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REVIEW

PDMS microfluidics: A mini review

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ABSTRACT: Polydimethylsiloxane (PDMS) is hailed as one of the foundational materials for microfluidics. Though a silicone-based elastomer of many desirable properties, the emergence of microfluidic fabrication techniques, especially soft lithography, has elevated its status to an exceptional one. In this mini review, we look at the salient aspects that make PDMS so special in achieving such a coveted status in the microfluidics community. A methodical approach is followed to touch upon the application of PDMS in various aspects of microfluidics with the advantages, limitations, and some future directions. © 2020 Wiley Periodicals, Inc. J. Appl. Polym. Sci. **2020**, *137*, 48958.

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INTRODUCTION

Polymers are ubiquitous in our daily lives, and synthetic polymers are one of the finest inventions of mankind. Intrinsically, they are highly tailored macromolecules which form the foundation for many of the applied engineering fields, from aerospace to targeted drug delivery and essentially impart an engineering facet of the complex material chemistry. In this regard, silicones deserve a special mention owing to their excellent properties for a wide variety of applications.

Microfluidics technology came to prominence in the 80s, providing many benefits to a gamut of areas in science and engineering, ranging from biochemistry to aerospace engineering. One of the important applications of the same in the biomedical research is the development of affordable devices by reducing the use of sample and reagents, fast detection and ability to mimic the *in vivo* environment. The earliest microfluidic devices were fabricated with glass and silicon wafers as the building materials which were time consuming and involved costly equipment and consumables even for single chips, not to mention a batch production. This is where the PDMS gained an edge, in the development of a cost-effective platform for microfluidics. With the emergence of microfluidics enabled lab-on-a-chip (LOC) devices in the last decade, there was a surge in the use of PDMS which proved to be a right material in the right time. It was adapted easily into the community and eventually became the single most used material in the domain of experimental microfluidics.

There are many other reviews that are based on the technique and application of PDMS in general, but none seemed to have explored the capabilities and the prospects of PDMS specifically for microfluidic applications. The aim of the present review is to assess the role of PDMS as a critical component in a wide spectrum of microfluidic applications. Table I gives the details of some of the past reviews and their themes. It can be seen that PDMS as a material stands out in many reviews which spent considerable part of the content on the application of PDMS to the science being reviewed.

At this point, it is relevant to ask why PDMS stands out among the myriad of other polymers that are used for engineering applications? There are reviews which compare PDMS against other commonly used polymers like polystyrene, poly(methyl methacrylate), and polycarbonate.[11] It is often argued that it was popularized by specific groups in the microfluidics community, most notably that of Whiteside's research group who established the soft lithography protocol as a micro fabrication technique.[12] Among the commercially available forms, Sylgard 184 (Dow Corning) is the most widely used. A quick search on any scholarly database clearly shows a diminishing trend of next widely used RTV 615 (GE Bayer Silicones) compared to the hugely popular Sylgard 184 in the recent years. This is clearly revealed in a comparative study of their mechanical properties.[13] Since the only available data are the datasheet from the manufacturer which lacks many scientific details and parametric sweep studies, detailed characterization is done for the specific make.[14] For any general applications including microfluidics, it is used in the two-part form—the base polymer and the crosslinker. The crosslinker concentration can directly impact the physicomechanical properties to a great extent and this itself forms a major variable parameter

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in many studies. From a fabrication point of view, quick, easy to integrate with glass systems and ability to replicate structures at nanolevel are the most desirable features for which practitioners are impressed with PDMS. Another promising and key aspect pertinent to microfluidics is the transparency, which enables the direct optical access into microchannels for real-time monitoring of the process for accurate quantification of the phenomena under consideration. Further, PDMS is found to show excellent biocompatibility and permeability and low autofluorescence, opening up a wide arena in the field of biotechnology and biomedical engineering. All these factors simply enhanced its candidature for cost-effective LOC applications both in academia and industry.

Along with all the above strengths, there exist disadvantages for PDMS as well.[15] One of the key issues in LOC applications is the absorption of molecules onto PDMS surface which is aggravated in presence of a favorable pH.[16] It also tends to swell in many common solvents, especially hydrocarbon-based ones. Another issue is the inherent hydrophobicity of PDMS which may be resolved with a plasma exposure, but not to last for a long time. This is a serious issue in biological assays as it enhances the protein absorption. Other downsides include evaporation of water through PDMS and a lower zeta potential compared to glass. However, as indicated by the number of staunch followers for this polymer in the microfluidics community, the desirable properties have clearly outweighed the shortcomings through careful mitigation strategies, giving rise to significant contributions in the field as evident from the expanding literature that utilize this material as a backbone to their experimental systems.

In the following section, we will look into the key applications of PDMS in microfluidics in some of the most important domains of science and engineering: (1) chemical and material, (2) mechanical and fabrication, (3) biological, biomedical, and LOC, (4) biomimetics, (5) sensors and actuators, and (6) miscellaneous. Though it is hard to draw a strict line between the above classifications, they are grouped for the ease of understanding according to the end-user application and the domains where they are referred to the most. Figure 1 shows this classification schematically along with the key application areas.

Chemical and Material

PDMS forms the backbone of many microfluidic systems by dictating the intrinsic interfacial phenomena, which, in turn, influence the flow physics. Being a polymer in its most basic form, the alteration of the chemical and material properties paves way for the easiest and quickest engineering of the material for developing novel utilities. Chemical modification of PDMS for microfluidics is widely explored as one of the most effective analytical LOC platforms. Surface treatments especially functionalization alter the physicochemical properties, thus tailoring the applications for highly specific objectives for a wide spectrum of PDMS-based microfluidic system for sensing applications. The most important surface modification techniques regularly used in microfluidics are plasma, ultraviolet (UV) and silanization. Plasma modification is the most commonly used method by which the polar functional groups (SiOH) are introduced on the surface. This can transform the usually hydrophobic nature of PDMS to hydrophilic.[17] Plasma polymerization is also employed to coat a layer of acrylic acid on PDMS surface to fabricate patterned hydrophobic/hydrophilic surfaces. Further, the same strategy is used to create double emulsions.[18] Maintaining the wettability is challenging in microfluidics applications as most of the surface treatments reverts the PDMS

