Current Status and Prospect of Microchannel Research

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Abstract. The application of microchannel in engineering field is becoming more and more extensive, which has attracted extensive attention of researchers at home and abroad. In the field of microelectronics technology, if the heat cannot be dissipated effectively, the working temperature of electronic devices will be seriously affected. Microchannel is an effective means to solve the heat dissipation problem. This paper shows the research status of microchannels by enumerating the research achievements of microchannels at home and abroad. By using the methods of literature review and comparison, four main problems of microchannel research in China are pointed out: the commercial production of microchannel. The problems caused by the application of micro channels to products, the risk of slow technological innovation is decreasing, the potential for future growth and the lack of uniform industry standards. Finally, the future development and research of microchannel are prospected, and some suggestions are put forward to provide reference for the future research and development of microchannel technology in China.

Keywords: Microchannel; Microchannel reactor; Research status; Prospect of Future development.

1. Introduction

Microchannel (also known as microchannel heat exchanger), is made of finishing and micro processing of a micro heat exchanger, usually in the diameter of 10 μm ~ 3000 μm. The concept of microchannels was first proposed by Tuckerman and Pease in the 1980s and has been evolving ever since. Microchannels have a wide variety of applications, excellent heat transfer performance, and energy saving, so they have been widely used in microelectronics and industrial fields. Microchannels have been well-researched and developed both at home and abroad. Countries such as Europe and the United States started the research on microchannels very early, and now it has developed into more in-depth fields, such as medicine, aerospace, and so on. However, the study of microchannels is still in the initial and ascending stage. Many microchannels are still in the function improvement of household appliances of daily necessities. As an emerging field, microchannel has a lot of content worth studying and exploring, which is also worthy of further exploration and mining by human beings in the future. The rise of microchannels is of great help and inspiration to human daily life and the development of science and technology.

2. Overview of related research at home and abroad

2.1. Research status of microchannel technology abroad

Compared with domestic, foreign countries began to research and innovation on microchannel technology earlier. In the 1990s, the United States, Japan, Germany, the Netherlands, and other countries have begun to invest in the research and development of microchannels. In medicine, industry, physics, aerospace, and many other fields have been more in-depth research and have achieved results. For example, from the Multifunctional Equipment Integration Group, Rendall Joseph, Turnaoglu Tugba, and Patel Viral K of Oak Ridge National Laboratory [1] developed a novel Metallograph Driven Magnetic The import of dual-channel is improved in dual-channel (PEDMA) to effectively solve the problem of decreased heat dissipation caused by uneven refrigerant distribution in dual-channel. Koldaeva Anzhelika and Tsai HsiehFu of Okinawa Institute of Science and Technology and Graduate University, Japan; Shen Amy Q and Pigolotti Simone [2] tried to extend the application of microchannel technology from industrial and medical fields to the fields of

genetics and biology. They tried to explore the influence of microchannels on population evolution by propagating certain microbial populations in microchannels. Helms Florian, Zippusch Sarah, and other researchers from Hannover Medical School in Germany [3] developed an artificial blood vessel tissue structure made of fibrin-based microchannels, which is more consistent with the original blood vessel structure and characteristics of the human body. It also allows patients to improve the biomechanical stability of the artificial tissue after vascular transplantation. Figure 1 is the reaction schematic diagram of microchannel reactor.

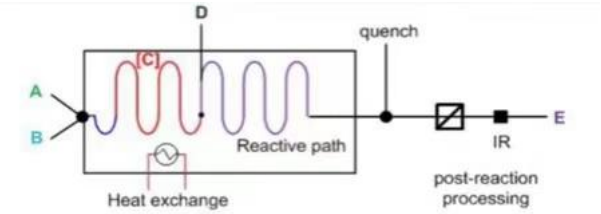


Fig. 1 Schematic diagram of the microchannel reactor reaction

And many companies began to independently develop and produce microchannels. According to incomplete statistics, at present, there are more than 50 production enterprises in the world that produce and serve as microchannel equipment suppliers, and more than 80% of them are from European and American countries. The following table lists the famous microchannel production and supply companies in Europe and America and the names of microchannel reactors produced and developed by these companies.

