

pumps, heaters, chips & connectors



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### Why Miniaturization?

Volume of	1μl	1nl	1pl
Is a Cube of	1mm <sup>3</sup>	100μm <sup>3</sup>	10µm³
# of Molecules (1nM solution)	600,000,000	600,000	600
Diffusion Time	17 min	10 s	100 ms
# of Reactions (diffusion controlled) Source: A. Manz, ISAS Dortmun	1.5/min/cm²	250/s/cm²	2,500,000/s/cm²

- 10 Fold Miniaturization
- 100 x faster separation
- 100 x capillarity

- 1000 x smaller volume
- 10 x lower reagent consumption

The two charts above illustrate why there is so much interest in Micro and Nanofluidics:

**Reduced Sample Size:** Researchers can use expensive or precious reagents in small quantity, reducing expense and allowing for increased research on trace amounts of sample.

**Decreased Scale of Experimentation:** Experiments are easier to automate; easier to do simultaneous multiple experiments in the same physical space as a macro experiment.

**Increased Experimental Productivity:** The ability to automate multiple simultaneous complete experiments creates increased experimental productivity.

#### **Conclusions:**

- Study more variables simultaneously per time period
- Study smaller phenomenon for greater understanding
- Increased experimental productivity
- More information faster than conventional techniques



## **Evolution of Research Reactor**

**Both Batch and Continuous Flow** 

pl/min

Flow Rate

Sample Size

Technicon Continuous Flow



ml/min

Large

1950

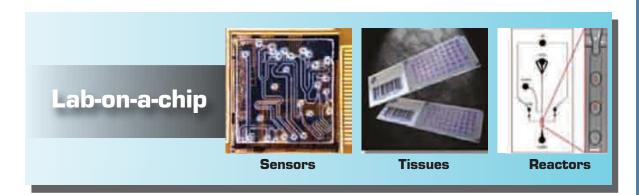
1960

1970

1980

Years

## Fluidic Devices



## Flow Injection Analysis Continuous Flow



#### **Batch Reactors**



#### **Glassware Reactors**

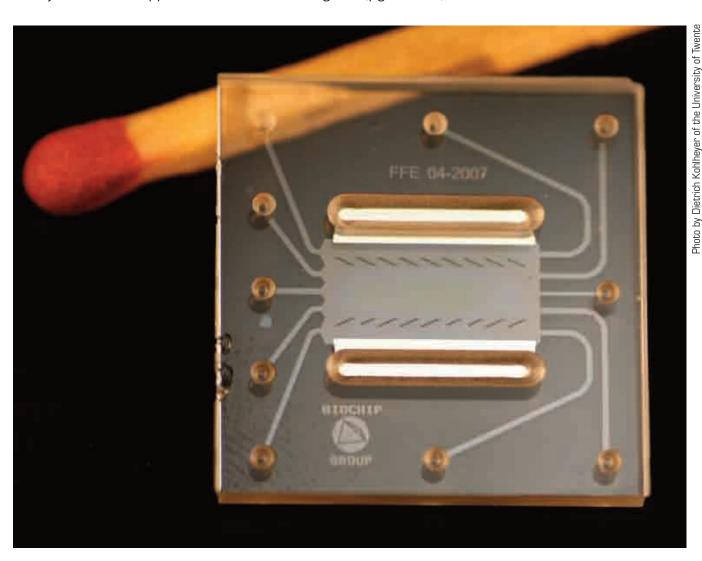


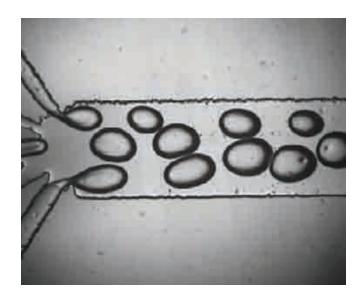
1990 2000 2010 AND BEYOND!

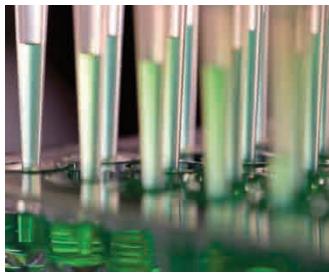
**Years** 

## What do we mean by Micro and Nanofluidics?

The science of micro and nanofluidics is the building of miniaturized devices with chambers and tunnels for the containment and flow of fluids. With devices measured at the micrometer level and fluids measured in nanoliters and picoliters, microfluidic and nanofluidic devices are widely used in the applications shown in this guide (pgs 8 & 9).







#### **Microfluidics:**

(10<sup>6</sup>) length scale is on the order of a micron. Liquid micro systems and components differ from macro systems primarily due to device fabrication of miniature systems.

#### Nanofluidics:

(10<sup>9</sup>) The science of building microminiaturized devices with chambers and tunnels for the containment and flow of fluids measured at the nanometer level. Harvard Apparatus 108 years of experience in low-flow science provides you with: low flow (microliter, nanoliter, picoliter and femtoliter) fluid delivery systems, with high accuracy and precision, pulse free pumping mechanisms and critical accessories for micro and nano fluidics.

#### Nanotechnology provides:

- Exquisite new tools to engineer novel materials and devices at the nanoscale level, A nanometer, one billionth of a meter, is about 10,000 times narrower than a human hair
- Biological systems on the nano scale resemble the semiconductor world where a molecule or a biological system is a series of atoms and energies
- Monitoring temperature, pressure, inserting things into a cell or moving fluids becomes an exercise in moving atoms and maintaining or monitoring energies

## Applications of Microfluidics

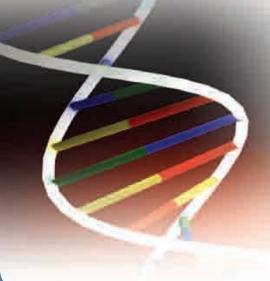
#### **BIOCHEMISTRY**

- Enzymatic assays
- The Polymerase chain reaction
  - Nucleic acid arrays
  - Biomolecular separations
- Immunohybridization reactions
- Piercing structures for DNA injection

#### **MICROFLUIDICS**

#### CELL BIOLOGY

- Flow cytometry/sorting
- Sperm/embryo tools: sperm motility, in vitro fertilization, embryo branding
- Force measurements with bending cantilevers
  - Dialectrophoresis/electroporation
  - Impedance monitoring for cell motility and micromotion
    - Chemical/physical substrate patterning



## **Applications of**

## **Nanofluidics**

#### **BIOLOGY**

#### **Physiology**

(filtration, superhydrophobicity, biolubrication, ion channels, actin/myosin, aquaporins)

**Genetics** (DNA)

Biochemistry

#### CHEMISTRY

#### Colloid Chemistry

(DLVO theory, electrokinetics, Donnan equil, semipermeability)

#### Nanobioscience

(single molecule studies)

