

# A Comprehensive Update on Lab On Chip Technology And Their Uses In Medical Diagnostics



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## Abstract

Lab on chip innovation has been for some time imagined to have enormous business potential, attributable to the capacity of such gadgets to embody a full scope of research center procedures in a solitary instrument and work in a port capable way, quickly and requiring little to no effort. Lab on chip gadgets is not only an accumulation of smaller scale channels. They additionally require incorporated pumps, anodes, valves, electrical fields and hardware to end up noticeably total Lab on chip diagnostics frameworks. There is additionally much research being done to enhance ebb and flow advancements for given applications including cell partition, DNA sequencing through nano pore, miniaturized scale qPCR and smaller scale reactors. On account of small scale PCR, this is a standout amongst the most encouraging innovations for future high throughput put diagnostics, look into concentrates essentially in empowering high parallelization by amultiplication of the PCR chamber, the utilization of computerized smaller scale fluidics to perform PCR in micro-beads and uses the most recent advances in sub-atomic science to perform concurrent PCR in a similar blend. Examine likewise emphatically concentrates on empowering lower discovery level and expanding PCR effectiveness while diminishing false positives and negatives.

**Keywords:** PCR; Lab on chip; Nano particals; DNA; RNA

## Introduction

Lab on chip innovation has been for some time visualized to have colossal business potential, inferable from the capacity of such gadgets to embody a full scope of research center procedures in a solitary instrument and work in a convenient way, quickly and requiring little to no effort. Gadgets are accepted to have potential in fields extending crosswise over therapeutic diagnostics, natural inspecting and a scope of purchaser items; in any case, to date not very many gadgets have achieved business achievement [1]. A Lab on chip is a gadget that coordinates one or a few research center capacities on a solitary chip of just millimeters to a couple square centimeters to accomplish robotization and high-throughput screening [2].

Miniaturized scale fluidic frameworks or "labs-on-chips" have been created for biochemical examines of little specimens. Ordinarily packing various electronic and mechanical parts into a compact unit no bigger than a MasterCard, they are particularly helpful for directing quick examination in the field. While these small scale fluidic frameworks essentially work at the smaller scale (that is, millionths of a meter), nanotechnology has contributed new ideas and will probably assume an expanding part later on. For instance, partition of DNA is delicate to entropic

impacts, for example, the entropy required to unfurl DNA of a given length.

Another way to deal with isolating DNA could exploit its section through a nano scale cluster of posts or channels to such an extent that DNA atoms of various lengths would uncoil at various rates [3]. Investigate on Lab on chip fundamentally concentrates on human diagnostics and DNA examination. Less frequently, Lab on chip inquire about spotlights on the blend of chemicals. Scaling down of biochemical operations ordinarily took care of in a research facility has various favorable circumstances, for example, cost proficiency, parallelization, ergonomony, indicative speed and affectability. The development of the Lab on chip field for the most part depends on two center innovations: small scale fluidics and sub-atomic science [4].

## Principle

Micro fluidic technologies advances utilized as a part of Lab on chip gadgets empower the creation of a huge number of miniaturized scale channels, each measuring unimportant micrometers, on a solitary chip that fits in the palm of your hand. The miniaturized scale channels empower the treatment

of liquids in amounts as low as a couple picolitre and also the control of biochemical responses at little volumes. Obviously, to empower these operations, Lab on chip gadgets are not only an accumulation of smaller scale channels. They likewise require coordinated pumps, cathodes, valves, electrical fields and gadgets to end up plainly total Lab on chip analytic frameworks. The start of the Lab on chip dream is to arrange onto a singular chip countless operations that ought to be conceivable by section a single drop of blood assembled from the patient remembering the true objective to get a correct finding of potential infirmities [4].

