REPORT DOCUMENTATION PAGE

Form Approved
OMB NO. 0704-0188

1. AGENCY USE ONLY (Leave Blank)	2. REPORT DATE 18 Dec, 2001	3. REPORT TYPE AND DATES COVERED Final Progress Report, 1 Jun 01 – 30 Nov 01

4. TITLE AND SUBTITLE

Sample Concentration Systems for Chemical and Biological Agent Detection in Water

5. FUNDING NUMBERS
G – DAAD19-01-1-0528

6. AUTHOR(S)
Jian-Qiao Sun

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

University of Delaware, Department of Mechanical Engineering
126 Spencer Lab
Newark, DE 19716

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)

U. S. Army Research Office
P.O. Box 12211
Research Triangle Park, NC 27709-2211

10. SPONSORING / MONITORING AGENCY REPORT NUMBER

42583.1-CH-11

11. SUPPLEMENTARY NOTES

The views, opinions and/or findings contained in this report are those of the author(s) and should not be construed as an official Department of the Army position, policy or decision, unless so designated by other documentation.

12 a. DISTRIBUTION / AVAILABILITY STATEMENT	12 b. DISTRIBUTION CODE
Approved for public release; distribution unlimited.	

13. ABSTRACT (Maximum 200 words)

This report summarizes the prototyping work of a concept micro pump for chemical concentration. The work conducted under this project is a six-month concept study. The application target of the research is to help improve the sensitivity of the chemical agent sensor developed at the Army Research Laboratory in Aberdeen, Maryland. The main objective of the work is to study the feasibility of a micro pumping that can be fabricated by the surface machining technology. A prototype of the pump is presented. The detailed analyses and design specifications of the pump are not studied in this short-term project, but warrant further investigations.

14. SUBJECT TERMS	15. NUMBER OF PAGES
Micro pumps, surface machining, miniaturization, sample concentration, chemical sensors	3
	16. PRICE CODE

17. SECURITY CLASSIFICATION OR REPORT	18. SECURITY CLASSIFICATION ON THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
UNCLASSIFIED	**UNCLASSIFIED**	**UNCLASSIFIED**	**UL**

NSN 7540-01-280-5500

Standard Form 298 (Rev.2-89)
Prescribed by ANSI Std. 239-18
298-102

20020322 050

MEMORANDUM OF TRANSMITTAL

U.S. Army Research Office
ATTN: AMSRL-RO-BI (TR)
P.O. Box 12211
Research Triangle Park, NC 27709-2211

☐ Reprint (Orig + 2 copies)

☐ Manuscript (1 copy)

☐ Technical Report (Orig + 2 copies)

☒ Final Progress Report (Orig + 2 copies)

☐ Related Materials, Abstracts, Theses (1 copy)

CONTRACT/GRANT NUMBER: G DAAD19-01-1-0528

REPORT TITLE:

Sample Concentration Systems for Chemical and Biological Agent Detection in Water

is forwarded for your information.

SUBMITTED FOR PUBLICATION TO (applicable only if report is manuscript):

Sincerely,

Jian-Qiao Sun
University of Delaware

REPORT DOCUMENTATION PAGE (SF298)
(Continuation Sheet)

Statement of the Work

The work conducted under this project is a six-month exploratory study. The application target of the research is to develop a sample concentration system that can improve the sensitivity of the chemical agent sensor using conductive polymer developed at the Army Research Laboratory in Aberdeen, Maryland. The main objective of the work is to study the feasibility of a concept pump that can be fabricated by the surface machining technology. The surface machining technology is the basic operation of semi-conductor industry, and has a potential to make miniature pumps that can be readily integrated with the electronic control circuitry. It should be noted that the prototype of the pump studied in this project is far from the goal of eventual miniaturization.

Summary of the Results

Modern semi-conductor industry heavily relies on the surface machining technology [1, 2]. The industry has created many new applications in chemical and bio-science areas [3]. A recent advance in this regard is the creation of micro chemical laboratory and bio-sensors on a chip, which is an integration of micro-mechanical and electrical components with chemical and biological agents. Among the mechanical components, micro pumps and valves are of interest to this project. Since the application target of the research is to help improve the sensitivity of the chemical agent sensor developed at the Army Research Laboratory in Aberdeen, Maryland, a micro pump that can be fabricated by the surface machining technology and can be readily integrated with the chemical sensor is relevant to the Army's interest.

This project is also a continuation of an earlier effort to develop micro pumps for sample concentration. As a result, we have refined the prototype of the earlier micro pump, and have delivered another device to the Army Research Laboratory for evaluation.

In the present study, we designed a concept pump that can be fabricated by the surface machining technology, and fabricated and tested a prototype. The components of the prototype pump are shown in Figure 1. The fluid is pumped through a small channel in a plexiglass body as indicated in Figure 1. We assembled the pump and did preliminary experiments. Two undergraduate students in the Department of Mechanical Engineering have been working on this project.

The pump is driven by an AC voltage source so that the coil generates an oscillating magnetic field. The magnetic shaft attached to the diaphragm is set into a linear motion by the magnetic field in the center of the coil. The diaphragm is then forced to pump the fluid. The whole system is confined in a $2.5\times6.3\times10\text{cm}^3$ rectangular body. This choice of the dimensions was made with a consideration of a possible pocket size implementation of the chemical and biological sensors.