**Biophysics** 

#### **PHYSICS**

## Physics of Fluids (CFD, cavitation, slip flow)

**Thermodynamics** 

#### **NANOFLUIDICS**

### Polymer Science

(DNA, protein conformation)

#### Separation Science

(chromatographic packings)

#### **Membrane Science**

(nanoporosity, size exclusion, semipermeability)

#### Surface Science

(SFA, wetting, absorption)

#### **Tribology**

(brush layers)

#### **Soil Science**

(water potential, zeolites)

#### **ENGINEERING**

#### Microengineering

(stiction, device fabrication)

#### **Bioengineering**

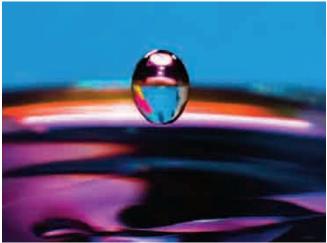
(tissue engineering, cartilage)

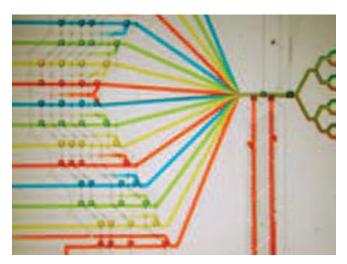
## 108 Years of Experience in Low Flow Science

Harvard Apparatus offers superior solutions for the challenges of microfluidic and nanofluidic applications. Harvard Apparatus' 108 years of experience in low-flow science provides you low flow (microliter, nanoliter, picoliter and femtoliter) fluid delivery systems with high accuracy and precision, pulse free pumping mechanisms and critical accessories for microfluidics and nanofluidics.

Harvard Apparatus offers singleand multi-channel volume and
pressure controlled pumps with flow
rates from picoliters to milliliters.
We can provide standard models,
specials and OEM modules designed
to meet your application needs.
In addition to pumps we carry
heaters/coolers (syringe, in-line
and chip), syringes, microfluidic
chips, connectors and tubing.







Our experienced technical support staff is READY to assist you at any time!



Harvard Apparatus utilizes a four part approach to solve the challenges of Micro and Nanofluidics!











- ADVANCED FAMILY OF LOW-FLOW PUMPING PRODUCTS
- BROADEST RANGE OF ACCESSORIES
- EXPERTS TO ASSIST YOU IN YOUR SELECTION
- SPECIALIZED FLUIDICS PRODUCTS

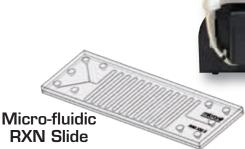
Innovative technology • 108 years low flow fluidics expertise • Varied product offerings customized for your fluidic requirements

## Harvard Apparatus...Family of Fluidic Solutions Companies from Nano to Micro





- SYRINGE & PRESSURE PUMPS
- CONNECTORS
- GLASS CAPILLARIES
- TUBING





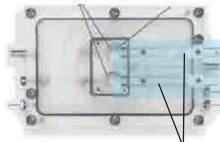




PLI-100 Nano Dispenser

#### **HUGO SACHS ELEKTRONIK**

The Physiology Specialists



HAS-HA Lung Slice Chamber

V Pipes

- PERFUSION MANIFOLDS
- DATA ACQUISITION
- BIOSENSORS
- TRANSDUCERS
- ELECTRODES
- AMPLIFIERS





Cell Imaging Chamber

- IMAGING CHAMBERS
- PERFUSION MANIFOLDS
- DATA ACQUISITION
- BIOSENSORS
- TRANSDUCERS
- AMPLIFIERS
- PNEUMATIC INJECTORS
- PULLERS

If you wish to receive some assistance, please have the answers to the following questions and we will help you select the appropriate pump for your application.

14. What temperature:todegree C	1.	Please describe your application?
<ol> <li>What size syringes are you working with?</li></ol>	2.	Do you need to infuse only or infuse/withdraw?
5. What flow rates are you working with? at the same flow rate or at different flow rates? 7. For what period of time are you infusing/withdrawing? 8. What's the viscosity of the liquid you are pumping (i.e. water, honey, peanut butter)? 9. What accuracy and precision are you looking for? 10. What are your pressure requirements? 11. Do you need RS232 compatibility (Do you want to control your pump via computer)? 12. Do you need a programmable pump? 13. Do you need temperature control for the: Fluidic line? Fluidic device: 14. What temperature: to degree C 15. Do you need to worry about system volumes: Tubing? Connectors?_ 16. Do you need chips? Do you make your own? 17. Do you need chips? Do you make your own? 18. What is your budget? 18. What is your budget? 19. The pumping with the same flow rate of pumping at the same flow rate or at the same f	3.	What volume do you want to infuse or withdraw?
6. How many channels do you need to pump? at the same flow rate or at different flow rates?  7. For what period of time are you infusing/withdrawing?  8. What's the viscosity of the liquid you are pumping (i.e. water, honey, peanut butter)?  9. What accuracy and precision are you looking for?  10. What are your pressure requirements?  11. Do you need RS232 compatibility (Do you want to control your pump via computer)?  12. Do you need a programmable pump?  13. Do you need temperature control for the: Fluidic line? Fluidic device?  14. What temperature: to degree C  15. Do you need to worry about system volumes: Tubing? Connectors?_  16. Do you need rigid connectors for support?  17. Do you need chips? Do you make your own?	4.	What size syringes are you working with?
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18. What is your budget?	16.	Do you need rigid connectors for support?
	17.	Do you need chips? Do you make your own?
Notes	18.	What is your budget?
	Vote	S

## The Proof is (PRFFS) in the Pump!

70-2217 Nanomite Syringe Pump









**Platforms** - Harvard Apparatus has 14 different capability platforms that are integrated into the product lines that provide you with the best solution for your fluidics application and budget. Harvard Apparatus can also provide total systems solutions.

**Reliability -** All of Harvard Apparatus syringe pumps come with a standard 2-year warranty. Harvard Apparatus' reputation is mainly due to our outstanding reliability and service

Force - With higher force, we can offer our customers the highest levels of performance, versatility and solutions to new applications areas: feeding stations, micro reactors delivery, viscous solution delivery, bolus injections of very small or large volumes with accuracy.

**Flow** - Harvard Apparatus has numerous flow type pumps so we can offer you the specific models for varied flow conditions: Low Flow, Smooth Flow and High Flow.

**Specials -** With the number of Capability Platforms that Harvard Apparatus offers, it is very easy to customize our pumps to fit the customer's application or OEMs.