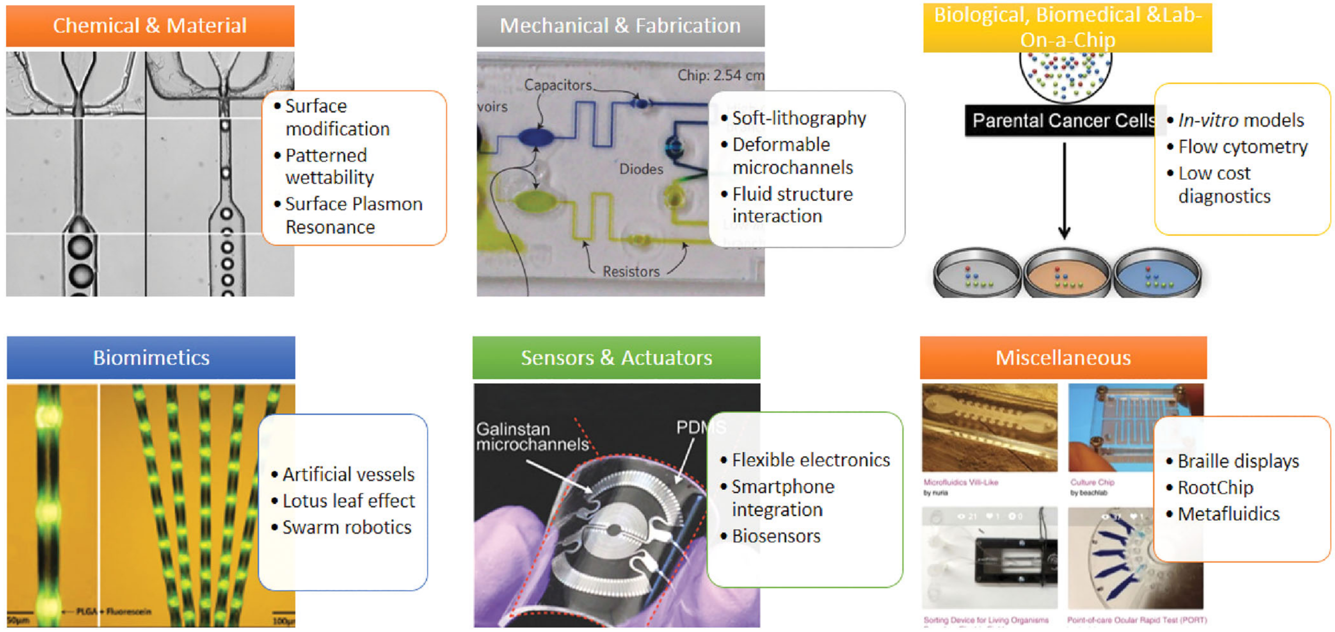

Figure 1. Aspects of PDMS considered for microfluidics applications in this review. [Color figure can be viewed at wileyonlinelibrary.com]

surface back to hydrophobic over a short period of time. To overcome the transient nature of the hydrophilicity offered by plasma treatment, a combination of polyethylene oxide (PEO) with PDMS is used for fabrication by which the hydrophilicity can be maintained for a long time.[19] Chemical modifications in PDMS devices are also employed for protein crystallization in nanoliter aqueous droplets which are evaluated by X-ray diffraction techniques.[20] Solvent interaction with the PDMS is one of the key disadvantages of using a wide range of chemicals as PDMS is susceptible swelling when exposed to many solvents which can damage the channel itself. Many researchers have mitigated this issue by adopting various operational approaches.[21] Further, PDMS channels can be coated with glass like layer by a method of sol–gel chemistry to avoid degradation from the action of organic solvents (Figure 2).[22]

Table I. Summary of Reviews Based on PDMS Materials and Their Themes

References	Applications reviewed
1	Surface modification of PDMS for biological assays
2	Fabrication of PDMS composites for making microfludic chips
3	Surface modification of PDMS for electrophoretic applications for bioassays
4	Devices fabricated in PDMS for various applications
5	Hydrodynamics in deformable channels using PDMS
6	Surface modifications of PDMS, both physical and chemical
7	PDMS for analytical chemistry applications
8	Surface modification of PDMS for biological applications
9	Surface modification of PDMS
10	PDMS microchannels for biological studies

UV modification is also routinely used on the PDMS to alter the surface properties, by tuning its intensity.[23] It can generate a thin layer of uncrosslinked oligomer coated to the channels walls in a PDMS microfludic device.[23] Further, PDMS beads are produced within microchannels for a number of useful applications. Silanization is another surface modification for the applications of making a monolayer of silane which will help in the easy removal during soft lithography, especially multilayer lithography.[24] Modified PDMS surfaces are adept for surface plasmon resonance (SPR) applications for estimating the binding of biomolecules and chemical interactions. It is used in the multiscale patterning of the plasmonic metamaterials using PDMS.[25] Chemical treatments are also helpful in preventive measures in microfluidics against external physiochemical agents that compromise the analytical efficiency of microfluidic platforms. As for the improvement of the polymeric backbone, blending of PDMS with nanocomposites is found to enhance their mechanical strength so to fabricate microchannels of high structural integrity and chemical stability.[26–30] The key idea of the surface modification strategies described above is to render it more useful for microfluidic applications. The consequences of these modifications, in terms of the altered wettability due to addition of functional groups, generation of thin layers over the PDMS surface significantly enhance the potential for microfluidics applications.

Mechanical and Fabrication

As the base material to fabricate the microchannels, PDMS offers the mechanical strength and durability at par with conventional glass and metal systems within the range of operational parameters

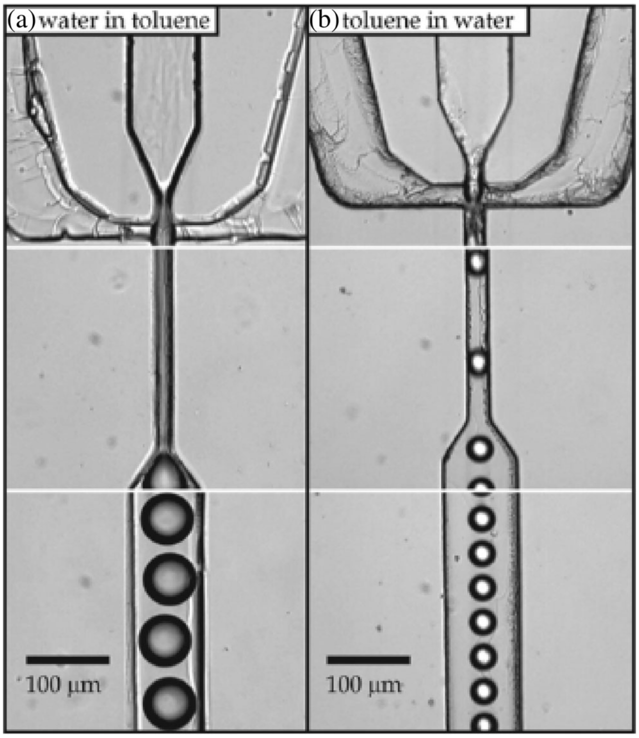

Figure 2. Generation of emulsion in coated and functionalized PDMS-based flow-focusing devices showing direct and inverted cases.[22] Reproduced with permission of The Royal Society of Chemistry.