### Core Technologies and Applications

Despite the fact that the use of LOCs is as yet novel and unassuming, a developing enthusiasm of organizations and connected research bunches has seen in various fields, for example, investigation (e.g. compound investigation, ecological checking, restorative diagnostics and cellomics) additionally in engineered science (e.g. fast screening and microreactors for pharmaceuticals). Other than further application improvements, explore in LOC frameworks is required to reach out towards downscaling of liquid taking care of structures also, by utilizing nanotechnology. Sub-micrometer and nano-sized channels, DNA mazes, single cell location and examination, [5] and nano-sensors, may end up noticeably achievable, permitting better approaches for connection with organic species and vast atoms.

Many books have been composed that cover different parts of these gadgets, including the liquid transport, framework properties, detecting systems, bioanalytical applications [6-10]. Today, all the principle uses of Lab on chip frameworks have been researched. For a few applications, Lab on chip not just demonstrates the limit of mix and parallelization additionally shows better execution thought about than ordinary advancements. For instance, on account of PCR (an innovation used to increase DNA for pathogen identification), the coordination of PCR onto a Lab on chip permits DNA to be intensified ten times speedier than with regular frameworks.

### Molecular Biology

For DNA/RNA intensification and location, Lab on chip offers high picks up regarding identification speed while keeping a similar affectability. Since DNA intensification utilizing PCR depends on warm cycles, the capacity to perform rapid warm moves at the small scale clarifies why Lab on chip turned into the quickest method for doing PCR [11].

For DNA and RNA sequencing, Lab on chip gave a radical new universe of chances. The primary human genome ventures took years and required the work of several analysts to grouping the human genome. Today, utilizing Lab on chip to incorporate a variety of DNA tests, we can succession genomes a great many circumstances quicker. Additionally, nano pore advancements, which still should be enhanced, hold awesome potential later on for being far quicker for genome sequencing than genuine

Lab on chip utilizing a variety of DNA tests. All the biomolecular operations are done in lab on chip indicate awesome potential for ultra quick microscopic organisms and infection location, additionally for malady biomarker recognizable proof (DNA and RNA). Moreover, lab on chip holds tremendous conceivable outcomes for immunoassays, which should be possible in several seconds rather than ten minutes as when utilizing plainly visible advances. In the field of sub-atomic partition as well, lab on chip show more productive division than with regular systems [12] (Figure 1).

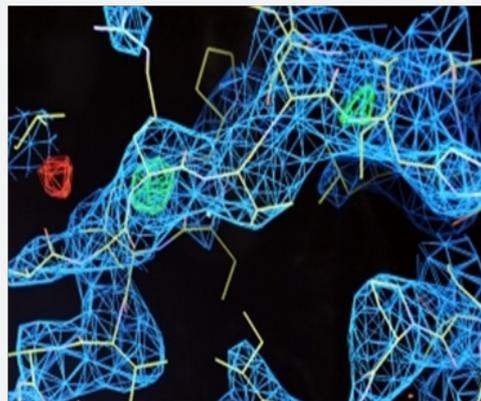


Figure 1: Lab on chip in Molecular Biology, (Source: Elveflow plug and play microfluidic).

### Proteomics



Figure 2: Lab on chip in Proteomics, (Source: Elveflow plug and play microfluidic).

In the field of proteomics Lab on chip gives the chance to perform protein investigations while incorporating every one of the means inside a similar chip: extraction from the cell, partition by electrophoresis, assimilation and examination utilizing mass spectrometry. These coordinated procedures demonstrate the capacity to extraordinarily abbreviate protein examination from hours with naturally visible framework to a couple of minutes with Lab on chip. Lab on chip demonstrates additionally extraordinary potential for protein (crystallization is an imperative research field since it uncovers the 3D structure of a protein). Utilizing Lab on chip, analysts can control at

the same time and in the quickest way that could be available every one of the parameters empowering the crystallization of a given protein. The most imperative element is the likelihood to enormously parallelize crystallization conditions and with a specific end goal to accelerate the disclosure of crystallization conditions for obscure proteins and study their structures utilizing X-beam diffraction, for example [13](Figure 2).