70-2002 PHD 22/2000

Programmable Syringe Pump

## Quality Flow with Accuracy & Precision



70-3005 PHD ULTRA™ Syringe Pump

- 1. Performance Accuracy, Precision, Smooth Flow
- **2.** Force 20, 50, 75, 200 or 450 pounds of linear force
- 3. Wide Flow Rate Ranges
- 4. Syringe Size and Rack Size Accommodate 1 to 10 syringes of various sizes
- 5. Reliability 2 year warranty
- 6. Control local or remote
- 7. Materials magnetic or non-magnetic
- **8. Programmability** keyboard or computer (RS-232 or USB)
- **9. Accessories –** Valves, tubing, adapters
- 10. Power Battery or Wall
- **11. Flow Characteristics –** Infuse, Withdraw and Push/Pull
- **12. Application –** Cellular Injections, MS Calibration, Nano Fluidics, Pumping Viscous Solutions, OEM Modules
- 13. Size
- 14. Price







## PHD ULTRA™ Syringe Pump

## The PHD ULTRA™ will change the way you think about syringe pumps!



## Smoothest and most accurate flow available

 New patents pending mechanical design for superior picoliter to hundreds of ml/min flows

#### **Unparalleled Versatility**

- Broadest range of applications including nanofluidics, MS, reactors dosing, electrospinning, aerosols and more
- Pump Models: infuse only, infuse/withdraw, infuse/withdraw programmable
- Pump Configurations: standard, remote, push/pull
- Syringe Racks from 1 to 10 syringes providing mult-channel or a large capacity reservoir
- Connectivity: USB, RS-232, RS-485, I/O

## Provides easy, intuitive operation for simple to complex applications

- Advanced high resolution, color touchscreen, with icons and GUI interface
- EZ PRO™software provides pre-programmed Quick Start methods and advanced method templates for PC-like functions without a PC
- Creates and stores >50 programs for easy recall and reuse
- Pre-programmed operational modes: Bolus, Pulse Flow, Concentration (mg/kg)
- Exchange methods with peers by email and download to the pump, reducing method development.

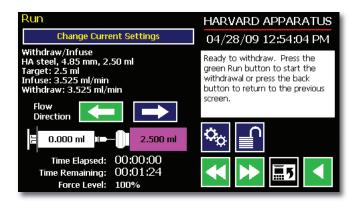
## PHD ULTRA™ Syringe Pump



**VERTICAL ORIENTATION** 

Syringe Selection		HARVARD APPARATUS
Custom Syringe		04/28/09 12:22:22 PM
Air-Tite HSW Norm-Ject	J)	Select an existing syringe manufacturer or select custom
Becton Dickinson Glass (all types)	Ш	syringe and then press Enter (green check mark) to accept or
Becton Dickinson Plasti-pak		press the Cancel button (red X) to return to the previous screen.
Hamilton Glass (all types)		
Harvard Apparatus Stainless Steel		
Cadence Science, Inc. Perfektum Glass		

#### New Easy to Use Touch Screen User Interface!



Specifications	
Accuracy	± 0.35%
Reproducibility	± 0.05%
Syringes (Min./Max.)	0.5 μl / 140 ml
Flow Rate:	
Minimum (0.5 µl syringe)	1.56 pl/min
Maximum (140 ml syringe)	220.97 ml/min
Display with Touchpad	4.3" WQVGA TFT Color Display
Non-Volatile Memory	Stores all settings
Connectors:	
RS-232	9 pin D-Sub Connector
RS-485	IEEE-1394, 6 pos
USB	Туре В
I∕0 & ∏L	15 pin D-Sub Connector
Linear Force (Max):	34 kg (75 lbs) @ 100% Force Selection
Drive Motor	0.9° Stepper Motor
Motor Drive Control	Microprocessor controlled with 1/16 microstepping
Number of Microsteps per one rev. of Lead Screw	12,800
Step Rate:	
Minimum	27.5 sec/µstep
Maximum	26 µsec/µstep
Pusher Travel Rate:	
Minimum	0.18 μm/min
Maximum	190.80 mm/min
Power	100-240 VAC:50/60 Hz 50 W, 0.5 A fuse
Dimensions	10.16 x 21.59 x 30.48 cm (4 x 8.5 x 12 in)
Weight	4.5 kg (10 lb)
Atmospheric Specifications	
Operating Temperature	4°C to 40°C (40°F to 104°F)
Storage Temperature	-10°C to 70°C (14°F to 158°F)
Humidity	20% to 80% RH, non condensing
Mode of Operation	Continuous
Classification	Class I
Pollution Degree	1
Installation Category	II
Supplier Name	Harvard Apparatus
Supplier Address	84 October Hill Rd., Holliston, MA 01746
Regulatory Certifications	CE, UL, CSA, CB Scheme, EU RoHS

Specials available on request for: Different racks, custom flow ranges and flow characteristics in those ranges, special accessories.

Item #	Description
70-3005	PHD Ultra Infuse Only
70-3006	PHD Ultra Infuse/Withdraw
70-3007	PHD Ultra Infuse/Withdraw Programmable

## Pico Plus Syringe Pump

### The Smallest Delivery Syringe Pump - 1.3 pl/min



#### **Applications**

- · Cellular injection i.e. oocytes
- Micro flow for FIA or capillary LC
- Micro reaction delivery

#### **Features**

- Infuse/withdraw capability
- Dual syringes for broad flow rate range
- Easy-to-read display, the injection rate can be changed from 0.0550 pl/sec to 0.0073 ml/sec
- Remote to micromanipulator injections are easy with non-obstructed viewing and no heavy weight to hinder positioning
- This pump has exceptional milliliter, microliter, nanoliter and picoliter smooth and accurate flow, set through the keyboard
- Injection can be controlled via manual start button, RS-232 through your computer or with included foot pedal
- Operating parameters are set with the membrane keypad and VFD display
- From the keypad the user can set pump to:
  - Infusion mode
  - Withdrawal mode (reversing switch on back panel)
- All to many micro tubing and connectors are available
- Volume mode enter a target volume, pump will stop when value is achieved
- Adjustable infusion limit switch and adjustable withdrawal mechanical stop
- An accessory pack is available for this pump.
   It contains 26 gauge blunt needles, fused silica connecting tube and connecting adaptors.

#### **Specifications**

Туре	Microprocessor dual syringe infuse/withdraw
Accuracy	±0.5%
Reproducibility	±0.1%
Syringe:	
Туре	Plastic or glass
Size Minimum	0.5 μΙ
Size Maximum	10 ml
Flow Rate:	
Minimum	1.3 pl/min
Maximum	0.8788 ml/min (using 2 x 10 ml syringes combined output)
Non Volatile Memory	Storage of all settings
RS-232	* Yes
TTL* *	Footswitch Control
Average Linear Force	25 lbs*
Drive Motor	1.8° step angle geared 36:1 motor
Motor Drive Control	1/4 microstepping
Motor Step per One Rev. of Leadscrew	14,400 steps
Step Resolution	0.0184 µm/step
Step Rate:	
Minimum	1 pulse in 27.6 sec
Maximum	200 steps/sec
Pusher Travel Rate:	
Minimum	0.0388 μm/min
Maximum	0.8333 mm/min
Input Power	12 VDC 1.5 Amps
Voltage Range	Universal input 100/240 VAC, 50/60 Hz, 18 watts
(Power Supply)	(Use only Harvard Apparatus approved supply and line cord)
Dimensions, H x W x D	11.4 x 22.9 x 11.4 cm (4.5 x 9 x 4.5 in)
Weight	2.3 kg (5 lbs)
* Actual force is higher. Not recom	nmended for applications more than 25 lbs of force.