The flow rate of the pump is dictated by the stroke length of the magnetic shaft, the size of the coil, and the diaphragm diameter. The diameter is 2.7cm in the prototype. In this short-term research, we have not been able to build up the facility to measure the stroke and the flow rate of the pump. Also, we have not developed a mathematical model of the whole system including the electromagnetic driver, the diaphragm motion, and its coupling to the fluid flow. These tasks should be addressed in the future project of the same nature with a longer term. The results of theoretical modeling will help to optimize the design of the pump, and to develop scaling rules for miniaturization purpose.

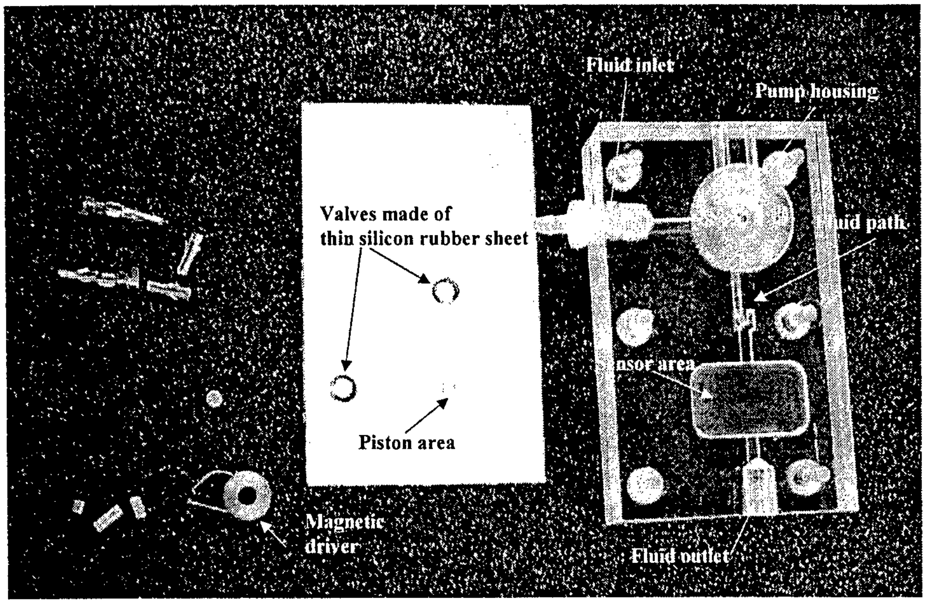

Figure 1. A large scale prototype of the proposed pump system that can be fabricated by surface machining technology, and can be integrated with chemical/biological sensors and electronics.

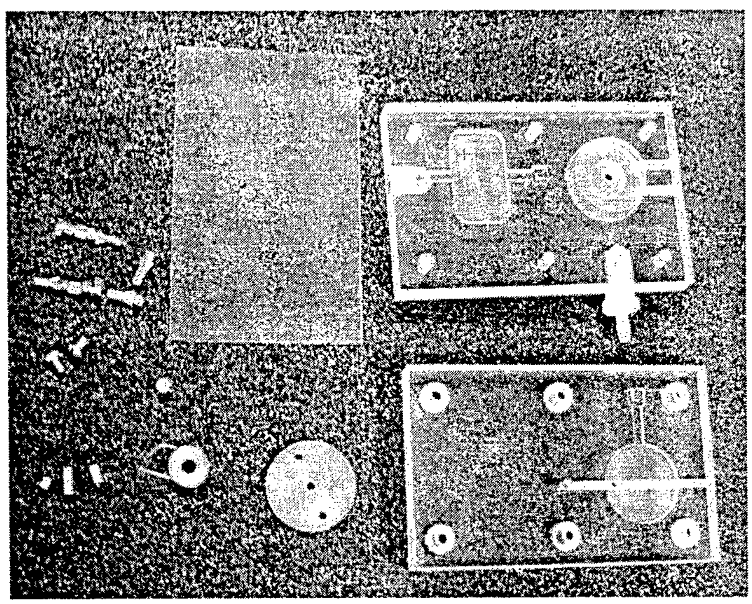

Figure 2. Another view of the prototype with the surface-machined plexiglass body separated. Electronics and the sensory materials will be integrated in the plexiglass body parts. The fluid channels, areas for electronics and sensory materials can all be surface machined.

The work of this short exploration demonstrates the potential of a pump design for sample concentration that can be fabricated by the surface machining technology, and can be miniaturized for hand-held chemical and biological agent detection device. Much more work needs to be done as discussed earlier. We need to quantify the capability of the proposed pump by developing mathematical model of the system, to optimize the design, and to develop scaling rules in order to miniaturize the system, and to develop an integrated system with the sensors and the supporting electronics.

List of Participating Scientific Personnel

Professor J.Q. Sun, Mechanical Engineering, University of Delaware
Todd M. Fitzgerald, sophomore undergraduate student, BS 2004, Mechanical Engineering, University of Delaware
Immanuel Johnson, sophomore undergraduate student, BS 2004, Mechanical Engineering, University of Delaware

Cited References

1. D. Barrow, J. Cefai and S. Taylor 1999 Chemistry and Industry(15), 591-594. Shrinking to fit.
2. S. Cowen 1999 Chemistry and Industry(15), 584-586. Chip service.
3. K. Ikuta, S. Maruo, T. Fujisawa and A. Yamada 1999 Proceedings of the 1999 12th IEEE International Conference on Micro Electro Mechanical Systems (MEMS), Orlando, Florida. 376-381. Micro concentrator with opto-sense micro reactor for biochemical IC chip family.