### Cell Biology

Since micro channels are the same typical size as cells, Lab on chip research soon turned its focus on cell biology. Lab on chip demonstrates the ability to control cells at the single-cell level while dealing with a large amount of cells in seconds. At the micro scale level flow switch can be very fast and goes down to just tens of milliseconds. Using fast optical detectors (such as the Opto Reader, for example) one can detect and isolate a given cell (such as cancerous cell made fluorescent using antibodies) with high throughput. There are several other applications for Lab on chip in cell biology, including micro patch clamp, control of stem cell differentiation, high-speed flow cytometry and cell sorting [14](Figure 3).

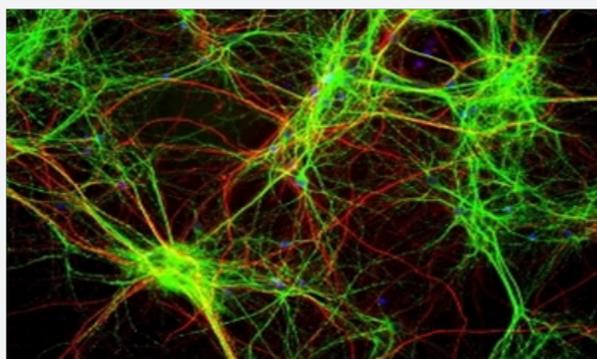


Figure 3: Lab on chip Cell Biology, (Source: Elveflow plug and play microfluidic).

### Chemistry



Figure 4: Lab on chip in Chemistry, (Source: Elveflow plug and play microfluidic).

The ability to perform fast heating and cooling at the microscale enables higher efficiency in some chemical reactions. Therefore, much research has been conducted on using lab

on chip as microsized and highly parallelized micro chemical reactors. Lab on chip devices can also be of interest when dealing with dangerous and explosive compounds in that they contain risks by dealing with smaller volumes at a time [14](Figure 4).

### Chip Materials and Fabrication Technologies

Lab on chip utilizes the most well-known microfluidic gadget creation innovations, and relying upon their applications, different polymers. Such innovations empower the reconciliation of miniaturized scale channels with sizes near 1 micromete [15]. The reason for most LOC manufacture procedures is photolithography. At first most procedures were in silicon, as these all around created advances were specifically gotten from semiconductor manufacture. In view of requests for e.g. particular optical attributes, bio-or substance similarity, bring down generation costs and quicker prototyping, new procedures have been created, for example, glass, pottery and metal scratching, affidavit and holding, polydimethylsiloxane (PDMS) preparing (e.g., delicate lithography), OSTEmer (OSTEmer) handling, thick-film-and stereo lithography and also quick replication strategies by means of electroplating, infusion shaping and emblazoning.

The interest for shabby and simple LOC prototyping brought about a straightforward procedure for the manufacture of PDMS microfluidic gadgets: ESCARGOT (Embedded Scaffold Removing Open Technology). [15]. This method takes into consideration the making of microfluidic channels, in a solitary square of PDMS, through a dissolvable platform (made by e.g. 3D printing) [16]. Moreover, the LOC field increasingly surpasses the outskirts between lithography-based microsystem innovation, nanotechnology and exactness designing.

### PDMS Lab on chip

Research labs regularly utilize PDMS for Lab on chip prototyping. PDMS (polydimethylsiloxane) is a straightforward and adaptable elastomer. PDMS is broadly utilized on the grounds that it is simple and shabby to create PDMS lab on chip by throwing. Besides, lab on chip made of PDMS take preferred standpoint of the simple mix of shudder miniaturized scale valves for quick stream switch and penetrability of air for cell culture and studies. Generally utilized for Lab on chip prototyping, PDMS demonstrates extreme impediments for modern generation. Since the material is liable to maturing, and on the grounds that PDMS ingests hydrophobic atoms, it is difficult to incorporate anodes into a PDMS chip [12].