<sup>\*</sup> Actual force is higher. Not recommended for applications more than 25 lbs of force

<sup>\* \*</sup> Using voltage to control the pump (ex. Footswitch control, external valve control)

Item #	Product
70-2213	Pump 11 Pico Plus

## Model 33 Syringe Pump

# Two Independent Pumps in a Single Package – Operate Each Pump at it's own Flow Rate of Infuse or Withdraw



#### **Applications**

- The injection of dyes, perfumes and flavoring in industrial applications
- Applications with liquids or viscous materials in micro-manufacturing
- Continuous injections of reactants into reactor vessels
- Simultaneous samplings from two sites
- Continuous injection for long term toxicology testing

Several modes of operation are available to accommodate a range of setups and experimental protocols. A unique movable limit switch mechanism is used to change direction or stop operation of the pump depending on the mode of operation.

- Reciprocal/Parallel Mode Syringe mechanisms can run in the same or opposite directions (i.e. both nfusing/withdrawing at the same time or one infusing and the other withdrawing)
- Proportional Mode Different flow rates and syringe diameters can be set for each syringe mechanism
- AutoStop Mode Pump stops operation when a limit switch is activated
- Continuous Run Mode When a limit switch is activated each syringe mechanism reverses direction

The pump has high pressure capability and TTL and RS-232 interface for data acquisition and control. The communication ports enable daisy-chaining of up to 100 pumps.

#### **Specifications**

•	
Туре	Microprocessor dual drive, single syringe, infuse/withdraw
Accuracy	±0.35%
Reproducibility	±0.1%
Syringe:	
Туре	Plastic, glass or stainless steel
Size Minimum	0.5 μΙ
Size Maximum	140 ml
Flow Rate:	
Minimum	0.0004 μl/hr
Maximum	106.6 ml/min
Non Volatile Memory	Storage of all settings
RS-232	* RJ11-4 conductor
TTL* *	9-pin connector
Average Linear Force	57 lbs
Drive Motor	2 motors, each 0.9° step angle motor
Motor Drive Control	Microprocessor controlled from 1/2 to 1/4 microstepping
Motor Steps per Rev. of Leadscrew	1,600 steps at 1/2 stepping or 3,200 steps at 1/4 stepping
Step Resolution	0.33 µm/step
Step Rate:	
Minimum	27.3 sec/step
Maximum	416.7 µsec/step
Pusher Travel Rate:	
Minimum	0.726699 μm/min
Maximum	95.25 mm/min
Power	45 W, 1.0 A fuse
Voltage Range	95 to 130 VAC, 60 Hz; 220 to 260 VAC, 50 Hz, selectable
Dimensions, H x W x D	15.2 x 31.1 x 28.6 cm (6 x 12.5 x 11.25 in)
Weight	6.8 kg (15 lb)

<sup>\*</sup> Using a computer to control single or multiple pumps (daisy-chain)

<sup>\* \*</sup> Using Voltage to control the pump (ex. Footswitch control, external valve control)

Item	#	<b>Product</b>
------	---	----------------

**55-3333** Pump 33

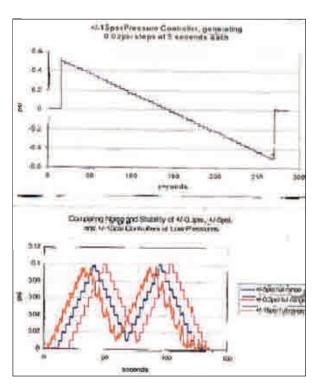
## Nanoleader™ Pressure Pump

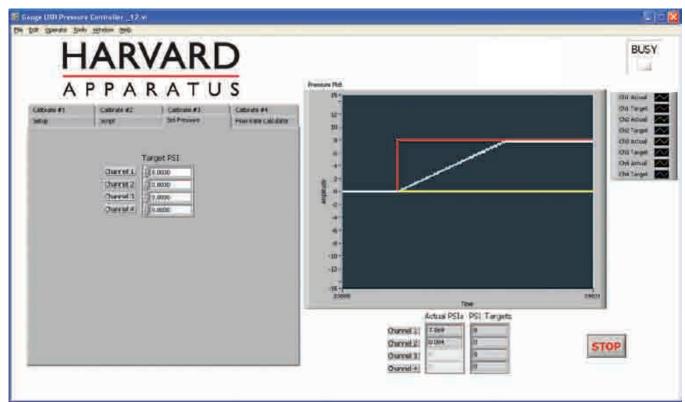
## Outstanding Flow Characteristics through Advanced Pressure Technology



#### **NLS110P Pressure Pump**

- High Performance
  - High Accuracy
  - High Precision
- Versatile PC Operation





## Nanoleader<sup>™</sup> Pressure Pump

## High Performance, Low Flow Pressure Control System – Harvard Apparatus NLS110P

Crecifications

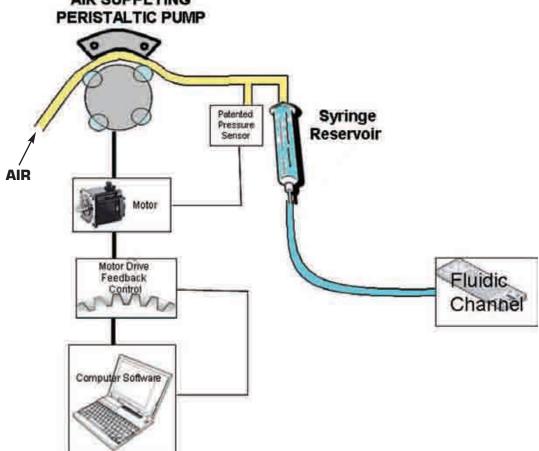
#### **NLS110P** How It Works:

- Pump generates a pressurizing flow of air
- Pulse of air is compressible and dampened
- 3. Liquid reservoir is pressurized
- 4. Pressure sensor maintains a pulse free flow based on pressure set

