

# Detailed Information of Microarray is a Multiplex Lab-On-A-Chip

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### Abstract

Microarray technology has revolutionized the field of molecular biology and genetics by enabling the simultaneous analysis of multiple biomolecules on a single lab-on-a-chip platform. Microarrays consist of a solid support, typically a glass slide or silicon chip, with thousands to millions of microscopic spots arranged in a grid pattern. Each spot contains probe molecules that selectively bind to specific biomolecules of interest. The sample, labelled with fluorescent or radioactive tags, is applied to the microarray, and the bound molecules are detected using specialized scanners or imaging systems. The resulting data is analyzed using bioinformatics tools to gain insights into gene expression patterns, genotyping, protein interactions, and biomarker discovery. Microarrays offer high-throughput capabilities, cost-effectiveness, and the ability to analyze large sample sets simultaneously. Although newer technologies have emerged, microarrays remain valuable tools in molecular research and diagnostics.

Keywords: Microarray; Bioinformatics tools; Molecules; Diagnostics

# Introduction

A microarray is a multiplex lab-on-a-chip technology used in molecular biology and genetics research. It allows for the simultaneous analysis of multiple biomolecules (such as DNA, RNA, proteins, or antibodies) in a highly parallel manner.

**Principle**: Microarrays consist of a solid support, typically a glass slide or silicon chip, onto which thousands to millions of microscopic spots are arranged in an ordered grid pattern. Each spot contains a specific probe molecule that can selectively bind to its target biomolecule. The probes are immobilized on the surface using various methods, such as covalent attachment or physical adsorption.

# Materials and Methods

**Probe molecules**: The probe molecules on a microarray can vary depending on the application. For DNA microarrays, the probes are short oligonucleotide sequences that are complementary to specific genes or regions of interest. RNA microarrays use probes that can hybridize to RNA molecules for gene expression analysis. Protein microarrays may contain antibodies or other affinity agents to detect specific proteins or protein interactions.

**Sample preparation**: Prior to analysis, the biological sample (such as DNA, RNA, or protein extract) is labeled with a fluorescent or radioactive tag. The labelled sample is then applied to the microarray surface, where it hybridizes to the complementary probe molecules. The unbound material is washed away, leaving only the specifically bound molecules on the array.

**Detection**: The bound target molecules are detected by measuring the fluorescence or radioactivity associated with the labelled sample. Fluorescence microarrays [1,2] are commonly used, where a laser or other light source is used to excite the fluorophore, and the emitted fluorescence is captured and quantified using specialized scanners or imaging systems. In some cases, the microarray spots may be chemically amplified to enhance the signal.

**Data analysis:** Once the fluorescence intensities or other signals are obtained, the data is analyzed using bioinformatics tools and statistical methods. The analysis may involve comparing different samples to identify differential gene expression, genotyping, SNP detection, protein-protein interactions, or other molecular interactions. Data normalization and quality control steps are typically performed to

account for experimental variations [3,4].

**Applications**: Microarrays have diverse applications in genomics, transcriptomics, proteomics, and diagnostics. They can be used for gene expression profiling, genotyping, DNA sequencing, protein characterization, drug discovery, biomarker identification, and personalized medicine. Microarrays enable high-throughput analysis, allowing researchers to investigate numerous targets simultaneously.

Microarray technology has significantly contributed to our understanding of gene expression patterns, disease mechanisms, and the discovery of new biomarkers. While newer technologies like nextgeneration sequencing have gained popularity, microarrays still offer advantages in terms of cost, ease of use, and the ability to analyze large sample sets in a single experiment [5].