### Thermo-polymers (PMMA) Lab on chip

Thermoplastic polymers are generally utilized by specialists to manufacture lab on chip. Regardless of the possibility that it is a tad bit more dubious and costly to actualize than PDMS, thermoplastics are great contender for the manufacture of lab on chip since they are straightforward, good with micrometer-sized lithography and more synthetically latent than PDMS. For specific

applications, some exploration groups acquired great outcomes with thermoplastic lab on chip, and since it is conceivable to incorporate microelectrodes into them, thermoplastic materials can be great possibility for the industrialization of some lab on chip [12].

### Glass Lab on chip

Transparent, perfect with micrometer measured machining, artificially dormant, with an extensive variety of surely understood substance surface medications and reproducible cathode coordination, glass is a decent possibility for the industrialization of lab on chip. From an exploration perspective, the creation of glass lab on chip requires clean rooms and specialists with a solid information of microfabrication. In this way, glass Lab on chip are not accessible to all exploration labs [12].

### Silicon Lab on chip

The primary Lab on chip was made in silicon, and it appears like a significant typical decision since smaller scale innovations depend on the micromachining of silicon. These days scientists don't frequently utilize silicon for lab on chip, for the most part since silicon is costly, not optically straightforward (with the exception of IR) and requires a spotless room and in addition a solid learning of microfabrication. Additionally, the electrical conductivity of silicon makes it difficult to use for Lab on chip operations requiring high voltage (like electrophoresis). Still, regardless of the possibility that these days silicon appears like an out of date contender for the industrialization of Lab on chip, we trust that taking into account the high precision of silicon machining, the maturity of and the investments put into the silicon micromachining industry, and the ability to integrate any kind of microelectrode and even electronics on the same chip, silicon may still be a relevant choice for the industrialization of some demanding Lab on chip applications [12].

### Paper Lab on chip

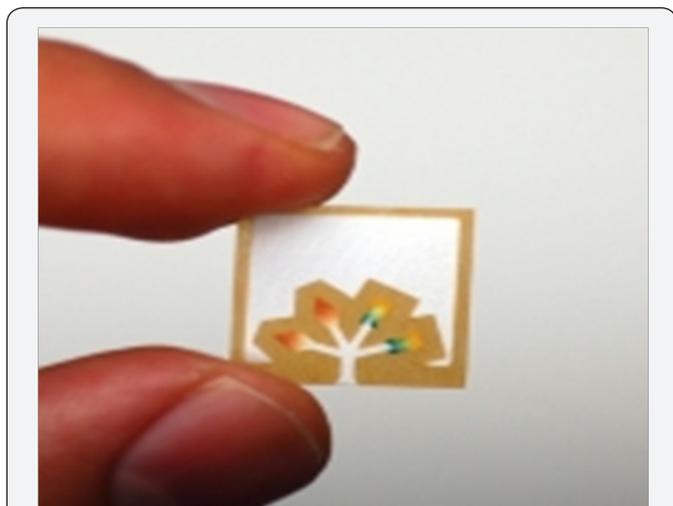


Figure 5: Paper Lab on Chip, (Source:Elveflow plug and play microfluidic).

Lab on chip gadgets in light of paper innovations may have solid results for applications requiring ultra low-costs. Upheld by G Whiteside, a standout amongst the most celebrated microfluidic specialists, paper lab on chip may discover their market later on. We trust it will as the thought is extremely alluring and could open up the field of diagnostics and make it available to lower-pay and constrained asset populations [12](Figure 5).

## Advantages of Lab On Chip Compared To Conventional Technologies

### Low cost

Micro advances will diminish the cost of investigation much in the way they diminished the cost of registered computation. Incorporation will empower various tests to be performed on a similar chip, diminishing to an irrelevant value the cost of every individual examination.

### High parallelization

Thanks to its ability for incorporating smaller scale channels, Lab on chip innovation will empower tens or many investigations to be performed at the same time on a similar chip. This will empower specialists to target particular diseases amid the season of a counsel with a specific end goal to endorse all the more rapidly and adequately the most appropriate anti-microbial or antiviral.