Table 1. Related products research and development in microchannels in foreign countries

Country	Name of the company (supplier)	Name of the microchannel system developed	Characteristics of microchannel
Germany	Siemens	Siprocess microreactor	The control is easier and more accurate, mostly used in household appliances
The United States	Corning	Lab-reactor, G1-G4	Used in industrial and chemical research fields, fast reaction and high efficiency
Netherlands	Chemtrix	Lab Trix,Plan Trix, Kilo Flow	High transfer rate,short contact time, less by-products,good operability, high safety
French	4D Cell	Microchannel Station	Light permeable and breathable, easy to exchange nutrients, mostly used in medical field
Germany	ICT-IMM	SIMM	The microfluidic industry application technology is mature
Britain	Syrris	Asia, Africa, Titan	Suitable for fast reaction and very slow reaction for heat transfer
Germany	Ehrfeld Mikro Technik BTS	Modular microreactor	Easy to disassemble and clean, functional diversification

By the table1, you can see that the current phase of microchannel foreign technology research, and related products research and development in microchannels has been relatively mature, and can use the microchannel solution in the field of industrial, medical, agriculture and biological aspects of problems. For example, the Microchannel Station independently developed by French 4D Cell Company (as shown in Fig. 2) can change its size within a certain range by developing a microchannel with PDMS as the main material, so as to achieve the effect that cells passing through it can migrate in the channel. This product is mainly used in biology, medicine and other research, can be used on

a 35 mm petri dishes at the same time also can use high resolution optical microscope system, observing the special micro channel development can make more researchers in a simulated three-dimensional micro environment to observe and study the behavior of cells and the motion state and so on. In the future, foreign companies will also microchannel are generalized to broader, more in-depth field research. On the one hand, it can provide reference for future generations to study microchannels, on the other hand, it can also create more valuable products.

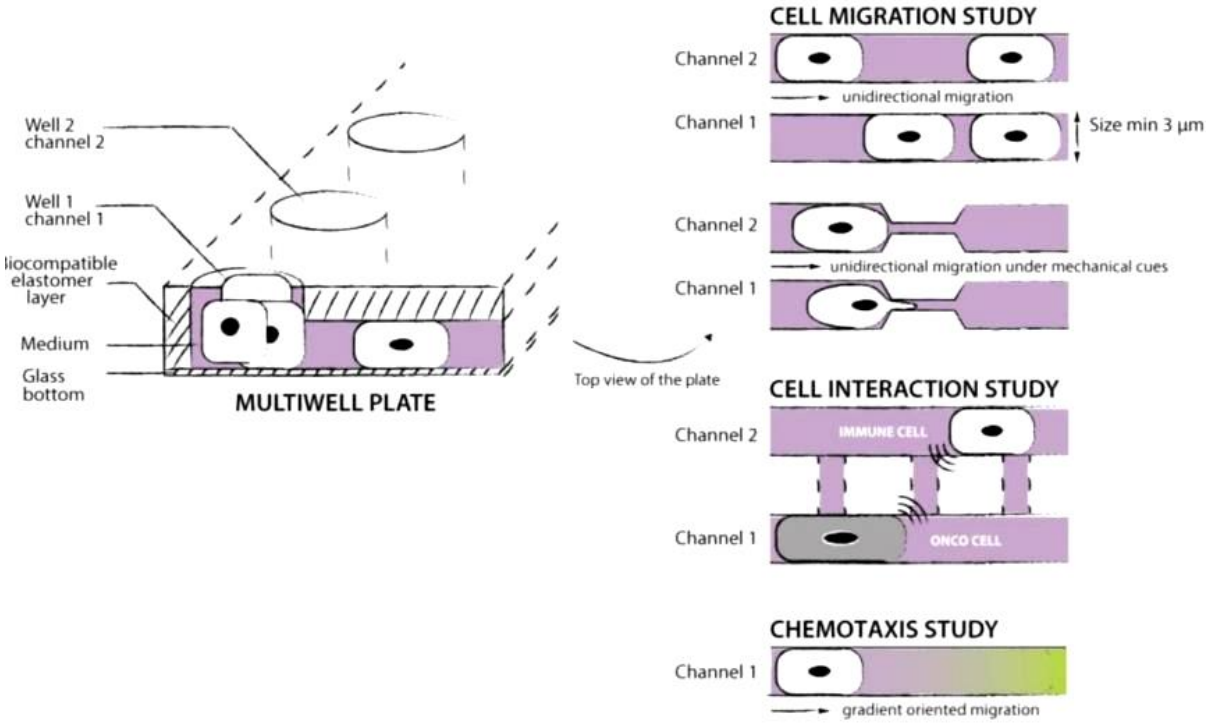


Fig. 2 Working principle of the Microchannel Station developed by 4D Cell from France

2.2. Research status of microchannel technology in China

Although the domestic research on microchannels started later than that of foreign countries, the depth and breadth of the research are no less than that of foreign countries. The research on microchannel mainly relies on the research of advanced research institutes and teachers and students in universities. For example, Beijing University of Chemical Technology has developed a soft-shell microreactor [4], which effectively solves the problem of dealing with ultra-low concentration pollutants. Qi Zhaogang from Shanghai Jiao Tong University studied the performance optimization of automobile air conditioning components and systems combined with microchannels to improve the refrigeration effect of air conditioning on vehicles [5]. The University of Science and Technology of China has developed ceramic microreactors, which are more stable and efficient than ordinary microreactors [6]. Some domestic enterprises also have independent research, but many of them are relying on the research team of universities and colleges. Moreover, compared with foreign countries, there is still a great gap in the number of enterprises that independently research microchannels.