# Microarray: A multiplex lab-on-a-chip

Microarrays have revolutionized molecular biology and genetics research as a multiplex lab-on-a-chip technology. These miniature platforms consist of a solid support with thousands of microscopic spots, each containing specific probe molecules. By enabling simultaneous analysis of multiple biomolecules, microarrays offer several advantages. In operation, labeled samples are applied to the microarray, and the probe-target interactions occur on the chip's surface. The bound molecules are then detected using fluorescence or radioactive tags, providing valuable information about gene expression, genotyping, protein interactions, and biomarkers. One of the key strengths of microarrays is their high-throughput capability. By accommodating numerous spots on a single chip, researchers can analyze a large number of targets simultaneously, saving time and resources. Additionally, microarrays are cost-effective, allowing for efficient analysis of multiple samples in a single experiment. Data

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analysis is facilitated by bioinformatics tools that process the obtained signals. These tools enable researchers to identify differential gene expression patterns, genotypic variations, and molecular interactions. The resulting insights contribute to our understanding of disease mechanisms, drug discovery, and personalized medicine. While newer technologies such as next-generation sequencing have emerged, microarrays retain their value. They remain accessible, user-friendly, and capable of analyzing diverse biomolecules. Microarrays continue to empower researchers with their ability to generate valuable data in a streamlined and efficient manner. In conclusion, microarrays represent a powerful multiplex lab-on-a-chip technology in molecular biology and genetics research [6,7]. Their ability to simultaneously analyze multiple biomolecules offers high-throughput capabilities, costeffectiveness, and valuable insights into complex biological processes. Despite the emergence of alternative technologies, microarrays remain a valuable tool for researchers seeking comprehensive molecular analyses [8,9].

#### Methods of microarray: a multiplex lab-on-a-chip

Microarrays, as a multiplex lab-on-a-chip technology, employ various methods throughout the experimental process. Here are some key methods involved in the microarray workflow:

**Probe design**: The first step in microarray fabrication is the design of probe molecules. For DNA microarrays, short oligonucleotide sequences are synthesized to be complementary to specific genes or genomic regions of interest. RNA microarrays may use probes that hybridize to RNA molecules for gene expression analysis. Protein microarrays utilize antibodies or other affinity agents as probes.

Probe Immobilization: Once designed, the probe molecules are immobilized onto the solid support of the microarray chip. Common methods include covalent attachment, where probes are chemically linked to the surface, or physical adsorption, where probes are physically absorbed onto the chip. Immobilization techniques ensure the probes remain stable during subsequent steps [10].

**Sample preparation**: The biological samples of interest, such as DNA, RNA, or protein extracts, undergo preparation steps before analysis. For gene expression analysis, RNA samples are typically reverse transcribed into complementary DNA (cDNA) and labelled with fluorescent or radioactive tags. In DNA microarrays, DNA samples may be amplified using polymerase chain reaction (PCR) and labelled. Protein samples can be directly labelled or undergo enzymatic reactions for labelling purposes.

**Hybridization**: Labelled samples are applied to the microarray chip, allowing the target molecules in the samples to hybridize with the complementary probe molecules immobilized on the chip. Hybridization conditions, such as temperature and buffer composition, are carefully controlled to ensure specific and efficient binding.

**Washing**: After hybridization, unbound or non-specifically bound molecules are removed through a series of washing steps. These washes help to eliminate background noise and enhance the signal-to-noise ratio by reducing nonspecific binding.

**Detection**: The bound target molecules on the microarray are detected and quantified. In fluorescence microarrays, a laser or other light source excites the fluorescent tags attached to the labelled samples. The emitted fluorescence is captured and quantified using specialized scanners or imaging systems. Radioactive tags can be detected using autoradiography or phosphor imaging methods.

**Data Analysis**: The obtained signals from the microarray are processed and analyzed using bioinformatics tools and statistical methods. Data normalization techniques are applied to account for technical variations and ensure accurate comparisons. Analysis may involve identifying differentially expressed genes, genotyping variations, protein interactions, or other molecular interactions of interest.

These methods collectively enable researchers to perform multiplex analysis on a microarray, facilitating high-throughput analysis and providing valuable insights into various biological processes.