### Usability and minimization

Lab on chip empowers the coordination of countless inside a little volume. At last, a chip of only a couple of centimeters squared combined with a machine as little as a PC will empower investigations tantamount to those done in full logical research facilities. Diagnostics utilizing Lab on chip will require significantly less taking care of and complex operations and much of the time; they will have the capacity to be performed nearby by a medical caretaker.

### Reduction of human error

Since it will firmly lessen human dealing with, programmed analyze done utilizing Lab on chip will incredibly decrease the danger of human mistake contrasted and established diagnostic procedures done in laboratories. Faster reaction time and finding: At the micrometric scale, dispersion of chemicals, stream switch and dissemination of warmth is quicker. One can change the temperature in many small scale (which empowers, for instance, quicker DNA enhancement utilizing PCR) or the blending of chemicals by dispersion in seconds (to empower speedier biochemical responses, for instance).

### Low volume tests

Because Lab on chip frameworks just require a little measure of blood for every examination, this innovation will diminish the cost of investigation by decreasing the utilization of costly chemicals. Last however not the minimum; it will allow the discovery of a high number of diseases without requiring extensive amounts of blood from patients.

### Ongoing procedure control and observing increment affectability

Thanks to quick reactivity at the microscale, one can control continuously nature of a synthetic response in the Lab on chip, prompting more controlled outcomes.

### Disposable

Due to their low value, mechanization and low vitality utilization, Lab on chip gadgets will likewise have the capacity to be utilized as a part of open air conditions for air and water observing without the requirement for human mediation.

### Share the health with everybody

Lab on chip will diminish symptomatic costs, the arrangement of medicinal staff and the cost of framework. Subsequently, Lab on chip innovation will make present day pharmaceutical more available to creating nations at sensible costs. In one sentence we can unmistakably anticipate that Lab on chip will spare various lives.

### Applications in Pharmacy

- I. Lab on chip is helpful in the production of single or multiple emulsions for drug delivery [17].
- II. Lab on chip preparation routes for organic nanoparticles and vesicular systems for nanomedicine [18].
- III. Used for Ultrasound assisted particle and cell manipulation on-chip [19].
- IV. On Industrial level the lab on chip is used for design, and scale-up for drug discovery and delivery [20].

### Limitations of Lab On Chip Compared To Classic Technologies

#### Industrialization

Most Lab on chip advancements are not yet prepared for industrialization. As to center application, the ultra multiplex conclusion, right now we are not sure which creation advancements will turn into the standard [11]. Flag/clamor proportion: For a few applications scaling down expands the flag/commotion proportion and therefore, Lab on chip gives poorer outcomes than traditional systems.

Morals and human conduct without directions, constant preparing and the boundless availability of lab on chip may produce a few feelings of dread of the untrained open diagnosing potential contaminations at home. In addition the DNA sequencing capability of Lab on chip may empower anybody to grouping the DNA of others utilizing a drop of salivation [12].

#### Lab on chip needs an external system to work

Regardless of the possibility that Lab on chip gadgets can be little and intense, they require particular hardware, for example, gadgets or stream control frameworks to have the capacity to work appropriately. Without an exact framework to infuse, split