Specifications	
Accuracy	+/- 0.5 psi
Reproducibility	+/- 0.1% over the operating range
Resolution	+/- 0.01 psi
Reservoir	Variable; comes standard with 1 cc reservoir
Flow Rate	Calibrated from experimental data
Pressure	+15 psi to - 15 psi
Serial Port	USB
Power	24VDC, 1.7A, 40W
Voltage Range 50/60 Hz	Universal Power Supply, 100-240 VAC,
Outputs	Time (ms) and PSI

70-5000 Nanoleader NLS110P Pressure Pump





## PLI-100 Dispenser/Injector

## Femtoliter to Microliter Dispenser/Injector – PLI-100



#### **Features**

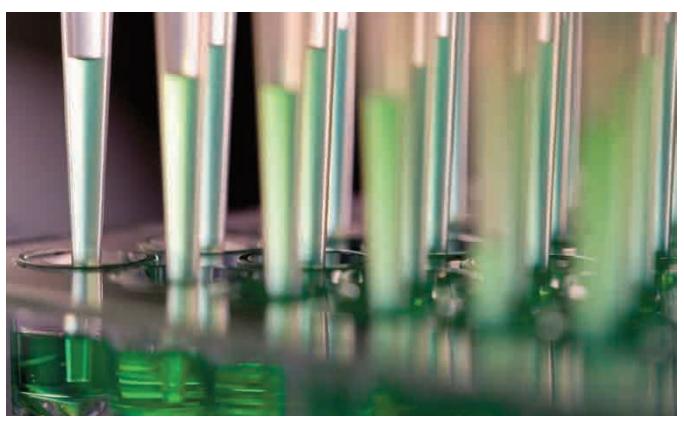
- 5 pressures: inject, balance, clear, fill and hold
- Reliable
- Femtoliter to microliters
- Reproducible
- Easy to use
- Most Published Nano Dispenser

#### **Applications**

Inject into:

- Cells
- Capillaries
- Lab-on-a-chip
- Microbeads
- Neurotransmitters
- Bacteria
- Multi-well plates

## PLI-100 Dispenser/Injector



		ons

opecinications	
Input Gas Pressure	70 to 105 p.s.i. (480 to 720 kPa)
Injection Pressure	0.2 to 60 p.s.i. (413 kPa), regulated, multi-turn control
Balance Pressure	0.1 to 3.5 p.s.i. (68.9 kPa), regulated, multi-turn control, other ranges available upon request
Fill Vacuum	Internally produced, -12.0 p.s.i. (-82 kPa), unregulated
Holding Vacuum	Internally produced, 0 to 3 in H <sub>2</sub> O (0 to 0.75 kPa or 0 to 0.1 p.s.i.), regulated
Clearing Pressure	Input gas pressure, unregulated
Injection Timer	0.01 to 0.99 sec in 10 msec steps; 1 to 99 sec in 1 sec Pulse Width steps
Injection Count Display	Digital, O through 9999
Duration Mode	Internally timed or externally gated
Time Trigger	Front panel, foot switch, or external TTL pulse (BNC)
Pressure Units	p.s.i./kPa; switch selectable
Pressure Monitor	BNC connector, 10 mV/p.s.i.
Pressure Readout	Inject, balance, clear, output port
Line Voltage	100/110/220/240 VAC
Power Usage	220 W
Meter Accuracy	0.1% full scale
Foot Switches	Inject, fill, hold, and gated; provided in plus and deluxe pkgs.
Weight	6.8 kg (15 lb)
Dimensions, H x W x D	11 x 38 x 25.5 cm (5 x 15 x 10 in)
Accessories Supplied	Input, output and holding hoses

Item #	Product
65-0001	PLI-100 Dispenser
65-0002	PLI-100 Plus Dispenser
65-0003	PLI-100 Deluxe Dispenser

## Microfluidic Chip Holders and Connection Kits

The Lab-on-a-chip platform Fluidic Connect offers a user-friendly way of creating your own lab-on-a-chip setup within minutes of time. The microfluidic chips within the platform enable several research subjects such as micro reaction, cell analysis and droplet generation. The products are affordable and meet the high quality standards of Harvard Apparatus. They can easily be used with standard laboratory equipment such as syringe pumps and microscopes.

#### Fluidic Connect 4515

Chip holder for making microfluidic chip connections. Simply place and replace the chips and reconnect them.

#### **Specifications**

Dimensions	80 x 55 x 9.5 mm max
Pressure	100 bar (1450 psi)
ltem #	Product
70-5002	Fluidic Connect 4515 Chip Holder



#### Fluidic Connection Kits

#### Fluidic Connections

Connect the Fluidic Connect and the microfluidic chip to external equipment such as a pump with the Fluidic Connection Kits. Every connection in the chip holder can be handled and tightened separately, making sure leak tight connections are realized in every configuration. Three Fluidic Connections Kits are available, each of them consisting of tubing, ferrules and nuts.



#### Fluidic Connect 4515 Kits

Item #	Product	Description
70-5003	Fused Silica Connection Kit	(375 μm OD, 150 μm ID), 5 one meter fused silica capillaries, 5 ferrules and 5 nuts
70-5004	Teflon Connection Kit	5 one meter teflon capillaries (1/16" $\mu$ m OD, 250 $\mu$ m ID), 5 fittings and rings, 5 nuts and OD, 250 $\mu$ m ID (5 ferrules, nuts and rings
70-5005	Stainless Steel Connection Kit	5 pieces of 0.5 meter stainless steel tubing (1/16" $\mu$ m OD, 250 $\mu$ m ID) 5 fittings and rings, 5 nuts

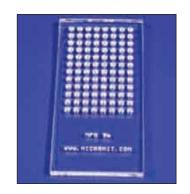
#### Microtiter Plate MPG 96.3

Microtiter plate with 96 powder-blasted wells of 1.5  $\mu$ l each. Bottom plate is 145  $\mu$ m thick.

#### **Specifications**

Chip Dimensions	22.5 x 45 x 1.25 mm	
Wells	96	
Well Volume	1.5 µl	
Bottom Size	145 μm	
Spacing	2.25 mm	

Call for more information.



### Microfluidic Chips

The chips are made of borosilicate glass and are delivered in a polymer (PP) cartridge that is 75 x 25 mm, the microslide standard, to be compatible with the Fluidic Connect 4515. Connect the Fluidic Connect 4515 and the microfluidic chips to external equipment such as a pump. Every connection in the Chip Holder can be handled and tightened separately, making sure leak tight connections are realized in every configuration.

#### Microreactor Chips

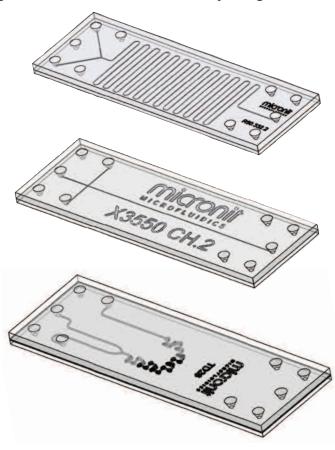
Chips with two inlets and one outlet. Two fluids can be injected separately and will mix by diffusion, without turbulence. The chemical reaction time of the fluids is determined by pressure or channel length.