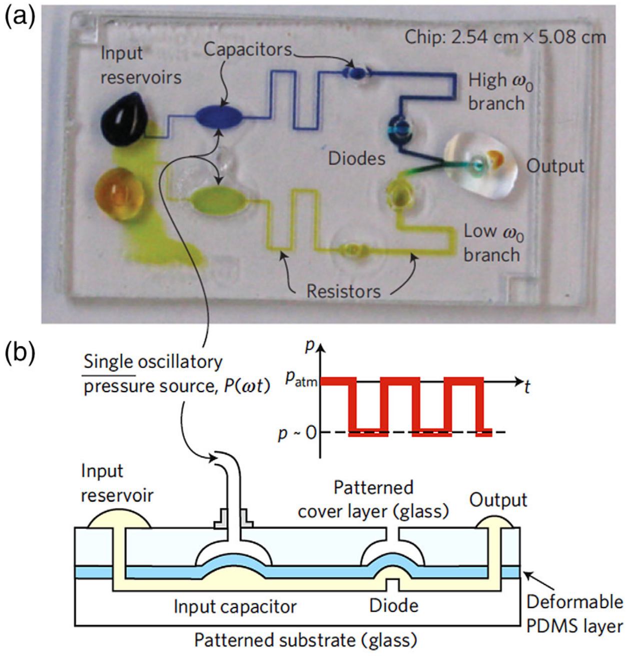

Figure 3. Microfluidic components with electronically analogous components.[61] Reproduced with permission of Springer Nature. [Color figure can be viewed at wileyonlinelibrary.com]

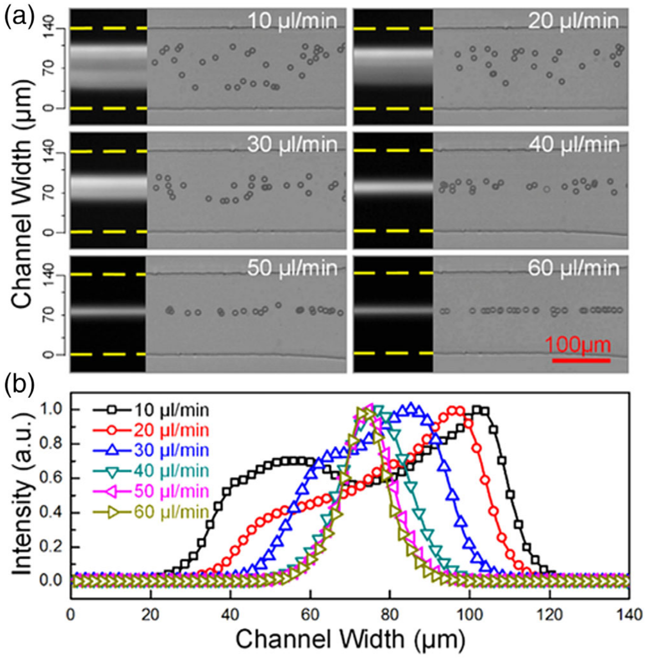

Figure 4. Flow focusing in PDMS microchannels with viscoelastic polymer solution.[73] Reproduced with permission of John Wiley and Sons. [Color figure can be viewed at wileyonlinelibrary.com]

found in microfluidics. The mechanical tunability results in the elastic and viscoelastic variations for the polymeric material. This can be different for different commercially available forms of PDMS.[13,31] Though it is considered as simple elastic material by most, the hyperelastic and viscoelastic models are also explored to model its stress–strain behavior.[32–35] Detailed polymer physics of PDMS is explored with rheometric measurements validates the time temperature invariance during the curing process. The same study confirms the Boltzmann superposition theorem and also predicts the creep compliance from relaxation modulus.[36] The contact mechanics pertinent to the deformation is analyzed in line with Oliver Phar analysis for which the data are obtained from profilometery and atomic force microscopy.[37,38] There is a plethora of studies that carried out the mechanical characterization of PDMS for microfluidics applications, despite it being a commercially available product.[32,39–41] The increase in the fraction of crosslinker will increase the mechanical strength and thus elastic modulus of PDMS.[40,42] Many of the mechanical characterizations have shown that simple linear elastic model is sufficient and the need for more generalized models like Mooney–Rivlin should be invoked only on special occasions. Being a thermoplastic elastomer, the temperature dependency on the crosslinking process is crucial in dictating the final mechanical properties, especially the elastic modulus (E) of the material.[43] This is particularly important during microfabrication as the thermodynamics of curing can give rise to issues while performing the soft lithography especially to fabricate structures of the order of nanometer dimensions.[44] The variation of mechanical properties with respect to temperature can be carefully exploited to get a gradient of elasticity for droplet actuation purposes.[45] Towards the fabrication of deformation resistant microchannels under flow induced pressure, increasing the curing agent concentration and thermal aging techniques are been proposed.[21] Another important concern during microchannel fabrication is the shear stresses developed during spin coating that alters the polymer chain alignments and cause the mechanical properties

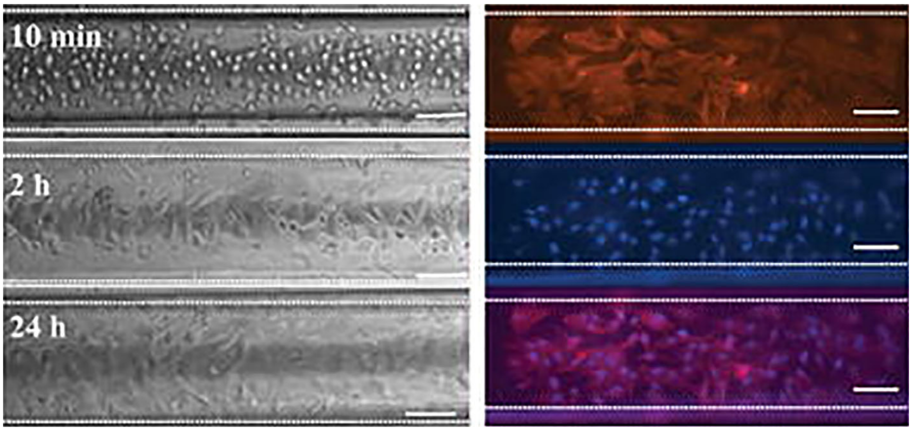

Figure 5. Human umbilical vein endothelial cells (HUVEC) cultured within a circular PDMS microchannel environment for various incubation time[84] (scale bars represent 100 μm). Reproduced with permission of Springer Nature. [Color figure can be viewed at wileyonlinelibrary.com]

to vary preferentially in a specific direction.[46] Other factors affecting the fabrication of microfluidic components using PDMS are curing time, presence of solvent, creep behavior, and adhesion characteristics.[42,47]

Hydrodynamic effects are thoroughly exploited using PDMS microchannels that stems from the fundamentals of fluid mechanics.[48–52] The deformable PDMS microchannels provide an excellent platform to investigate the fluid structure interaction (FSI) at the microscale.[5,53–57] The flow induced deformation such channels has been modeled using both thin plate and thick plate approximation.[54,58] Particularly for pulsatile flows, the insightful electronic capacitor analogy of the microchannel compliance forms a fundamental element of programmable microfluidic circuits (Figure 3).[59–61] Another novel implication is the electrowetting-on-dielectric systems where PDMS-based substrates are used to actuate the droplets using electric field by exploiting the electrical double layer at the solid–liquid interface.[62,63] They form the backbones for various digital microfluidics platforms towards futuristic applications of precise droplet maneuvering with electronic control which can be logically programmed.[64] The stiffness is found to affect many microfluidic phenomena, electrophoretic and coffee ring effect.[65] Further hydrodynamic effects are utilized in the paradigm of inertial microfluidics, leveraging the wall lift forces acted upon the particles to selectively focus based on the requirement.[66] This mechanism is extensively exploited in the recent past for effective manipulation of the particles in the flow.[66–72] Precise manipulation is also possible using elastoinertial effects (Figure 4).[73] The elastocapillary phenomena are explored in PDMS channels even at nanoscale.[74] In a special case for controlling the microfluidic flows analogous to electronic circuitry, valves and fluidic diodes are fabricated with PDMS.[75]