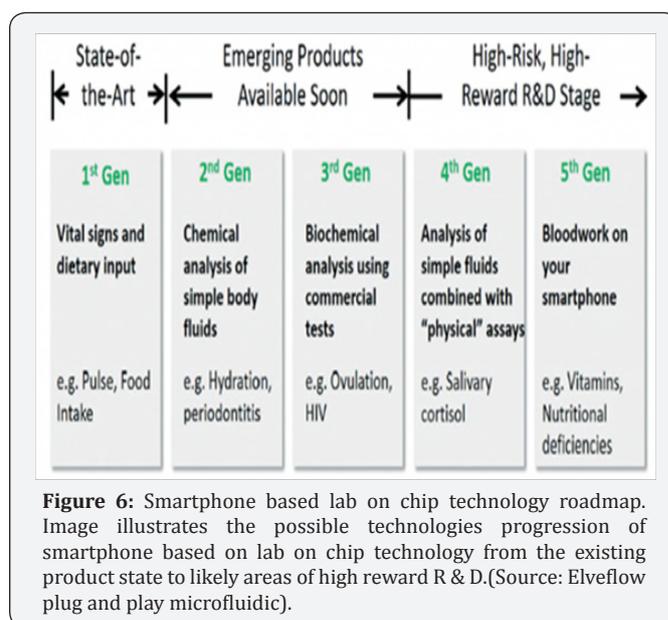
and control the situating of tests, lab on chip are pointless. Outer gadgets increment the last size and cost of the general framework and a few, especially stream control hardware, can frequently posture restrictions for Lab on chip performance [13].

### Current Challenges And Research

#### Contemporary research on Lab on chip innovation concentrates on three principle angles

The industrialization of Lab on chip advancements is to make them prepared for commercialization. This incorporates the adjustment of manufacture procedures, the outline of particular surface medicines, stream control framework (in the event that you require an accomplice for your lab on chip industrialization). The expansion in the most extreme number of natural operations can be incorporated on a similar chip and the expansion in parallelization to accomplish the discovery of several pathogens in the same microfluidic cartridge.

Essential research is on sure advancements with a high potential effect, for example, DNA perusing nanopore, which requires more examination so as to be appropriate [14]. There is additionally much research being done to enhance ebb and flow advances for given applications including cell division, DNA sequencing through nanopore, small scale qPCR and smaller scale reactors. On account of micro PCR, which is a standout amongst the most encouraging innovations for future high throughput diagnostics, inquire about concentrations essentially in empowering high parallelization by an augmentation of the PCR chamber, the utilization of computerized microfluidics to perform PCR in small scale beads and uses the most recent advances in atomic science to perform concurrent PCR in a similar blend. Investigate additionally unequivocally concentrates on empowering lower discovery levels and expanding PCR effectiveness while diminishing false positives and negatives [21](Figure 6).



**Figure 6:** Smartphone based lab on chip technology roadmap. Image illustrates the possible technologies progression of smartphone based on lab on chip technology from the existing product state to likely areas of high reward R & D. (Source: Elveflow plug and play microfluidic).

Today some labs on chip are already commercialized for targeted applications such as glucose monitoring or specific pathology detection. In a near future we can expect that lab on chip will widely be used in hospitals everywhere and eventually inside the practitioner office. Later we can expect that Lab on chip technologies will be able to provide real time monitoring of health at home. This is why governments and companies are investing more and more in lab on chip since it is now clear that these technologies will change our daily lives [21].

## Conclusion and Perspectives

In a not so distant future, Lab on chip gadgets, with their capacity to perform finish conclusion of a patient amid the season of a counsel, can change our method for rehearsing solution. Finding will be finished by individuals with lower capabilities, in this way empowering specialists to concentrate just on treatment. Continuous analysis will build the odds of survival for patients in crisis benefits and will empower the suitable treatment to be given to every patient. A total determination will significantly diminish antibio-resistance [21], which is presently one of the greatest difficulties of the decade. The capacity to perform conclusion requiring little to no effort will likewise routinely change the way we see pharmaceutical and after that empower us to identify diseases at a prior stage and regard them at the earliest opportunity. In creating nations, Lab on chip will empower human services suppliers to open diagnostics to a more extensive populace and to give the fitting treatment to individuals who truly require it without the utilization of uncommon and exorbitant prescriptions.

Taking a gander at late inquires about and items entering the market, we now can make certain that Lab on chip will change the way we do diagnostics in a not so distant future. A few lab on chip have been marketed for some key applications, for example, glucose checking, HIV discovery or heart assault diagnostics. The test for mechanical research will be to fuse on a similar Lab on chip the greatest measure of individual operations keeping in mind the end goal to diminishing expenses and increment ergonomics and the speed of finding. Right now, advancements are not bound together and no one can state which innovations and which materials will be the most encouraging for high throughput diagnostics.

