表題：

酸素濃度制御下の細胞実験のためのマイクロ流体デバイスの設計

Designing of microfluidic device for cellular experiment under controlled oxygen tension

著者名：

船本健一 [1)]，ヤニス・ゼルバントナキス [2)]，ロジャー・カム [2)]

Kenichi Funamoto, Ioannis K. Zervantonakis, Roger D. Kamm

所属先：

1) 東北大学流体科学研究所

Institute of Fluid Science, Tohoku University

2) マサチューセッツ工科大学

Massachusetts Institute of Technology

連絡先：

〒980-8577

仙台市青葉区片平２－１－１　東北大学流体科学研究所

Institute of Fluid Science, Tohoku University

2-1-1 Katahira, Aoba-ku, Sendai 980-8577, Japan

Tel & Fax: 022-217-5254

Email: funamoto@reynolds.ifs.tohoku.ac.jp

本文：

がん治療や再生医療の進展には、低酸素状態における細胞の挙動の解明が不可欠である。本研究では、細胞の低酸素応答の 3 次元リアルタイム観察を可能にするマイクロ流体デバイスを設計した（図 1）。COMSOL Multiphysics を用いてデバイス内の酸素濃度の数値解析を行い、デバイス内に供給するガスや細胞培養液の流量の最適な組み合わせを明らかにした。また、低酸素状態を生成するためには表面から拡散してくる酸素を最小化することが重要であることがわかった（図 2）。

It is important to elucidate cellular behaviors under hypoxia for cancer therapy and regenerative medicine. We designed a microfluidic device for three-dimensional real-time observation of cellular response under hypoxia (Fig. 1). The device had a central gel channel of 1.3 mm width, which was flanked by media channels of 500 μm width. In addition, gas channels of 500 μm width existed on both sides though which suitable gas mixtures were supplied. All channels had a height of 150 μm; the partitions between media and gas channels on both sides were set at 150 μm. Numerical simulations of oxygen tension in the microfluidic device were conducted by using COMSOL Multiphysics to investigate the effects of various parameters, such as gas and media flow rates, device thickness, and diffusion coefficients of oxygen. Minimizing oxygen diffusion from the top surface of the microfluidic device was found to be essential for maintaining low oxygen tensions. Hence, a film with a low oxygen diffusion coefficient was needed to be embedded in the device in proximity above the channels to prevent the oxygen diffusion from the incubator environment into the device (Fig. 2). Moreover, the optimum combination of the flow rates of media and gas to control oxygen tension was obtained, showing establishments of a low uniform oxygen tension or an oxygen gradient. The numerical simulations were useful to design the novel microfluidic device for cell culture under controlled oxygen tension.

