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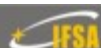
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Digital Sensors and Sensor Systems: Practical Design

Sergey Y. Yurish



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The goal of this book is to help the practitioners achieve the best metrological and technical performances of digital sensors and sensor systems at low cost, and significantly to reduce time-to-market. It should be also useful for students, lectures and professors to provide a solid background of the novel concepts and design approach.

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- Easy-to-repeat experiments
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Digital Sensors and Sensor Systems: Practical Design will greatly benefit undergraduate and at PhD students, engineers, scientists and researchers in both industry and academia. It is especially suited as a reference guide for practitioners, working for Original Equipment Manufacturers (OEM) electronics market (electronics/hardware), sensor industry, and using commercial-off-the-shelf components

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Conference Announcement



Topic E2: Transportation & Mobility

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Quartz Crystal Microbalance DNA Based Biosensor for the Detection of *Brugia malayi*

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Abstract: This Lymphatic filariasis is the major public health problem caused by *Brugia* spp. by the conventional methods as PCR cannot discriminate well, takes a few days or several hours. This study demonstrates a sensitive and specific quartz crystal microbalance (QCM) biosensor combined with polymerase chain reaction (PCR) for diagnosis of *Brugia malayi*. The procedure concludes: formation of self-assembled monolayer (SAM) on gold quartz crystals surface, attachment of the avidin to activated carboxyl groups by EDC/NHS, attachment of the biotin-modified probe to the avidin, and hybridization of probe to the target PCR. The PCR-QCM biosensor system was more specific than a PCR-gel electrophoresis assay in detecting the DNA of *B. malayi* and *B. pahangi*.
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Keywords: QCM, DNA immobilization sensing, Lymphatic filariasis, *B. malayi*.

1. Introduction

Lymphatic filariasis or elephantiasis is the major public health problem that infected over billion people in over 80 countries. Among them, *Brugia malayi* is mainly distributed in Asia countries such

as China, South Korea, Japan, India, Myanmar, Indonesia, Malaysia, Borneo islands, the Philippines, and Thailand [1]. It has been infected in cats, dogs, monkeys and humans previously reported [1-3], but *B. pahangi* as closely related species that can infect cats [2-6]. Therefore, these animal reservoirs play an important role as the carrier diseases which can lead to the problem of eradication in endemic area. However, differentiation of *B. malayi* and *B. pahangi* microfilaria by using traditional Giemsa staining even though the technique is convenient and inexpensive cannot morphologically distinguish between those two species. Acid phosphatase staining is sensitive, but it is not reproducible and the procedure is complicated. As well, The PCR based methods is the high sensitivity and specificity but, this method cannot recognize mixed infection between closely related species [7-9].

Recently, there has been an increasing interest real time quartz crystal microbalance QCM based biosensor technology by this biosensor is one of the candidate devices of biosensor technology for detection of DNA hybridization that is rapid and sensitive detection among them, especially QCM based biosensor by using oligonucleotide hybridization detection method. The system using a QCM based biosensor in a flow cell might be developed for automated or continuous operation. The relationship between the oscillation frequency change of a quartz resonator in contact with liquid and accumulated mass had first realized by Kanazawa and Gordon in 1985 [10] that derived a relationship by expressing the change in oscillation frequency of a quartz crystal in contact with a fluid. This biosensor has its own advantages that the detection method is label-free from radioactive or fluorescent tags [11]. There are many reports about the development of QCM specific DNA-based biosensor for detection many pathogenic bacteria in real time such as *Staphylococcus epidermidis* [12], *Escherichia coli* [13], and *Pseudomonas aeruginosa* [14] by using of PCR for the preparation of bacterial target DNA

This objective was study of the QCM based biosensor for rapid and specific detection of *B. malayi*. This method consists of the quartz crystal which was immobilized by using three probes as biotin-modified oligonucleotides probe that were designed from *HhaI* repetitive region (HR) sequence element specific for *B. malayi*. This study can be extended to develop the new method which is high sensitivity, specificity, cheap, easy to use, and rapid for detection of *B. malayi* in many fields of work in clinical diagnosis.

2. Materials and Methods

2.1. Chemicals and Reagents

The chemicals and reagents used in the study were included 98% sulfuric acid (Sigma-Aldrich, USA), 30 % hydrogen peroxide (Merck, Germany), sodium chloride (Merck, Germany), sodium phosphate (Na_2HPO_4 ; Merck), ethanolamine (Fluka, Switzerland), ethylenediaminetetraacetic acid (EDTA; Merck), 3-mercaptopropionic acid aqueous solution (MPA) (Sigma, USA), 1-ethyl-3(3-dimethylaminopropyl) carbodiimide ethanolic solution (EDC) (Sigma, USA), *N*-hydroxysuccinimide aqueous solution (NHS) (Fluka, Switzerland), ethanolamine (Fluka, Switzerland), and hydrogen chloride (HCl; Merck).