Biological, Biomedical, and Lab-on-a-Chip

A major part of the biological application using PDMS comes in terms of its function as a structural material for *in vitro* and *in vivo* studies. In terms of the mechanical properties and compliance of the physiological vessels, deformable channels are used to study the biological FSI to mimic physiological vessels *in vitro* as discussed before.[55,76,77] As an enhancement to the role as a mechanical backbone of a vessel model, biological cells like endothelial ones can be grown over the PDMS channel walls to make it more suitable for cell-based microfluidics studies towards the realization of the organ-on chip paradigm (Figure 5).[78–84] To this end, cellular coculture studies have been carried out with special emphasis on angiogenesis and vessel sprouting.[85,86] The elasticity tuning of PDMS can significantly affect the cell adhesion, especially for fibroblasts.[87,88] For a traction force microscopic technique to assess the mechanobiological interactions around cells, PDMS microfluidic channels offer an excellent platform.[89] PDMS is extensively used in bioassays and targeted drug delivery systems using implantable microfluidic devices.[90,91] Detailed biocompatibility tests of PDMS have proved it to be an excellent choice for bioreactor applications to culture cells with improved reactor performance.[79,92] Holey PDMS membranes are used to pattern different type of cells on the same substrate (Figure 6).[93] Plasma dry etching on PDMS is employed to perform patterned cell culture inside microfluidic devices.[94] For cancer detection using PDMS-based microfluidics devices, the interfacial aspect of cancer cell phenotypes is crucial and the effect of different coating material and stiffness should be accounted for (Figure 7).[95] The adsorption capacity of PDMS plays a critical role as far as the biomolecular detection and quantification is concerned in a microfluidic system. To evaluate this, partition coefficients of a series of biomarkers are measured to evaluate the adsorption capability and thus the efficiency of the detection system.[96] In a novel development, multilayer PDMS devices are developed to accommodate brain slice from a rat having independent control over multiple fluids to monitor electrophysiological parameters.[97]

The biomedical applications of PDMS in the realm of microfluidics consist of rapid diagnostics and on-chip equipment. Many lab-on-a-CD platforms utilize PDMS as the base material due to enhanced signal response and ease of fabrication.[98] To exploit the combined advantage with paper microfluidics devices, PDMS-paper hybrid microchannels are fabricated with a versatile graphene backbone for sensing applications (Figure 8).[99–101] Derivatives of PDMS and its blends are used in implants and other applications inside the human body especially cartilage and cochlear implants which are proved be of excellent biocompatibility.[102,103] Towards the study of microswimmers and microbial organisms, chemotactic pathways are amply investigated in

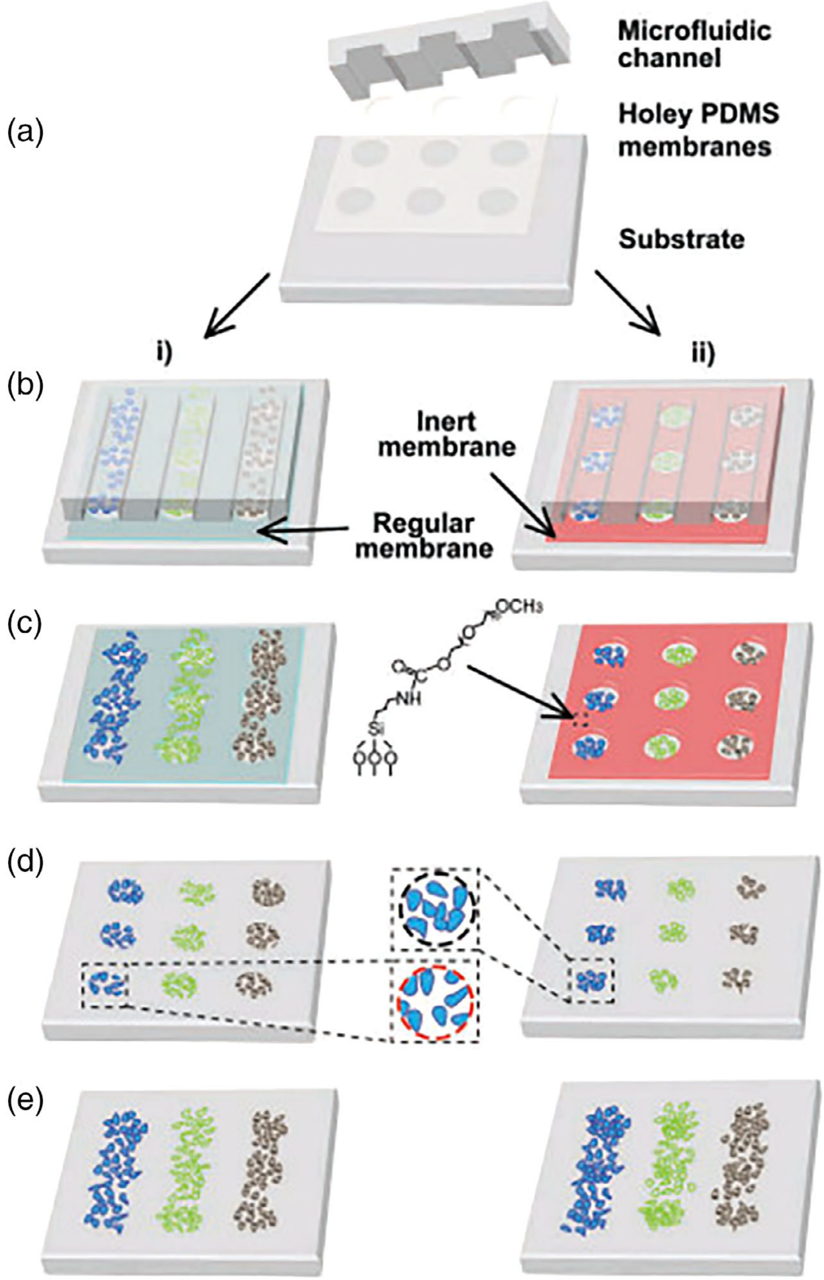

Figure 6. Patterning of different types of cells by changing the surface properties of PDMS.[93] Reproduced with permission of John Wiley and Sons. [Color figure can be viewed at wileyonlinelibrary.com]