#### **Cross Channel Chips**

Chips with two channels crossing each other (X-cross). Suitable for focus-flow applications or droplet generation.

#### **Micromixer Chips**

Triple layer chips offering very short mixing times, ideal mixing conditions, and efficient mixing even at low pressures.



item #	Top Glass Layer (µm)	Medium Glass Layer (µm)	Bottom Glass Layer (µm)	Internal Volume (µl)	Channel Width (µm)	Channel Depth (µm)
Microreactor Chips	<u> </u>	, ,	, ,			
70-5006	1100	-	700	6	150	150
70-5007	1100	-	700	13	150	150
70-5008	1100	-	700	0.3	50	20
70-5009	1100	-	700	0.6	50	20
70-5010	1100	-	145	0.3	50	20
70-5011	1100	-	145	0.6	50	20
Cross Channel Chips						
70-5012	1100	-	700	0.1	50	20
70-5013	1100	-	145	0.1	50	20
Micromixer Chips						
70-5014	1100	175	700	1	200	150
70-5015	1100	175	700	2	200	150

Starter Chip Packs are also available. These Chip Packs are an efficient solution to start your microfluidics experiments with different microfluidic chips.

**The Fluidic Chip Pack** includes one pack each of the following: 70-5006 and 70-5008 Microreactor Chips, 70-5013 Cross Channel Chips and 70-5014 and 70-5015 Micromixer Chips.

The Microfluidic Microreactor Chip Pack includes one pack each of all six of the Microreactor Chips.

The Microfluidic Micromixer Chip Pack includes one pack each of the two Micromixer Chips.

### Temperature Control

Depending upon the experiment multiple levels of temperature control may be required. Harvard Apparatus can provide heating and cooling for chips, lines, syringes and microscopes.

#### WP-10 and WP-16 Warmed Platforms



These warmed platforms are designed to maintain the temperature of 35 and 50 mm Petri dishes, as well as glass slides and chambered slides, on a microscope stage.

- Temperature Control from 25° to 65° C
- Stage Adapters for all major brand
- Microscopes Low cost systems

#### CO. Microscope Stage Incubator



The Electric CO<sub>2</sub> Microscope Stage Incubator fits all the XY stages on the market, and it is suitable at the same time for high magnification microscopy and multipoint experiments. A wide choice of interchangeable inserts adds flexibility to the equipment and allows the use of any cell culture support (Petri-dishes, glass slides, mutiwell plates, etc.).

- Low cost solution for long term experiments
- One model fits all XY stages
- Suitable for high-magnification microscopy
- Temperature control from Ambient + 3°C to 50°C
- Wide selection of cell culture support adapters

#### **TB-3 CS Thermal Insert**



The Warner TB-3 CS Thermal Insert is a versatile platform for cell/tissue culture work on the NanoScanZ stage from Prior Scientific.

- Designed for use with Prior Scientific NZ200CE NanoScanZ Piezo Z stage
- Optimized for rectangular chambered slides and chambered cover glass
- Can accept up to 1 x 3' slides
- Temperature control from 5° to 50°C
- Magnetic stainless steel allows use of magnetic holders
- Additional stage adapters available

### **Temperature Control**

#### **Syringe Warmers**



The SWS-Series Syringe Warmers from Warner Instruments provide a simple and effective method for maintaining a stable temperature within a syringe. The compact design of this warmer allows it to be used either with a syringe pump or mounted on a support stand.

- Syringe heaters designed for use on a syringe pump or a support stand (for gravity flow applications)
- Accommodates 10, 60, and 140 cc syringes
- Scale marking ports allow user to monitor volume in syringe during use
- Can be powered by 12 volt battery for sensitive electrophysiology applications

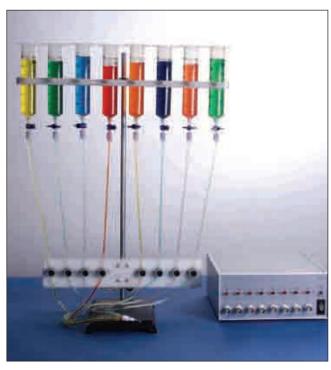
#### SH-27B and SF-28 Single Inline Solution Heaters



In-line solution heaters are the most direct way to warm solutions flowing into a series of devices. Small size allows placement close to imaging and recording chamber so as to minimize convective heat losses.

- Single line in-line solution heaters include T1 thermistor embedded within aluminum housing for feedback control
- Designed to operate with TC-324B or TC-344B temperature controllers
- Output temperature from ambient to 50°C

#### **Perfusion Valve Control Systems**

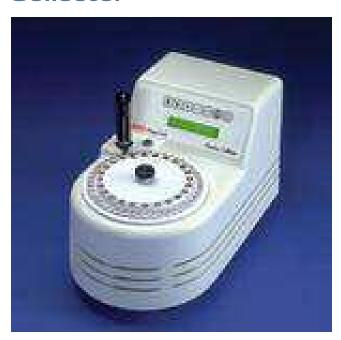


The VC-8 valve controller lies at the heart of a multi-valve perfusion system designed to automate and control the delivery of solutions to WarnerInstruments imaging and recording chambers.

- Spill sensor circuitry included provides auto shut-off capability
- Choice of Std. Pinch, Teflon 2-way, or Miniature 3-way Valves
- Manual or computer controlled
- Low noise
- Low self-heating design

## **Specialized Fluidics Products**

# Heated and Cooled Capillary Fraction Collector



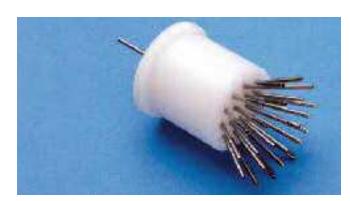
#### **Fraction Collector**

- Efficient thermoelectric cooling—vials refrigerated at 4°C
- Collect from one or two separate probes with optional second needle
- Reproducibly collect samples volumes from 5 to 200 μl
- Open architecture—remove/replace vials during operation
- Carousel removes easily for transfer of vials
- Simple method setup via front panel keypad and LCD

Item # Product

72-6909 Fraction Collector

## Manifolds – 24 ports to one



#### **Manifolds**

MPP 64-0339

• Material: Delrin

• Small Diameter: 4.7mm

• Large Diameter: 9.4mm

• Tubing: PE 50

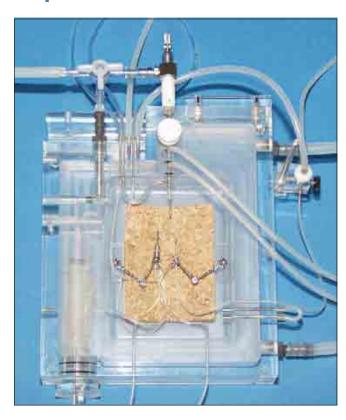
Item # Product

**64-0339** Manifold\*

\* Other Manifolds available

## **Specialized Fluidics Products**

Organ, Tissue & Cell Perfusion Baths Utilizing Solid State Liquid Circuits for Macro to Nano Experimentation