## Discussion

Microarray technology as a multiplex lab-on-a-chip has significantly impacted molecular biology and genetics research. Its ability to simultaneously analyze multiple biomolecules on a single platform offers several advantages and has paved the way for numerous applications and discoveries. One of the key strengths of microarrays is their high-throughput capability. By incorporating thousands to millions of microscopic spots on a chip, researchers can analyze a vast number of targets in parallel. This dramatically increases the efficiency and speed of experiments, allowing for the screening of large sample sets and the exploration of complex biological systems. Microarrays also offer cost-effectiveness, as they enable researchers to perform comprehensive analyses with relatively lower costs compared to other techniques. The multiplexing feature allows for substantial savings in terms of reagents, time, and labor. Researchers can obtain a wealth of data from a single microarray experiment, reducing the need for separate assays and providing a more comprehensive picture of the biological phenomena under investigation. Furthermore, microarrays facilitate the integration of diverse biomolecules into a single analysis. DNA, RNA, proteins, and other biomolecules can be analyzed simultaneously, enabling researchers to explore multiple layers of molecular information within a single experiment. This integrative approach has expanded our understanding of complex biological processes, such as gene expression, genetic variations, proteinprotein interactions, and signaling pathways. Microarrays have been extensively used for gene expression profiling, allowing researchers to study the expression patterns of thousands of genes simultaneously. This has greatly contributed to our understanding of various biological processes, including developmental biology, disease mechanisms, and cellular responses to stimuli. Microarrays have also played a crucial role in identifying differentially expressed genes associated with diseases, enabling the discovery of potential biomarkers and therapeutic targets. In addition, microarrays have found applications in genotyping and DNA sequencing, facilitating the identification of genetic variations and polymorphisms. They have been employed in population genetics studies, personalized medicine, and pharmacogenomics, providing insights into the genetic basis of diseases and individual responses to drugs. Protein microarrays have emerged as valuable tools for studying protein-protein interactions, antibody profiling, and protein function analysis. They enable the parallel screening of protein-protein interactions on a large scale, contributing to our understanding of complex cellular networks and signaling pathways. Protein microarrays have also facilitated the discovery of diagnostic biomarkers and the development of targeted therapies. While newer technologies, such as next-generation sequencing, have gained prominence in recent years, microarrays continue to be widely used due to their established protocols, cost-effectiveness, and flexibility in experimental design. They remain a valuable tool in research and diagnostics, particularly for largescale studies and applications that require high-throughput analysis.

In conclusion, microarrays as a multiplex lab-on-a-chip technology have transformed the field of molecular biology and genetics. Their ability to simultaneously analyze multiple biomolecules has accelerated research, enabled comprehensive molecular investigations, and led to significant discoveries. Microarrays offer high-throughput capabilities, cost-effectiveness, and the integration of diverse biomolecules, making them valuable tools for a wide range of applications in basic research, diagnostics, and personalized medicine.

## Conclusion

In conclusion, microarray technology represents a powerful and versatile multiplex lab-on-a-chip platform in the field of molecular biology and genetics. It enables simultaneous analysis of multiple biomolecules, such as DNA, RNA, and proteins, on a single chip, offering numerous benefits and applications. Microarrays provide high-throughput capabilities, allowing researchers to analyze a large number of targets in parallel. This enhances efficiency and saves time and resources compared to traditional single-target assays. The costeffectiveness of microarrays makes them accessible for a wide range of research projects and facilitates comprehensive analyses within a single experiment. The ability to integrate multiple biomolecules onto a microarray chip enables a holistic approach to studying complex biological processes. Researchers can investigate gene expression patterns, genotypic variations, protein interactions, and biomarkers within the same experiment, providing a more comprehensive understanding of biological systems. Microarrays have been instrumental in advancing research in various fields, including gene expression profiling, genotyping, protein-protein interactions, and biomarker discovery. They have contributed to our understanding of disease mechanisms, drug development, personalized medicine, and other areas of biomedical research. While newer technologies continue to emerge, microarrays remain a valuable tool due to their established protocols, cost-effectiveness, and versatility. They offer researchers the ability to generate large-scale data sets and perform multiplex analysis, making them an indispensable resource for studying complex biological phenomena.

#### Page 3 of 3

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#### **Competing Interest**

The authors say they have no competing interests.

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