PDMS microchannels for *E. coli*[76] and *C. elegans*.[104] However, with the extensive use in biomedical engineering one should not overlook the disadvantages of it being a synthetic polymer. While doing biological studies with PDMS, the leeching of the uncured polymer and the partitioning of the hydrophobic molecules into the bulk of the polymer should be carefully taken care of, thus posing a limitation to the architecture that can be improvised to biomicrofluidic systems with PDMS.[80]

Biomimetics

The term biomimetics is used somewhat ambiguously in terms of the microfluidics applications. There are bioinspired biomimetics and biological biomimetics that deal with constructing materials that is akin to the biological counterparts to replicate its function. Applications like lotus leaf replica fall in the former category while cell laden microfluidic channels fall in the latter. PDMS has been extensively used to replicate practically every natural surface, owing to the maneuverability of its microstructures using soft lithography, functioning as a mold during replication. The lower surface energy of uncured PDMS allows it to wet even the smallest features and thus replicate with high fidelity. Along with lotus leaves, pitcher plant leaves, rose petals, leaf venations, insect shell, and gecko feet add to the fleet of structural biomimetics with botanical and zoological underpinning.[105] The lotus leaf replica is

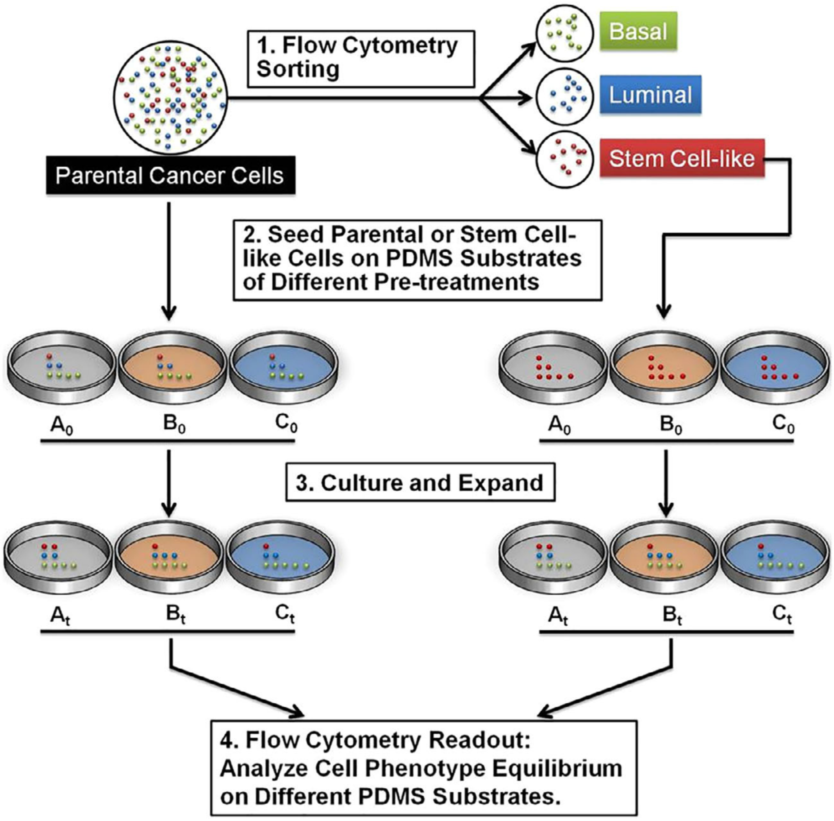

Figure 7. Cytometric detection system on PDMS substrates of different pretreatments.[95] Reproduced with permission of Springer Nature. [Color figure can be viewed at wileyonlinelibrary.com]

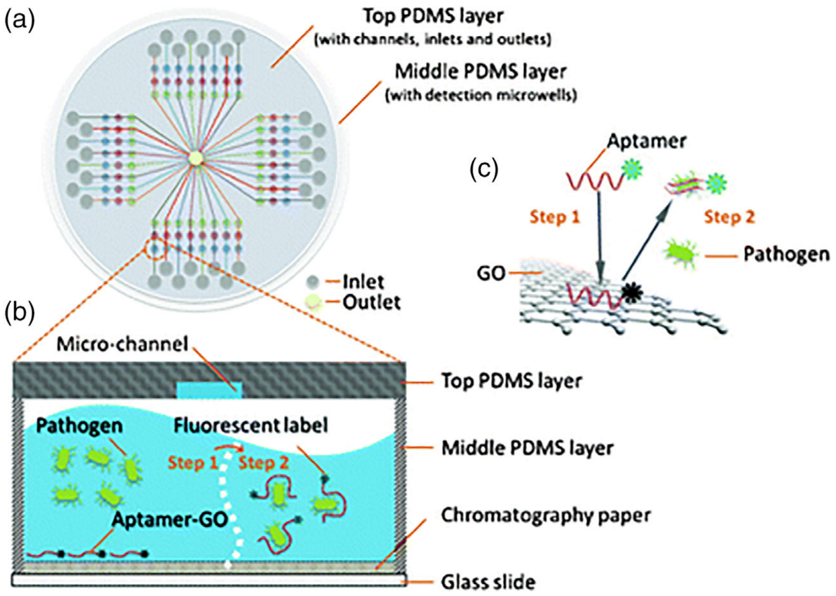

Figure 8. Hybrid PDMS-paper microchannel for the detection of pathogens.[100] Reproduced with permission of The Royal Society of Chemistry. [Color figure can be viewed at wileyonlinelibrary.com]

particularly interesting that it can be used for drag reduction and mixing in microfluidic channel flows at the same time due to the tunable nature of wetting owing to the well-known Cassie–Wenzel transition.[106,107] Apart from the supherhydrophobicity offered by many natural subjects, the promising superoleophobic surfaces also utilize PDMS for its versatile application in oil separation and

