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Microscope-on-a-disc: Wireless Powered/Transmitted Real-time Microscopic Imaging

Edwin En-Te Hwu[1], Laura Serioli[1], Sriram Thoppe Rajendran[1], Kinga Zor[1] and Anja Boisen[1]
[1] The Danish National Research Foundation and Villum Foundation's Center for Intelligent Drug Delivery and Sensing Using Microcontainers and Nanomechanics (IDUN), Department of Micro- and Nanotechnology, Technical University of Denmark, Kgs. Lyngby, 2800, Denmark
etehw@nanotech.dtu.dk

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Abstract: A miniature optical microscope on a disc (MoD) is developed for monitoring microscopic samples while spinning. The MoD is wirelessly powered, which streams real-time video wirelessly to a smartphone. The MoD can monitor micro sized containers movement on a spinning disc from 0 to 2,400 rpm.

Centrifugal microfluidics disc or so-called Lab-on-a-disc (LoD) integrates mixing, filtering, metering, and routing operations, which is a compact, affordable and scalable platform for biosensing [1]. However, it is tedious to capture an optical image on a spinning disc. A conventional approach utilizes strobe photography based imaging method [2]. The strobe imaging method requires precise synchronization between a strobe light source and a camera shutter setup. Also, the strobe imaging system is heavy and bulky that limits portable optical sensing based applications.

We developed a miniaturized optical microscope-on-a-disc (MoD) which is powered by commercial mobile device wireless inductive "Qi"[3] energy transmission interface, as shown in Fig. 1 a). The MoD integrates a miniaturized Complementary Metal-Oxide-Semiconductor (CMOS) sensor with color and infrared imaging ability. Moreover, an infrared light source (wavelength 1,050 nm) can illuminate microscopic sample while imaging. The CMOS captures real-time video and picture which are transmitted to a mobile device or a PC through a Wi-Fi transmitter. A high numerical aperture (NA) optics enables an optical imaging resolution of 10 µm. Fig. 1b) shows a microscopic image captured by the MoD at 0 rpm. A micro-container with a known diameter of 300 micron works as a scale bar for MoD resolution analysis. Fig. 1c) shows a photo of the MoD spinning test while streaming real-time video to a smartphone. A mobile app controls the MoD functions such as imaging resolution (1080p, 720p, 640p), infrared illumination adjustment and video/photo capture switching.

Fig. 1 d) - i) shows microscopic images captured by the MoD at different spinning speed (video online). The µ-container 1 and 2 were moved by centrifugal force at 1,200 and 2400 rpm, respectively. The horizontal noise lines in Fig. f) – i) were caused by the non-homogeneous background of the spin stand. The preliminary experiment shows that the MoD is capable of imaging microscopic structures and streaming real-time video to mobile devices. The MoD optics can be optmized for higher imaging resolution. Furthermore, the MoD can equip multiple CMOS sensors for multi-channel real-time imaging on a disc. The MoD may unleash optical imaging based LoD tasks in a portable fashion, such as on-site multi-channel antibiotics testing, real-time cell growth monitoring and portable cell counting applications.

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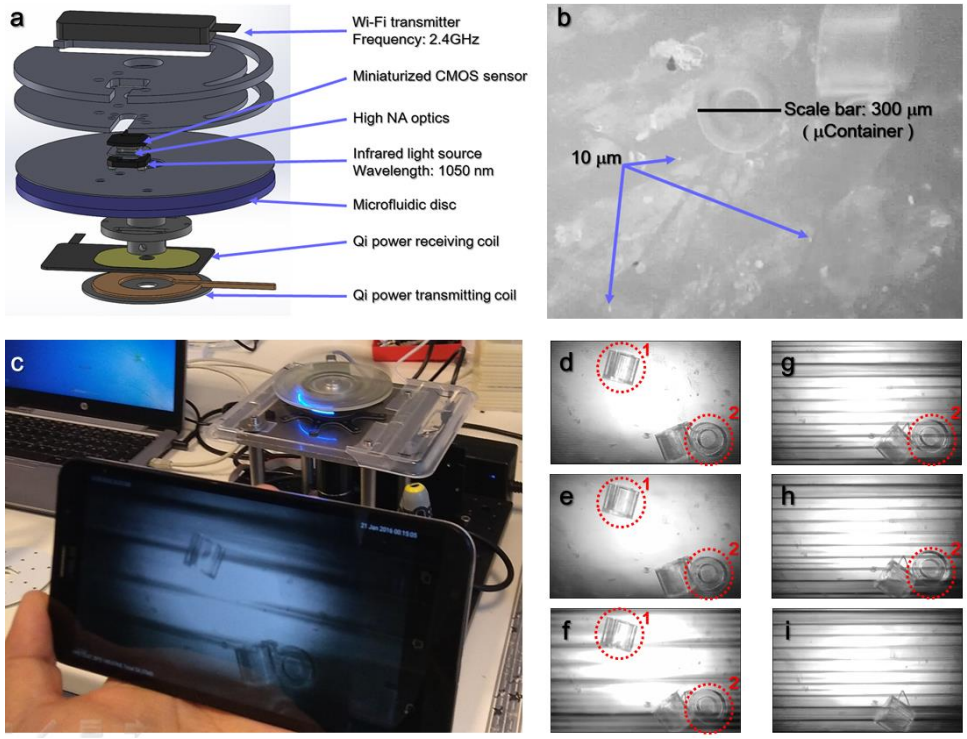

Fig. 1 a) Diagram of the MoD components, **b)** Resolution analysis of the MoD, **c)** Preliminary imaging test of the MoD, **d)** Microscopic image captured at 0 rpm, µ-container 1 and 2 are marked by red circles, **e)** captured at 300 rpm, **f)** captured at 600 rpm, **g)** captured at 1,200 rpm, the centrifugal force moved the µ-container 1 outside the field of view, rpm **h)** captured at 1,800 rpm, **i)** the µ-container 2 disappeared at 2,400 rpm.