Systems for: Heart, Lung, Liver, Skin and Tubular Organs



Cell Imaging & Perfusion Chambers

## Application - Reactor/Detector

Amperometric determination of Nitric Oxide from pulmonary artery endothelial cells immobilized in a microchip channel to research pulmonary resistance

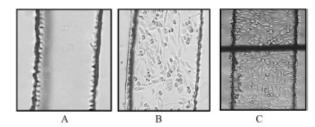


Fig. 3 Micrographs of a 130 μm × 100 μm channel in a PDMS microchip. In (A), bPAECs were aspirated into a channel that was not coated with fibronectin. After 1 h, fresh cell culture medium was introduced to the channel which forced all of the cells out of the channel. In (B), bPAECs were introduced into a fibronectin coated channel. The cells were treated with medium 1 h after aspiration into the channel and remained immobilized, thus demonstrating the necessity of the fibronectin. Immobilized bPAECs are shown over a carbon microelectrode in (C).

Dana M Spence, Nicholas J. Torrence, Michelle L. Kovarik and R. Scott Martin, Amperometric determination of Nitric Oxide from pulmonary arterty endothelial cells immobilized in a microchip channel, Analyst, 129, 995-1000, 2004 US

Model 11 experimental flow NA Pump range 0.0014ul/hr to 26.56 ml/min

Fabrication of microfluidic reactors and mixing studies for Luciferase Detection in Bioluminescent assays

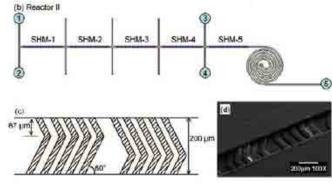


Figure 1.

(a) Schematic diagram of a microfluidic device referred to as reactor I. The device consisted of multiple T-shaped indets, a straight channel, a spiral channel for reactions, and one outlet. The inlets used in this work were numbered. (b) Schematic diagram of reactor II. It is the same as reactor I except for the SIIM included in the straight channel region. (c) The architectural details of one cycle of the staggered herringbone ridges. (d) SEM photograph of the SHM on the bottom surface of a PMMA device.

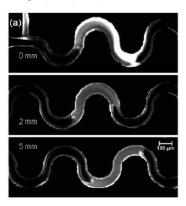
Mei Zheng Xia Feng Xu † Steven A. Soper D Z. Hugh Fan
Fabrication of Microfluidic Reactors and Mixing Studies for
Luciferase Detection Qian Department of Mechanical and Aerospace Engineering, University of Florida, P.O. Box 116250,
Gainesville, Florida 32611, Department of Chemistry, Louisiana State University, Baton Rouge,Louisiana 70803, and
Department of Biomedical Engineering, University of Florida,
Anal Chem AUGUST 1:80(15): 6045-6050.DORI:10:1021/AC800843V *US* 

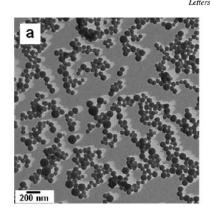
Phd 2000 experimental flow Pump range 0.0001ul/hr to 220.82 ml/min

## Application - Reactor/Microspheres

Formation and Shear-Induced Processing of Quantum Dot Colloidal Assemblies in a Multiphase Microfluidic Chip to manufacture new materials and devices.

500 Langmuir, Vol. 24, No. 19, 2008





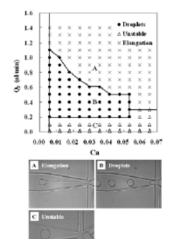
Mixing chambers

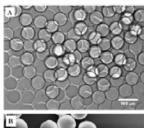
Product

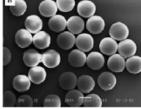
Greg Schabas, Chih-Wei Wang, Ali Oskooei, Huda Yusuf, Matthew G. Moffitt and David Sinton. L Formation and Shear-Induced Processing of Quantum Dot Colloidal Assemblies in a Multiphase Microfluidic Chip Langmuir, 24(19), 10596-10603,DOI:10.1021/la8022985August 2008 Korea

PHD 2000 experimental flow 1.1-4.8 ul/min Pump range 0.0001ul/hr to 220.82 ml/min

In Situ Microfluidic Synthesis of Monodisperse PEG Microspheres for advanced coatings, adhesives, catalysts







Chang- Hyung Choi, Jae-Hoon Jung, Tack-Sung Hwang and Chang-Soo Lee In Situ Microfluidic Sythesis of Monodisperse PEG Microspheres Macromolecular Research Vol 17,NO.3 pp 163-167(2009) Korea

PHD 2000 experimental flow 1.1-0.2 ul/min Pump range 0.0001ul/hr to 220.82 ml/min

## **Application - Device**

Use of self assembled magnetic beads for on-chip protein digestion for studying the human proteome

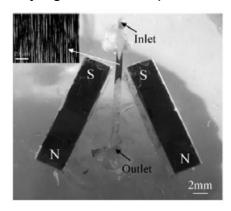


Fig. 1 Microreactor with the plug of magnetic beads maintained between the two magnets; the inset is a 100× microphotograph of the columns at the beginning of the formation of the plug.

Marcela Slovalova et al, Use of self assembled magnetic beads for on-chip protein digestion, Lab Chip 5,935-942, 2005 France

Model 11+ experimental flow NA Pump range 0.0014ul/hr to 26.56 ml/min

Experimental and Numerical Study of Droplets Hydrodynamics in Microchannels to optimize nanovolume batch reactors

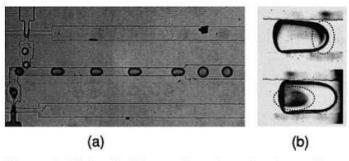


Figure 1. Mixing inside a microchannel where microdroplets are transported in a continuous oil stream (high-frequency image acquisition).

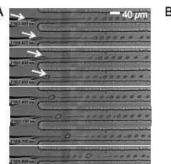
(a) General view of the device. The central channel section is  $50\times60~\mu\text{m}$ . (b) "Dead zones" inside the droplets underlined by a colored acid–base reaction.