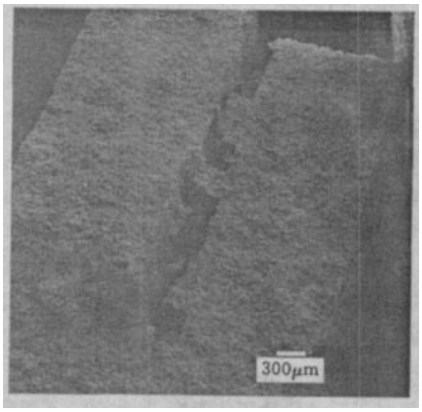


Fig. 3 Ceramic microchannel reactor pipe section [6]

The main directions of microchannel research in China are radio electronics, physics, medicine and so on. Compared with foreign countries, the research of microchannel in aerospace field is insufficient, but in medical science, especially in urinary science for microchannel research is far more than foreign countries. For example, Liu Jun and Wang Xiaoming from the Department of Urology, Yudu Hospital of Traditional Chinese Medicine, Ganzhou City, Jiangxi Province, studied the influence of microchannel percutaneous nephrolithotomy on the stone clearance rate and renal function of patients with complex kidney stones, and studied the help provided by microchannel for kidney stone surgery by comparing the intraoperative blood loss and other factors [7]. Moreover, many domestic experts and scholars have made a lot of progress in the measurement and research of micro-channel related values. Shi Dongshan, Li Jinhui and Liu Zhaomiao from Beijing University of Technology summarized and analyzed the numerical calculation methods and models of microchannels, and also summarized the boundary slip conditions and discrete algorithms for calculating some complex microchannel equations, which laid a foundation for the theoretical study of microchannels [8]. Chen Yan and Liu Xiangnong et al. from Hefei University of Technology simulated the numerical value of microchannel separation heat pipe and analyzed its performance, and obtained the change of heat exchange corresponding to different indoor temperatures [9]. In general, the microchannel research in China is in a good state of continuous development and progress.

3. Problems and shortcomings of minichannel research（Take our country as an example）

3.1. Problems arising from the application of microchannels to products (Taking the field of refrigeration and air conditioning as an example)

As one of the most applied fields of microchannel research results in China, air conditioning refrigeration is also closely related to the lives of ordinary people. Although the use of microchannels in air conditioning refrigeration can improve the efficiency of air conditioning and reduce energy consumption, but also more environmentally safe, there are still technical problems. Zhu Chuanhui et al. [10] put forward two main problems in the application of microchannel radiator in the field of refrigeration and air conditioning. The first is defrosting. When the micro-channel is used as an evaporator in the outdoor environment, it will lead to the discharge of blocked condensed water, so it is easier to make the pipeline frosting, thus affecting the cooling capacity and refrigeration efficiency of air conditioning. The second is the problem of microchannel refrigerant shunting, which will lead to the decrease of the refrigeration effect of the microchannel and also affect the defrosting effect, reducing the life of the whole system. Ding Hanxin et al. [11] also put forward that microchannels will be more used in the field of household and commercial refrigeration and air conditioning in the future, but to achieve the universal use of microchannels, this series of problems are also worth further research and efforts to find solutions.

3.2. Commercial production problems of microchannel

At present, China’s domestic industry level is still in the developing stage, the industrial sector is facing enormous pressure. As a new technology in the industrial field, microchannel also faces the problem of conflict between production and research. In addition, different from other technologies, microchannels cannot be applied to commercial production such quickly. Microchannels require a longer time from production, debugging, and final project approval. Many machinery enterprises and Party A are impatient to wait for such a long time. In this way, the production and operation pressure of many enterprises will be further increased. In addition, at present, the sales volume of many micro channel enterprises in China seems to be very considerable, but the real profit is not much due to the high research cost and the investment of manpower and material resources.

3.3. The slow pace of technological innovation risks diminishing the potential for future growth

Even at the present stage, China's attention and investment in the microchannel industry are not small, but the development potential of the microchannel field is not optimistic. Firstly, China's industrial industry is not as strong as that of developed countries such as Europe and the United States, and the weak basis of industrial production also results in the development of microchannels being limited to a certain extent, including the defects in research funds and research talents. Secondly, as some merchants pay too much attention to the benefits brought by the commercialization of microchannels, they will transform the original microchannels or even directly replace them with other mechanical structures to sell at a lower price. Thirdly, at present, most of the research and experiments on microchannel are carried out under the guidance of the scientific research team in universities. Unlike in foreign countries, the number of enterprises specially studying microchannel and developing microchannel heat sink is not so much.Not to mention, many researches in universities need the support of human and material resources.In addition, some research results in universities and colleges have not been tested by the market, which is out of line with the reality of the market. In this way, the weak combination of production and learning will slow down the overall progress of microchannel research and the output of effective research results. What's worse, with the rapid development of microchannel technology in China, countries such as South Korea, Germany, Japan, and so on have also started the patent layout in China, which will seize the market and research the future of microchannel in China. These will all slow down the further development of microchannel technology in China [12].