2.2. Fabrication of Quartz Crystal Surface in Stepwise

The quartz crystals were commercially available as 12 MHz, AT-cut type (diameter 8 mm) coated with gold electrodes (diameter 4 mm) on both sides (Kyocera-Kinseki Co.,Ltd., Thailand). The gold electrode surface was cleaned with hot piranha solution for 30 seconds. The crystals were thoroughly washed with distilled water, air-dried, and immediately used. The initial resonance frequency (f_0) was recorded as the baseline. The cleaned quartz crystal was soaked in the optimal concentration of MPA

for 1 hour, rinsed with absolute ethanol, washed with distilled water. To activate the monolayer, 100 mg/ml EDC/NHS was placed left to react on the surface of gold electrode to form MPA monolayer for 30 minutes followed by water rinsing. After that added 0.1 mg/ml avidin in immobilization buffer (300 mM NaCl, 20 mM Na₂HPO₄, 0.1 mM EDTA, pH 7.4) was placed on the electrode surface for at least 1 hour before washing and then, the quartz sensing was exposed to a 1 mM ethanolamine for 30 minutes, rinsed with distilled water and immobilization buffer. The DNA biotin-modified probes optimal detection as 1 μM (Kaewphinit et al. 2010) (5'-Biotin-TTTTTT ATG ACA ACT CAA TAC TCG AC-3') was placed over the gold electrode surface for 20 minutes prior to washing with immobilization buffer, distilled water, resonance frequency (f_1) was recorded and kept at 4 °C for use.

2.3. Hybridization in Liquid Phase

One face of the quartz crystal was exposed to a 50 μl flow-through chamber, which was connected to an inlet and outlet-flow tube drove by the peristaltic pump (ISM 834, USA). The whole flow cell was placed in a shielding box to avoid some environmental interference. The apparatus included a peristaltic pump to assure a 50 μl/min constant flow of the solutions.

The procedure of liquid phase QCM sensor was began the study while the frequency of the system was regular frequency shift within ±1 Hz. Initially, the hybridization on the surface by using the buffer for 30 seconds that the baseline as resonance frequency (f_1) of the probe immobilization prior to injection of DNA target (complementaly DNA probe; 5'GTC GAG TAT TGA GTT GTC AT-3') corresponded to position of *HhaI* repetitive region of *B. malayi* to hybridized with probe for 5 minutes, then washed to remove unbound and frequency shift (f_2) can observe. After the flow DNA target to probe hybridization on QCM sensor for 5 minutes. The frequency difference (Δf) between resonance frequency of initial and final values was determined ($\Delta f =$ frequency of the immobilization probe on the quartz crystal (f_1) - frequency of the hybridization reaction (f_2), with $f_1 > f_2$). The frequency shift ($\Delta f = f_1 - f_2$) was related to the amount of target DNA hybridized to the DNA biotin modified probe immobilized on the quartz crystal surface [15].

2.4. Blood Samples

Blood samples were taken from two cats naturally infected with *Brugia* from *B. malayi* endemic area of Narathiwas and *B. pahangi* non-endemic area, the Lad Krabang district of Bangkok, Thailand. The samples were previously screened by using the traditional blood smear technique before undergoing the parasite isolation.

2.5. Parasites Isolation

Five milliliters of microfilaria-infected blood were taken from a host and transferred to a test tube containing 7 mg/ml of EDTA as an anticoagulant. The blood was diluted with an equal volume of phosphate buffer saline (PBS), pH 7.0, and was filtered through a 5 μm polycarbonate membrane (Millipore). Microfilarias were then resuspended in PBS and centrifuged at 5,000 rpm for 10 minutes at 4 °C. The pellet was washed with PBS for three times prior to storage at -70 °C until use.