Flavie Sarrazin, Kathine Loubiere, laurent Prat and Christophe Gourdon, Experimental and Numerical Study of Droplets Hydrodynamics in Microchannels, AlChe Journal Vol.52, NO12, 2006 France

Model PHD 2000 experimental flow NA Pump range 0.0001ul/hr to 220.82 ml/min

## **Application - Device**

Microfluidic High-Throughput encapsulation and hydrodynamic self-sorting of a single cell for diagnostics and research



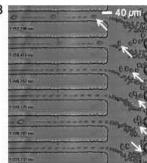


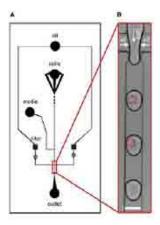
Fig. 2. Images from video sequences of cell encapsulation obtained by high-speed videomicroscopy (negative timescale). Scale bar for each image sequence is 40  $\mu$ m.  $Q_0 = 150 \mu$ M;  $Q_C = 8 \mu$ M. (4) Jet neck breaking by the passage of a cell (white arrow), and consecutive destabilization of the jet (triggered Rayleigh-Plateau instability, see also Si Movie 1). (8) Sorting of positive droplets. The white arrow points to the mechanism by which some positive drops (generally those smaller than the average size of positive drops) can be "lost" when a series of closely spaced positive drops exits the focusing region: the positive droplet marked by the arrow is pushed down by the train of larger ones that follows it (see also Si Movie 2).

Max Chabert and Jean-Louis Viovy, Microfluidic High-Throughput encapsulation and hydrodynamic self-sorting of a single cell, PNAS, Vol. 105,No.9,3191-3196, March 4,2008 France & US

PHD 2000 experimental flow 150ul/hr -50ul/hr Pump range 0.0001ul/hr to 220.82 ml/min

## Droplet-Based Microfluidic Platforms for the encapsulation and screening of Mammalian Cells and Multicellular Organisms

Encapsulated Cells for reduced evaporation



Jennifer Clausell-Tormos, et al Droplet-Based Microfluidic Platforms for the encapsulation and screening of Mammalian Cells and Multicellular Organisms Chemistry & Biology 15, 427-437 May 2008 France & US

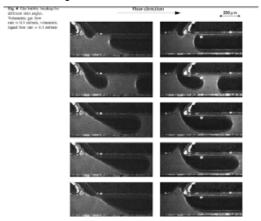
PHD 2000 experimental flow 2000 ul/hr -660nl/hr Pump range 0.0001ul/hr to 220.82 ml/min

## **Application - Device**

Impact of inlet design on mass transfer in gas-liquid rectangular microchannels

For optimized chemical reactor performance

Inlet design and mass transfer in microcircuits

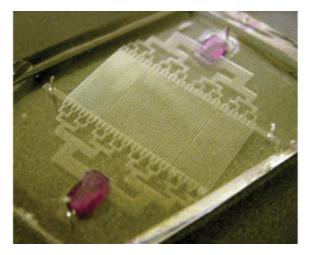


Donata Maria Fries, Phillip Rudolf von Rohr, Impact of inlet design on mass transfer in gas-liquid rectangular microchannels
Microfluid Nanofluid 6:27-35 2009 Switzerland

PHD 2000 experimental flow 2000 ul/hr -660nl/hr Pump range 0.0001ul/hr to 220.82 ml/min

## **Application - Detection**

Development of an integrated microfluidic platform for dynamic oxygen sensing and delivery in a flowing medium

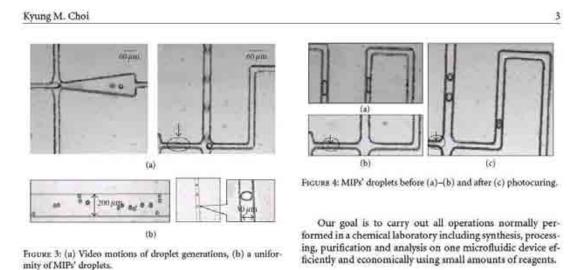


Adam P. Vollmer, Ronald F. Probstein, Richard Gilbert and Todd Thorsen ,Development of an integrated microfluidic platform for dynamic oxygen sensing and delivery in a flowing medium, Lab Chip 5,1059-1066 2005 US

Model 11 experimental flow 50ul/min-5 ml/min Pump range 0.0014ul/hr to 26.56 ml/min

## **Application - Reactor**

Microfluidic reactors for synthesis of micro or nano sized molecularly imprinted polymer particles for creation of synthetic receptor sites to create novel materials



Kyung M. Choi, Microfluidic Approach for the synthesis of Micro-or Nanosized Molecularly imprinted Poly Particles Research letter, Hindawi publiching Corp., Research letters in Matterial scienceVolume 8, art. ID 458158, 3 pages, 2008 US

PICO PLUS experimental flow 1.0 -2.5 ul/min Pump range 1.3pl/min to0.44ml/min

## Precise Control of the Reimer-Tiemann Reaction using integrated heating and thermochromic liquid crystals

Microfluidic channels with integral heating

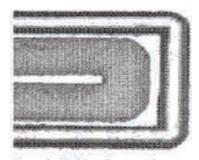


Figure 2, TLC beads occupying a collateral microfluidic channel

Robin Fortt, Alexander Iles and Andrew de Mello, Precise Control of the Reimer-Tiemann Reaction using integrated heating and thermochromic liquid crystals 7<sup>th</sup> international conference on Miniturized Chemical and Biochemical Analysis Systems, October 5-9, 2003, Squaw valley, California US UK

Model 11 experimental flow 5.0 ul/min Pump range 0.0014ul/hr to 26.56 ml/min

Sarunas Petronis, Michael Stangegaard, Claus BoVöge Christensen, and Martin Dufva. **Transparent Polymeric Cell Culture Chip with Integrated Temperature Control and Uniform Media Perfusion.** BioTechniques<sup>®</sup> March 2006 Volume 40, Number 3: pp 368-375 Research Report.

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*Lung-Hsin Hung, Robert Lin and Abraham Phillip Lee.* **Rapid Microfabrication of Solvent-Resistant Biocompatible Microfluidic Devices.** Lab Chip, 2008, 8, 983 - 987, DOI: 10.1039/b717710k.

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Theron J. Pappasa and Lisa A. Holland, a Fluid Steering in a Microfluidic Chip by Means of Thermally Responsive Phospholipids. Sensors and Actuators B: Chemical Volume 128, Issue 2, 15 January 2008, Pages 427-434.

Yung-Chieh Tan 1, Yao Li Ho 1 and Abraham Phillip Lee 1 (1) Department of Biomedical Engineering, University of California Irvine, Irvine, California, USA. Microfluidic sorting of droplets by size Journal Microfluidics and Nanofluidics Publisher Springer Berlin/Heidelberg ISSN 1613-4982 (Print) 1613-4990 (Online) Issue Volume 4, Number 4 / April, 2008 Category Short Communication DOI 10. 1007/s10404-007-0184-1 Pages 343-348. Subject Collection Engineering Springer Link Date Friday, June 29, 2007.

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