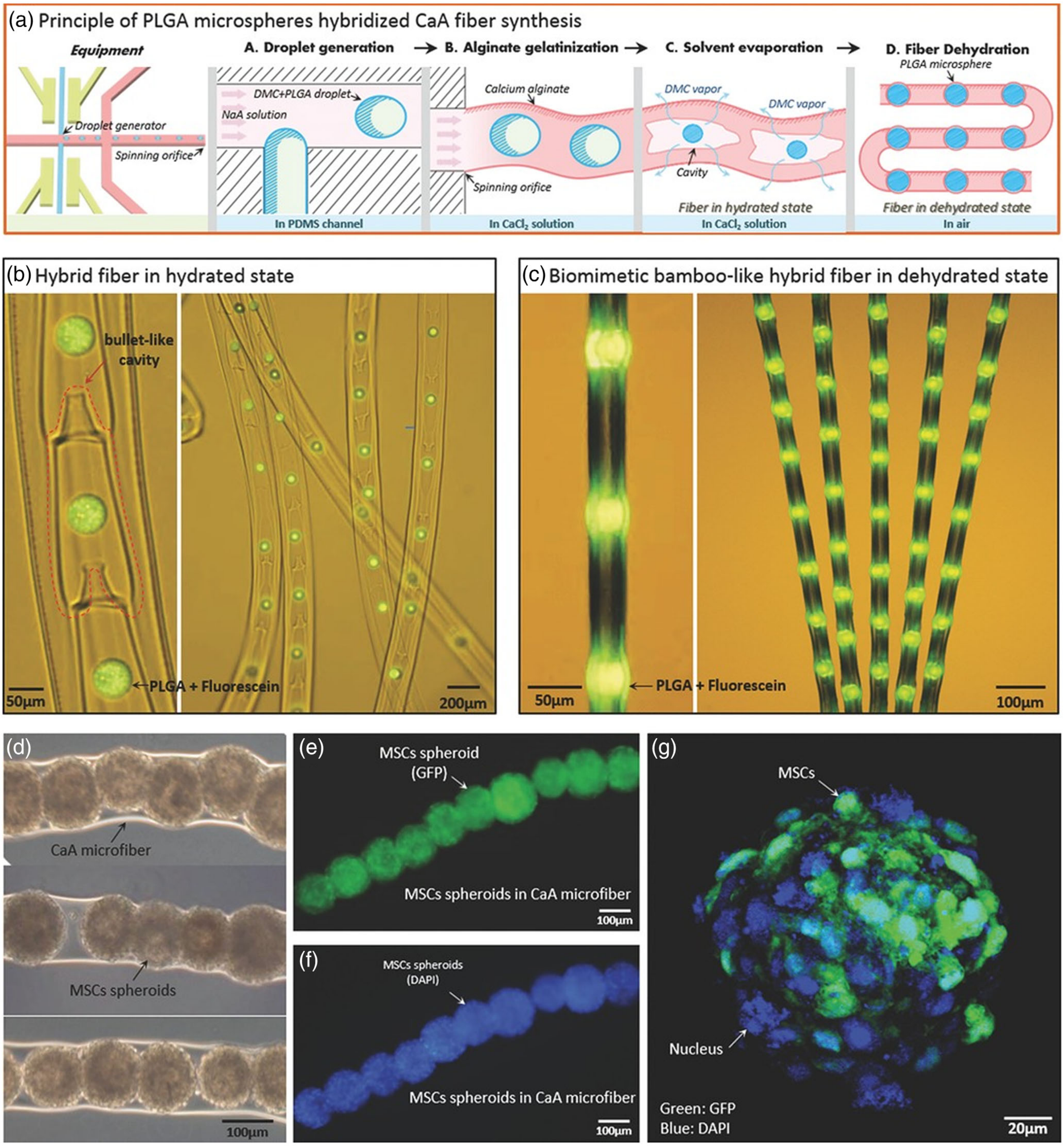

Figure 9. Fabrication of bamboo like microfibers using PLGA spheres within a PDMS miarochannel.[111] Reproduced with permission of John Wiley and Sons. [Color figure can be viewed at wileyonlinelibrary.com]

spill control applications.[108] Further, multilevel hierarchical replication of leaves with anisotropic sliding properties are demonstrated for droplet actuation.[109]

Biomimetic multiscale honeycomb structures are fabricated using poly(lactic-*co*-glycolic acid) (PLGA) in a PDMS-based microfluidic flow focusing device.[110] Bamboo-like microscale hybrid PDMS fibers are fabricated by combining droplet microfluidics and wet-spinning process (Figure 9).[111] A biomimetic model of retina is fabricated to examine the migratory behavior of retinal lineage cells.[112] An antiadhesive nanofilm coating of polysaccharide is found to mimic the glycocalyx layer inside the body.[113] Utilizing a PDMS substrate, multilayer cell-matrix architecture is used to construct a 3D system that serves as a biomimetic arterial structure.[114] Using resonating PDMS pillars created using an underwater

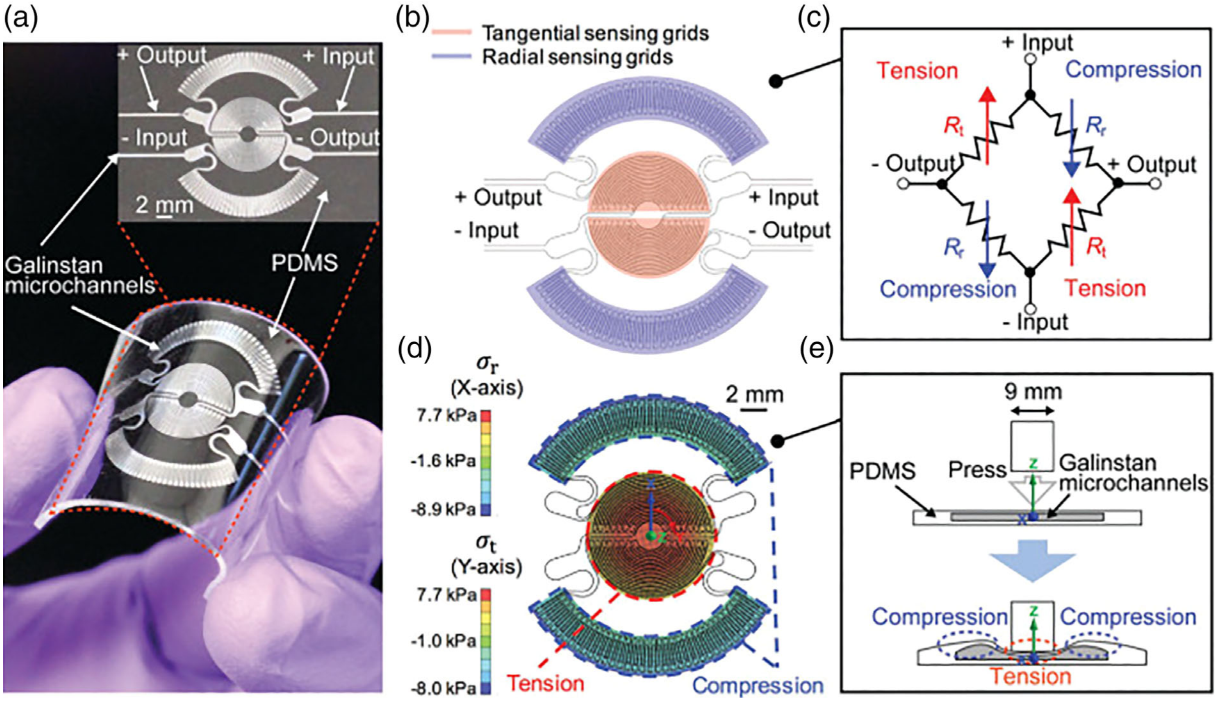

Figure 10. Flexible diaphragm-based pressure sensor embedded within PDMS matrix for tactile sensing.[118] Reproduced with permission of John Wiley and Sons. [Color figure can be viewed at wileyonlinelibrary.com]

