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Hacking Consumer Electronics for Biomedical Imaging

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Abstract

Trillions of USD have been dedicated to the development of consumer electronic technologies, to produce drones, wireless chargers, spy cameras, and DVD/Blu-ray optical data storage systems. Consequently, these have been perfected into compact, reliable, high-performance, and low-cost devices. This work reviews the complete repurposing (hacking) of consumer electronics for biomedical imaging and sensing applications.

Keywords: hardware hacking, wireless power, lab on disc, optical pickup unit (OPU), atomic force microscopy (AFM)

Introduction

The essential components of novel biomedical imaging technologies may already be well developed and mass-produced for consumer electronics. By hacking consumer electronics, we can achieve new features, higher performance, lower cost, and faster commercialization, which are mutually exclusive.

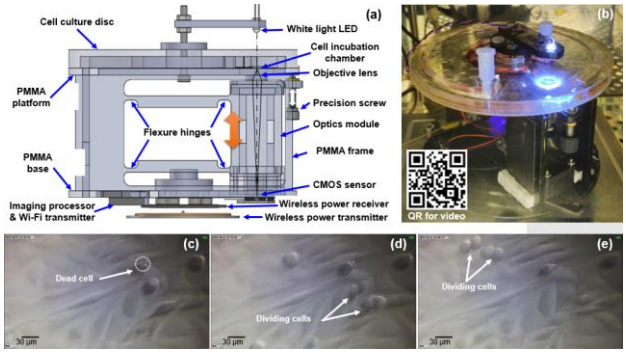

Figure 1. Real time cell culture and imaging system design (a) and photo (b). HeLa cell imaged (c) 5 hours; (d) 8 hours; and (e) 10 hours after seeding.

1. Cell culture and real-time imaging on a disc

Microfluidic cell cultivation typically requires complex systems for nutrient perfusion and waste removal. Centrifugal systems simplify the process, but the spinning of the chamber encumbers imaging of cell development. Fig. 1 shows an optical microscope based on a spy camera, powered by a wireless charger. It rotates with the substrate, to monitor cell cultures continuously, remotely, and in real time [1].

2. All-in-one powered lab-on-a-disc (APELLA)

The drone motors driven APELLA combines a spy camera can achieve unprecedented temporal resolution to image rapid microfluidic mixing event [2] (Fig. 2.)

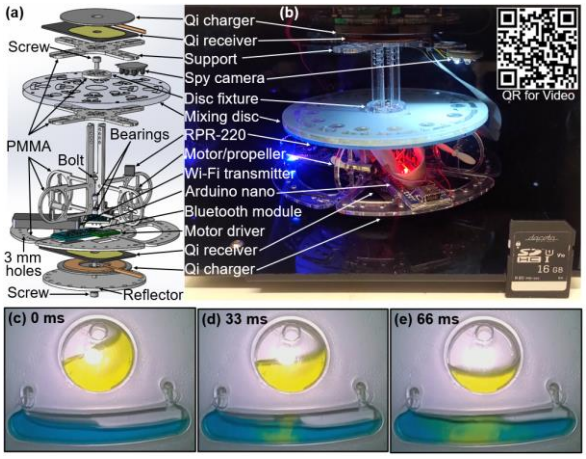

Figure 2. Design (a) and photo (b) of the all-in-one powered lab-on-a-disc system. A rapid liquid mixing event (c)-(e), imaged by a spy camera which rotates with the disk, imaging at 30 fps.

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3. Optical pickup unit (OPU) based cell imaging

DVD/Blu-ray data storage OPUs have been hacked into atomic force microscopes (AFMs) [3], allowing experiments on nano-metrology [4], molecular biology [5], chemistry [6], stiffness [7], biomarkers [8], diabetes [9], force [10], microstructure [11], etc. [12]. OPU-based microscopes can achieve better contrast than high-end optical microscopes [13], as shown in Fig. 3.

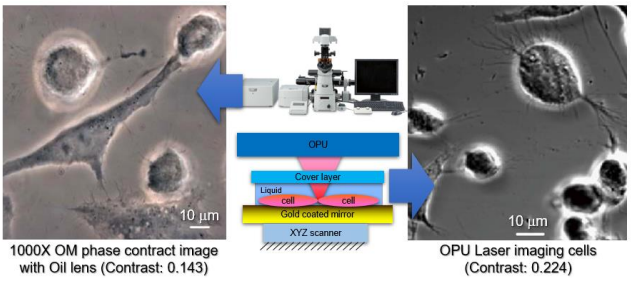

Figure 3. Astrocyte images by phase contract conventional (left) and OPU-based (right) microscopes.

4. High-speed dermatological AFM (HD-AFM)

An OPU-based HD-AFM (Fig. 4) measures corneocyte nanotexture and provides quantitative dermal texture index (DTI) to assess the severity of atopic dermatitis and related conditions [14].

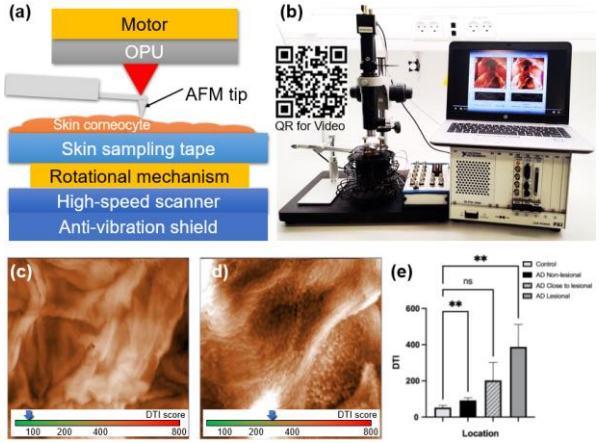

Figure 4. Schematic design (a) and photo (b) of the HD-AFM. Healthy (c) and AD (d) skin DTI. The HD-AFM can quantitatively assess the severity of AD (e).

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