3.4. There is no uniform industry standard

There are no uniform standards by industry and there are two main parts. One is that there is no certain standard for the conversion rate of a reaction. Microchannels are actually more efficient conversion of substances in a better way, but due to the present domestic research of microchannel levels not neat, different enterprises and individuals to develop ability of microchannel are very different, and because it is a new and rising industry in a developing stage, a lot of judging the quality of microchannel standard has not been set. This also indirectly led to many unscrupulous businessmen to cut corners. Second, the patents related to microchannel research are not well protected. At present, the research and manufacturing of microchannels in China is mainly in universities, and there are few large enterprises. Most of the enterprises studying microchannels are small and medium-sized enterprises, most of them are weak in production, economy and other aspects, and are in the initial stage of capital accumulation. Many enterprises lack patent awareness, leading to the plagiarism of research results. There are also a lot of people in the market opportunism and unauthorized appropriation of others' patents. As a new field, the microchannel industry is not paid enough attention. However, the existence of these phenomena has brought many negative effects to the microchannel industry, which is also a difficult point and key point to standardize the research and production of microchannels in the future.

4. Prospects of future development of minichannel technology

Microchannel, as an emerging technology in our scientific research and commercial field is developing steadily, compared to the traditional channel structure, the microchannel has a better heat transfer function, but also more energy-saving and efficient. With the improvement of people's living standards and science and technology, the application of microchannel will be more and more widely in our country in the future, the related technology will become more skilled and there will be more small, medium-sized enterprises and universities independently developing microchannel, and the connection between microchannel technology and business will also become more and more standardized. The establishment of industry guidelines will also promote good competition and cooperation in the industry and common development, all of which can make the microchannel field in our country develop in a positive direction.

Firstly, the application of microchannels in the Chinese industrial field is still some basic aspects, such as the production technology of air conditioning refrigeration devices, mobile phone radiators and so on. But compared with foreign countries, our country in high-tech fields such as aerospace, engineering, and other fields of study is insufficient. It is also affected by the development of China's industrial level.Along with our country's industrialization system gradually mature, and our country enters the new stage of green development and global industrialization, the research and application of microchannel technology can be used in aerospace and other fields. At the same time, our country will also vigorously develop and invest in the microchannel industry. In the enterprise can increase investment and subsidies, increase research and development costs but also increase the possibility of trial and error; In colleges and universities, relevant majors and courses can be set up to cultivate corresponding micro-channel research talents. At the same time, the cooperation between universities and enterprises can also be strengthened. On the one hand, enterprises can take the lead in the study of micro-channel-related topics, and on the other hand, universities can transfer their talents to enterprises for further training.

Secondly, more standardized industry standards will be developed in the field of microchannels in the future. First of all, for the detection of the transformation efficiency of the manufactured microchannels, a certain standard is required to check whether the produced microchannels meet the standards of production and application in the products and relevant regulatory testing and identification institutions will be set up to assist the implementation of the policy. The second is the control and protection of microchannel-related patents, including the establishment of a microchannel patent database or microchannel intellectual property database. At the same time, the establishment of relevant laws. Both the regulation of microchannel enterprises and the regulation of intellectual property rights and patents need to be restricted by laws. Of course, these also need to be maintained and supervised by microchannel industry practitioners and the public.

Finally, the future research and development of microchannel reactor should focus on how to reduce the impact of production and R&D on the surrounding environment and the loss of relevant equipment materials. While the reaction time and efficiency of microchannel is due to the traditional heat exchange cooling channel, but efficient thermal conversion rate brings a lot of energy consumption, along with the environmental problems become a worldwide hot topic. One of the microchannel as a representative of the industry in the future again also need in the future development of miniaturization and efficient. In order to ensure the original high efficiency and at the same time friendly to the environment, the micro-channel industry is bound to maintain and occupy a high competitiveness in the future development.

5. Conclusion

Through the analysis of the current related research situation at home and abroad, we know that for our country in the continuously developing the industrialization, there is great progress for the microchannel research regardless of the depth or the breadth, but there are also many hidden risks and deficiencies. These are also subject to the current level of scientific and technological

development and social and economic level of many factors. However, I believe that in the future, with the continuous maturity of industrial technology, the increase of technical elites, the strong support of government and national policies, and the formulation of more standardized industrial standards. Research and development in the field of microchannel will achieve a major breakthrough, and will always develop in the direction of advanced, diverse and vigorous.

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