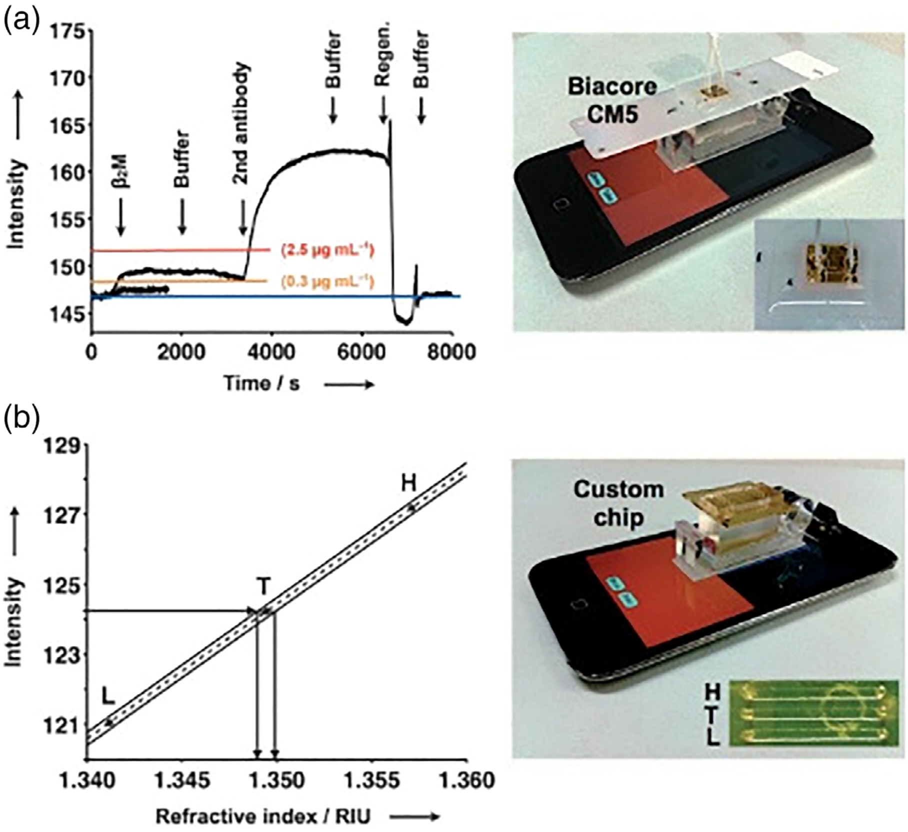

Figure 11. SPR-based biosensor with a PDMS microchannel using screen illumination and camera of a smartphone.[129] Reproduced with permission of John Wiley and Sons. [Color figure can be viewed at wileyonlinelibrary.com]

fabrication method, biomimetic cilia is shown to mimic the compliance and beating of a biological counterpart.[115] Micro- and millisoft robots, based on the principle of swarm robotics, are inspired by insect swarm and are actuated with microfluidic channels that mediate the stimuli. They are multifunctional units that can perform locomotion, sensing, capture, and release.[116] Further, combinatorial microfluidics is used to create a droplet generation platform with enhanced stability to synthesize biomimetic materials for various applications.[117]

Sensors and Actuators

With the growing use of miniaturized electronic gadgets like fitness trackers lies a huge potential for PDMS-based devices as the foundational material. The wearable sensors which are flexible are promising for the future (Figure 10).[118] PDMS-based microfluidic sensors have played a considerable role in the widely used LOC platforms that are available today. A highly flexible and sensitive diaphragm-based bioelectronic pressure sensor employing Galinstan microchannels was developed for tactile sensing that can be attached on limbs.[118] By fabricating conducting PDMS surfaces, they can be used as a sensor for heat and temperature.[119] An evanescent field-based optical fiber sensing device is developed with PDMS microfluidics to measure the refractive index of liquids.[120] The main advantage in using PDMS in strain sensors is the capacity to undergo strains up to 200% without failure. Using multilayer soft lithography in PDMS microchannels, a pressure sensor is fabricated which is filled with ionic liquid filled is found to be highly stable for a wide range of operation.[121] Moreover, a flexible, multilayered microfluidic channel force sensor is developed using capacitive technology in which liquid metal alloy is used to modify the electrical and mechanical properties, exploiting the electrokinetic effects within the microfluidic paradigm.[122–126] Highly stable monodisperse PDMS microbeads are produced using microfluidic methods which can be used as oxygen sensors.[127]

A self-contained large-area wireless strain sensor is developed on the principle of multilayer microfluidic stretchable radiofrequency electronics (μSFREs) with a large range of operation.[128] Angle-resolved SPR detection system that can be used with the illumination and optical detection with cell phones, thus making it highly portable and easily integrated with other digital platforms for data management.[129] A microwave microfluidic sensor is developed using complimentary strip-ring resonator to estimate the dielectric properties of a liquid sample.[130] To realize cost-effective sensor technology for microfluidic applications, a lab-on-chip glucose biosensor is developed using a frugal additive manufacturing technique on PDMS surface by inkjet-printed deposition of nanoparticles to function as the electrode.[131] The integration to mobile phones is easy with PDMS devices for development of user-friendly microfluidic analytic platforms using SPR (Figure 11).[129]

Miscellaneous

There are several riveting off-beat applications with the PDMS microfluidics varying from membrane-based sponges for oil–water seperation[132] to tunable lenses.[133] A refreshable braille display using PDMS-based microfluidics is demonstrated to control pumps and valves in microfluidic networks (Figure 12).[134] In another case, braille display module is developed that is driven by a thermopneumatic actuator.[135] For the selective absorption of oil from water, sugar-templated microporous PDMS sponge is developed.[132] A rather intriguing PDMS microfluidics platform called RootChip is used as an effective platform to study the root biology that can easily control the growth conditions and can also amenable to imaging.[136] In a matter of pedagogic interest, a modular microfluidics module using PDMS is developed that can be potentially used as an educational platform to teach the fundamentals of the topic.[137] An eco-friendly and polymer-encapsulated fluorescent carbon dots are developed *via* PDMS microfluidics that can be used for bioimaging and drug delivery.[138] PDMS is an excellent choice for Do-it-Yourself (DIY) applications since it is not expensive and can be bought without restrictions or legal hassles, making it a perfect candidate for do-at-home scientific projects. To leverage the power of internet-based sharing platforms, metafluidics, an open-source and community driven repository for microfluidic devices, is introduced as an excellent starting point for DIY enthusiasts (Figure 13).[139] Further, an optofluidic fabrication technology is introduced to fabricate submicron 3D microparticles within PDMS microchannels.[140] It can be seen that many out of the box ideas that are realized with the particularly versatile characteristics of this polymer. It is further envisaged that advanced studies in PDMS microfluidics will not only open of several new applications, but also will trigger outstanding developments in advancing the understanding of fundamental fluidic transport processes and systems.[82,83,141–150]