## Reference

- Mazher IM, Steven H, Ian G (2015) Challenges of commercialization lost in translation. *Procedia Technology* 20: 54 - 59.
- Volpatti L R, Yetisen A K (2014) Commercialization of microfluidic devices. *Trends in Biotechnology* 32(7): 347-350.
- Nanotechnology (2011) *Encyclopædia Britannica*. Encyclopædia Britannica Ultimate Reference Suite. Chicago: Encyclopædia Britannica.
- Abgrall P, Gue A M (2007) Making a microfluidic network and coupling it into a complete microsystem, a review. *J Micromech Microeng* 17: 15-49.
- Chokkalingam V, Jurjen T, Florian X, Xin L, Sergey S, et al. (2013) Probing cellular heterogeneity in cytokine-secreting immune cells using droplet-based microfluidics. *Lab on a Chip* 13(24): 4740-4744.
- Kirby BJ (2010) *Micro- and Nanoscale Fluid Mechanics: Transport in Microfluidic Devices*. Cambridge University Press.
- Bruus H (2007) *Theoretical Microfluidics*. Oxford University Press. UK.
- Karniadakis GM, Beskok A, Aluru N (2005) *Microflows and Nanoflows. Fundamentals and Simulation*.
- Tabelling P (2005) *Introduction to Microfluidic*. OUP Oxford, UK.
- Ghallab Y, Badawy W (2004) Sensing methods for dielectrophoresis phenomenon from bulky instruments to lab-on-a-chip. *IEEE Circuits and Systems Magazine* 4 (3): 5-15.
- Jiang L, Oncescu V, Erickson D, O'Dell D, Gumus A, Lee S, et al. (2014) Smartphone technology can be transformative to the deployment of lab-on-chip diagnostics 14(17): 3159-3164.
- Oncescu V, Matthew M, David E (2014) Cholesterol testing on a smartphone. *Lab Chip* 14(4): 759-763.
- Gallegos D, Kenneth D, Hojeong Y, Peter P, Clark C, et al. (2013) Label-free biodetection using a smartphone. *Lab Chip* 13: 2124-2132.
- Chen A, Royal W, Candace R S, Bever L, Siyuan X, et al. (2014) Smartphone-interfaced lab-on-a-chip devices for field-deployable enzyme-linked immunosorbent assay. *Biomicrofluidics* 8(6): 25-29.
- Saggiomo V, Velders H A (2015) Simple 3D Printed Scaffold-Removal Method for the Fabrication of Intricate Microfluidic Devices. *Advanced Science* 2(9).
- Simple fabrication of complex microfluidic devices - YouTube.
- Chun-Xia Zhao (2013) Multiphase flow microfluidics for the production of single or multiple emulsions for drug delivery. *Advanced Drug Delivery Reviews* 65: 1420-1446.
- Lorenzo C, Dario C, Stefania M, Claudio N, Xunli Z (2013) Microfluidic and lab-on-a-chip preparation routes for organic nanoparticles and vesicular systems for nanomedicine applications. *Advanced Drug Delivery Reviews* 65: 1496-1532.
- Helen M, Sandy C, Martyn H (2013) Ultrasound assisted particle and cell manipulation on-chip. *Advanced Drug Delivery Reviews* 65: 1600-1610.
- Goran T, Nauman K, Marcos A, Takashi K, Mitsutoshi N, et al. (2013) Design, applications and scale-up for drug discovery and delivery. *Advanced Drug Delivery Reviews* 65: 1626-1663.
- Hejazian M, Li W, Nguyen NT (2015) Lab-on-a-chip for continuous-flow magnetic cell separation. *Lab-on-a-chip* 15(4): 959-970.



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