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微纳技术与精密机械

全血微流控芯片的高灵敏度多参数光探测

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摘要: 针对微流控芯片尺寸小引起吸光度检测方法中光程短的问题, 提出了基于类法布里-珀罗(F-P)共振腔的全反射光探测结构并采用离心驱动方法实现了微流控芯片上全血的高灵敏度多参数分析。首先, 理论分析了取得最大光程和最佳信噪比的条件, 分析表明: 探测池体积一定时, 理论最大光程仅与入射光斑直径平方成反比, 信噪比与反射次数与反射率有关。然后, 优化设计了一探测池结构, 通过检测亚甲基蓝溶液实验验证了所设计探测池结构的灵敏度, 其光程提高了1~2个量级。最后, 在芯片上检测全血中的白蛋白和葡萄糖两种物质, 结果表明, 亚甲基蓝溶液、白蛋白试剂、葡萄糖试剂3种物质的线性相关系数分别为0.999 07、0.993 94、0.992 87, 线性度很好, 为微流控芯片实现全集成全血的多参数测量奠定了基础。

关键词: 微流控芯片 类法布里-珀罗腔 光程 信噪比 线性相关系数

Highly sensitive and multi-parameter optical detection for whole blood on centrifugal microfluidic chip

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Abstract: The absorbance measurement method has a shorter optical path due to the microfluidic chip with smaller sizes. Therefore, a multireflection structure based on a quasi Fabry-Perot cavity was proposed to enhance the optical path length and complete the highly sensitive and multi-parameter detection for the whole blood on the centrifugal microfluidic chip. First, the optimal condition of the largest path length and the proper Signal and Noise Ratio(SNR) were analyzed theoretically. The results indicate that the maximum path length is only inversely proportional to the square of the beam diameter and the SNR is dependent on the reflectivity of the mirror and the number of reflections. Then, a detection pool was designed, the structure sensitivity of the pool was verified by the methylene blue solutions with different molar concentrations, and its path length was proved to be improved by two orders. Finally, the albumin and glucose in the whole blood on the centrifugal microfluidic platform was measured, and the good linearity with typical R²(linear relation coefficient) values of 0.999 07, 0.993 94, and 0.992 87 were obtained. From these results, it concludes that the quasi Fabry-Perot cavity is suitable for the whole blood biochemical detection and can satisfy the requirements of accuracy.

Keywords: Microfluidic chips Quasi Fabry-Perot cavity Pathlength SNR R² value

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