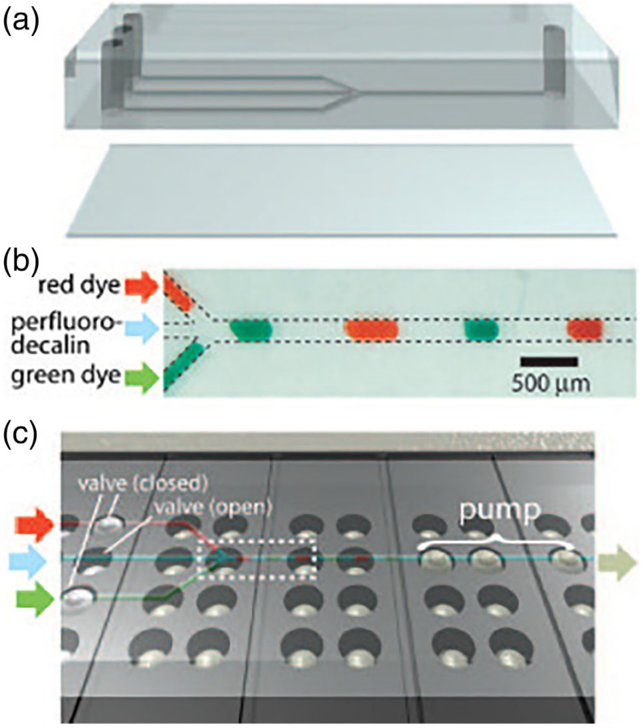

Figure 12. Braille display-based microfluidics using PDMS.[134] Reproduced with permission of National Academy of Sciences. [Color figure can be viewed at wileyonlinelibrary.com]

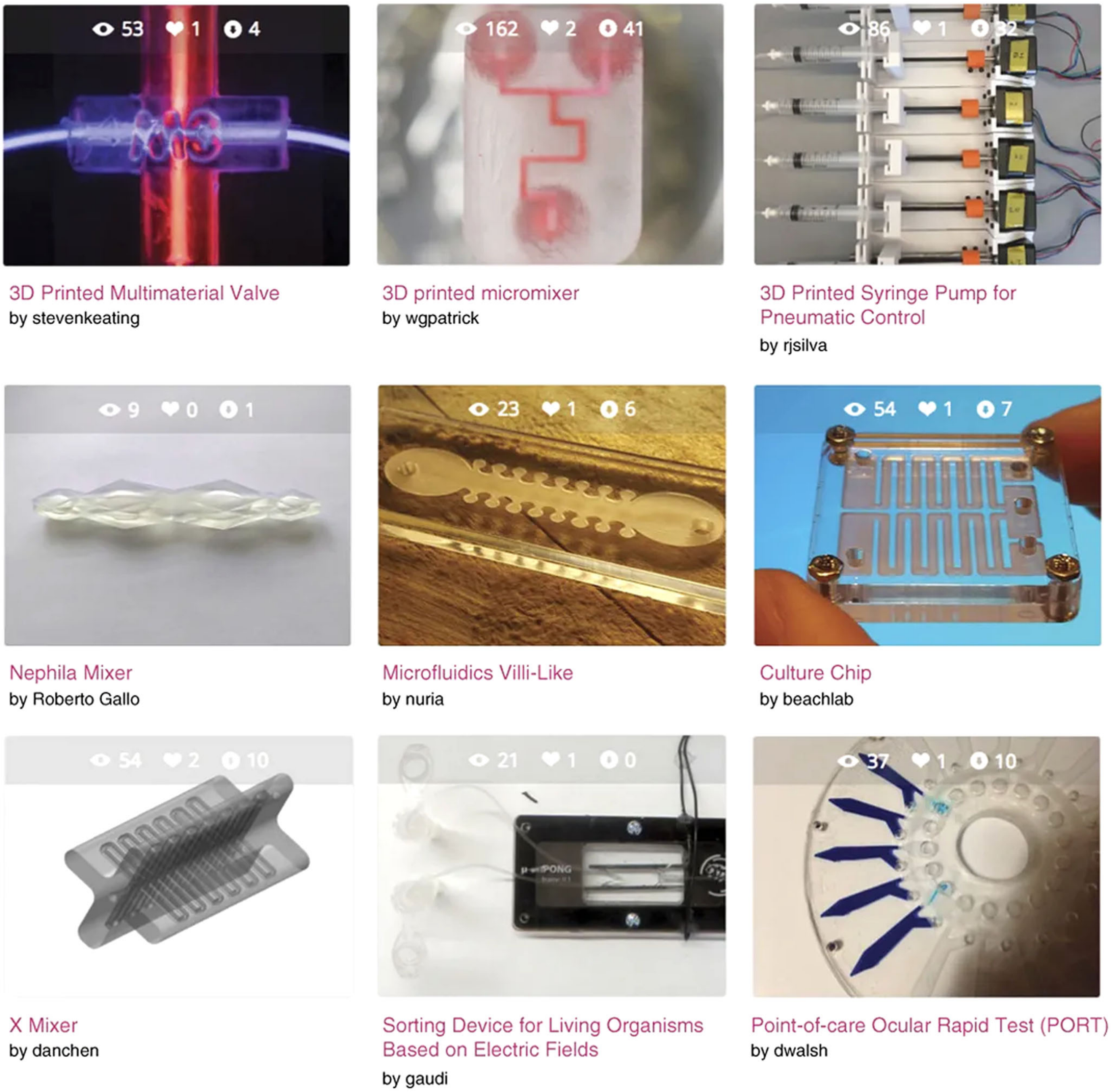

Figure 13. Open source platform-Metafluidics as a sharing space for microfluidics projects.[139] Reproduced with permission of Springer Nature. [Color figure can be viewed at wileyonlinelibrary.com]

FUTURE DIRECTIONS

PDMS will reign the field of microfluidics for the years to come. More commercialized versions of this chemical are yet to come, possibly overcoming the many disadvantages of existing ones. Soft lithography, indeed, plays an irreplaceable role in the bioanalytical platforms, although alternatives have emerged in the form of rapid prototyping using additive manufacturing (3D printing), albeit not without disadvantages. With a multidisciplinary approach, the technique already caters a number of communities outside the polymer technology. It is often argued that many of the lab-on-chip devices have not produced to an industrial scale to reach the customers as end products. A streamlined and synergistic action of entrepreneurs and scientists is the need of the hour. The policymakers also have a critical role, especially in the developing economies. However, a balance must be struck between the commercial interests and the advancement of science in terms of fundamental investigations into the underlying physics of polymers for eco-friendly and ethically sound applications.

CONCLUSIONS

Emergence of microfluidics fabrication techniques like soft lithography and associated on-chip platforms owes its charm to PDMS in many ways. In this review, we have looked at a wide range of fields where it left impressions for many innovative solutions to real-life problems albeit at a rudimentary level. It is evident that scientists have aggressively pursued challenging problems, most notably in the biomedical arena using PDMS microfluidics, pushing the limits of their respective domains. From this perspective, this unique domain has channelized people across the spectrum of science and technology to work towards a common cause of the enhanced global healthcare. We hope this review may serve as a practical guideline to carefully utilize the material, taking leverage on the already established applications to formulate new ones and to avoid the pitfalls that previous researchers have committed.

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