参考文献

K. Funamoto, et al., *Lab on a Chip*, 12 (2012), 4855-4863.

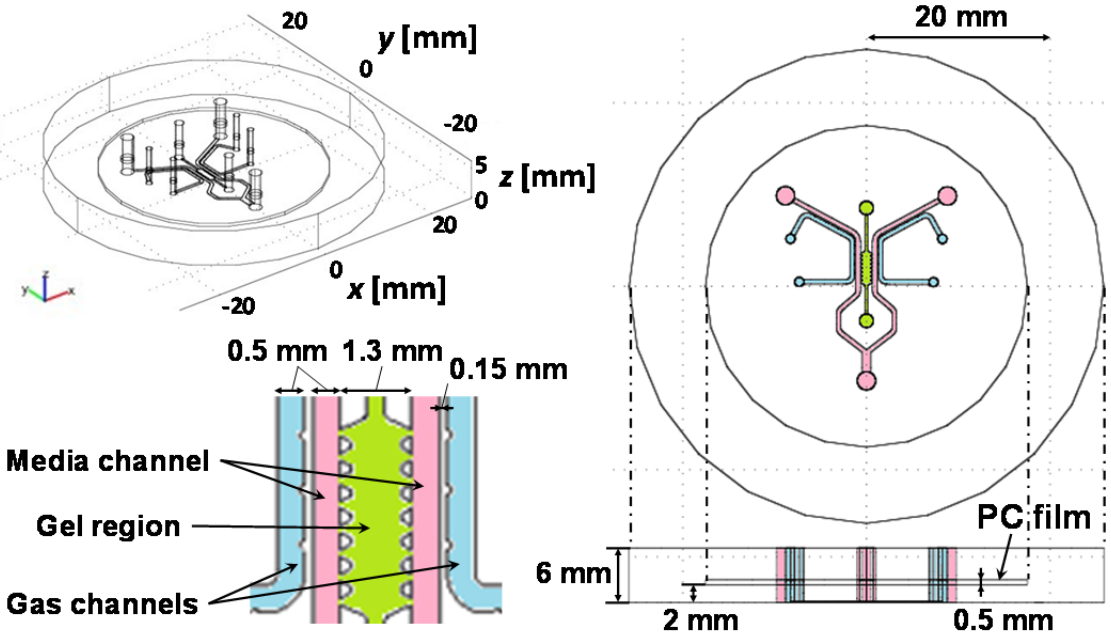


図 1　　酸素濃度制御マイクロ流体デバイスの概略図

Fig. 1　　Schematic of microfluidic device for cell culture under controlled oxygen tension.

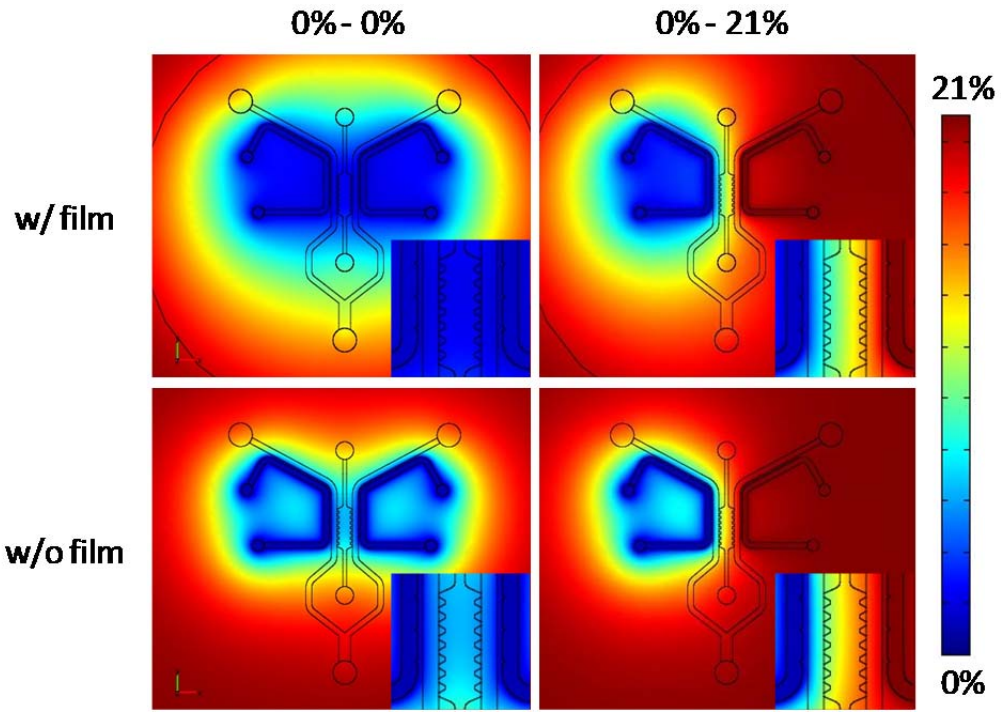


図 2　　マイクロ流体デバイス内の酸素濃度分布：低ガス透過性フィルムの内包の有無による比較と、両側ガス流路に酸素濃度 0%のガスを供給した場合（0%-0%）と、それぞれのガス流路に酸素濃度 0%および 21%のガスを供給した場合（0%-21%）の比較。

Fig. 2　　Steady oxygen tension on a crosssection ($z$ = 1.0×10$^{-6}$ m) of the microfluidic device with/without a film of low diffusion coefficient of oxygen, supplying 0% oxygen gas to both gas channels (0%-0%) or supplying it to the left-hand side gas channel, while supplying 21% oxygen gas to the right-hand side (0%-21%).