cell plane that is sufficient to generate holograms of each cell individually (see Figure 2).

In comparison to existing cytometry techniques, LUCAS has several major advantages.⁵ First, it is a massively parallel on-chip imaging modality, where a complete reservoir of cells is immediately imaged. Specifically, we recently showed that the LUCAS platform can monitor a heterogeneous cell solution all in parallel over a field of view of $\sim 18\text{cm}^2$. This throughput is simply not possible in other on-chip cytometry systems.

Another significant aspect of LUCAS is that most of its basic components (including the sensor array) already exist in most commercially available cellphones. This suggests that it will be cost-effective to incorporate an existing cellphone device into LUCAS, an extremely important consideration when developing telemedicine applications.⁶

In conclusion, LUCAS does not rely on any bulky and expensive components such as microscope objective lenses or mechanical microstages, and so it promises a compact, light-weight, and cost-effective point-of-care cell-analysis platform. When combined with simple sample-preparation steps, this may significantly help to combat infectious diseases such as malaria, tuberculosis, and human immunodeficiency virus in resource-scarce settings. We aim to take this telemedicine platform to field tests in Africa starting in the spring of 2010 to automate diagnosis of malaria-infected blood.

Acknowledgments

The author acknowledges support from the Okawa Foundation, Vodafone Americas Foundation, the Defense Advanced Research Project Agency's Defense Sciences Office (grant 56556-MS-DRP), the National Science Foundation (award 0754880 and 0930501), the National Institutes of Health (NIH, under grant 1R21EB009222-01 and the NIH Director's New Innovator Award, number DP2OD006427 from the Office of the Director, NIH), the Air Force Office of Scientific Research (under project 08NE255), and the Office of Naval Research (through a Young Investigator Award 2009).

References

1. Information from the GSM Association on cellphone signal coverage world-wide in 2009. [Accessed 13 January 2010]. http://www.coveragemaps.com/pubs/GSM_WorldPoster2009A.pdf
2. Ozcan A, Dmirci U. Ultra wide-field lens-free monitoring of cells on-chip. *Lab Chip* 2008;8:98–106. [PubMed: 18094767]
3. Su TW, Seo S, Erlinger A, Ozcan A. High-throughput lensfree imaging and characterization of a heterogeneous cell solution on a chip. *Biotechnol Bioeng* 2009;102(3):856–868. [PubMed: 18853435]
4. Seo S, Su T-W, Erlinger A, Ozcan A. Multi-color LUCAS: lensfree on-chip cytometry using tunable monochromatic illumination and digital noise reduction. *Cell Molec Bioeng* 2008;1(2–3):146–156.
5. Seo S, Su T-W, Tseng DK, Erlinger A, Ozcan A. Lensfree holographic imaging for on-chip cytometry and diagnostics. *Lab Chip* 2009;9:777–787. [PubMed: 19255659]
6. Eisenberg, A. Turn a cellphone into a microscope. *NY Times*; Nov 7. 2009 Far from a lab?. <http://www.nytimes.com/2009/11/08/business/08novel.html>

Biography

Aydogan Ozcan received his PhD at Stanford University's Electrical Engineering Department in 2005. After a short postdoctoral fellowship there, he joined the Wellman Center for Photomedicine at Harvard Medical School in 2006 as a research faculty member. He has been an assistant professor at UCLA since summer 2007, heading the bio- and nanophotonics laboratory in the Electrical Engineering Department. He has written one book and co-authored more than 70 peer-reviewed research articles. He holds 15 patents and has seven applications pending. In addition, he is a member of the Institute of Electrical and Electronics Engineers (IEEE), the IEEE Lasers and Electro-Optics Society (LEOS), the IEEE Engineering in Medicine and Biology Society, the Optical Society of America, SPIE, and the Biomedical Engineering Society. He is a member of the program committee of the SPIE Photonics West Conference, SPIE International Symposium on Defense, Security, and Sensing, as well as the IEEE Photonics Society Annual Meeting. He is the general co-chair of the 2010 IEEE Winter Topical Meeting on Advanced Imaging in BioPhotonics. In 2009, he received the National Institutes of Health Director's New Innovator Award, the Office of Naval Research Young Investigator Award, the LEOS (IEEE Photonics Society) Young Investigator Award, the

Massachusetts Institute of Technology's TR35 Award and the Wireless Innovation Award organized by the Vodafone Americas Foundation. He had previously been given the 2008 Okawa Foundation Award.

Figure 1. Overview of the holographic LUCAS platform. The bottom-left insert illustrates a bench-top LUCAS system that can image a field of view of more than 10 cm^2 .

Figure 2. Holographic LUCAS images of blood cells, digitally cropped from a much larger field of view of more than 20mm^2 . WL: Wavelength. RBC: Red blood cell.