2.6. PCR Amplification of DNA Target

The genomic DNA was extracted from filarial parasites using a genomic DNA Purification Kit (Gentra Systems, USA). Isolation was performed according to the instruction manual provided by the company. PCR amplification of the HR from purified parasite DNA was performed using primers, BM1-5' GCG CAT AAA TTC ATC AGC AA 3' and BM2-5' ATG ACA ACA CAA TAC ACG AC 3' previously described by Chansiri [6]. All reactions were 25 μ l volume containing 50 ng of genomic DNA in 10x PCR buffer, 1 μ M each of primers, 100 μ M of dNTP, 1.5 mM MgCl₂ and 1.5 units of proof reading *Taq* DNA polymerase (Invitrogen®). PCR was performed by using a DNA thermal cycler (MJ Research PTC-200 Peltier thermal cycler) for 30 cycles. Each cycle consisted of denaturation at 94 °C for 1 minute, annealing at 62 °C for 1 minute and extension at 72 °C for 1 minute. PCR amplicon was analyzed by electrophoresis in a 1.5% agarose gel at 110V for approximately 30 minutes prior to staining in 0.5 μ g/ml ethidium bromide solution and observation under ultraviolet light. PCR fragment was eluted from the gel and purified using the QIAGEN® Purification system prior to hybridization with probe. Purification was performed according to the instruction manual provided by the company.

2.7. Sensitivity of Detection

The amplified PCR DNA fragments were denatured at 95 °C for 2 minutes to generate single stranded DNA. Then, the reactions were subsequently cooled at 0 °C 1 minute, the flow dilutions of DNA target as 0, 0.05, 0.1, 0.2, 0.5, and 1 μ g/ml onto the quartz crystal for hybridized with the probe for 5 minutes.

2.8. The Specificity of Detection

Three quartz crystals were hybridized with DNA positive of each target solution of *B. malayi*, *B. pahangi*, and buffer in total 50 μ l were separately added to each quartz crystal.

3. Results and Discussion

3.1. The Responses of Complementary DNA Target

QCM was applied for detection specific DNA target sequences of *B. malayi* in infectious lymphatic filariasis's disease. In the QCM based biosensor system for rapid detection DNA target could be measured ΔF in continuous online monitoring, the resonant frequency of quartz crystal decreased relationship with the mass increased on the quartz crystal surface. The complementary DNA target concentrations of 0.25, 0.50, 0.75, 1.00, 1.50, and 2.00 μ M caused the frequency shift was decreased from 20 \pm 4.36 to 80 \pm 5.1 Hz. The frequency shift of each reactions (n=3) was presented as mean \pm S.D. as shown in Fig. 1.

3.2. The Sensitivity of Detection

The genomic DNA of *B. malayi* and *B. pahangi* was extracted from sample as described in Materials and Methods. Upon PCR amplification of HR region from genomic DNA, the 280 bp fragment was obtained in Fig. 2. PCR fragment was eluted from the gel and purified using the QIAGEN® Purification system was denatured at 95 °C for 5 minutes prior to hybridize with DNA biotin-modified probe. The PCR amplicons were diluted with hybridization buffer ranging from 0, 0.05, 0.1, 0.2, 0.5,

and 1 µg/ml. All of these PCR amplicons were denatured by heating denaturation as following; heated at 95 °C for 2 minutes, chilled in ice bath for 1 minute, and hybridization assayed on specific QCM based biosensor immediately. The concentrations of amplified *B. malayi* DNA target was diluted from by measuring quality PCR amplicons at A_{260} / A_{280} , the frequency shift decreased from 28 ± 7.85 , 74 ± 7.51 , 108 ± 12.77 , 166 ± 10.30 , and 167 ± 14.34 Hz , respectively which the frequency shift of each reactions (n=3) was presented as mean \pm S.D. as shown in Fig. 3. However, the detection limit of this system as 0.05 µg/ml when can be the detection of real DNA target.

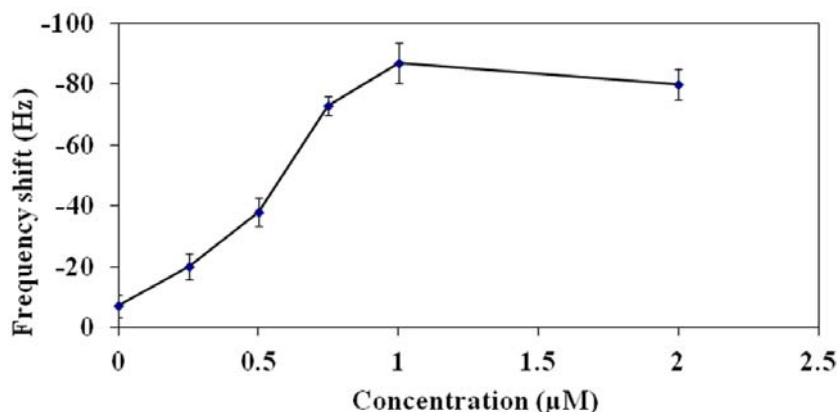


Fig. 1. The frequency shift of hybridization relationship between concentration of complementary DNA target and specific probe. Error bars indicate the standard deviation (n=3).

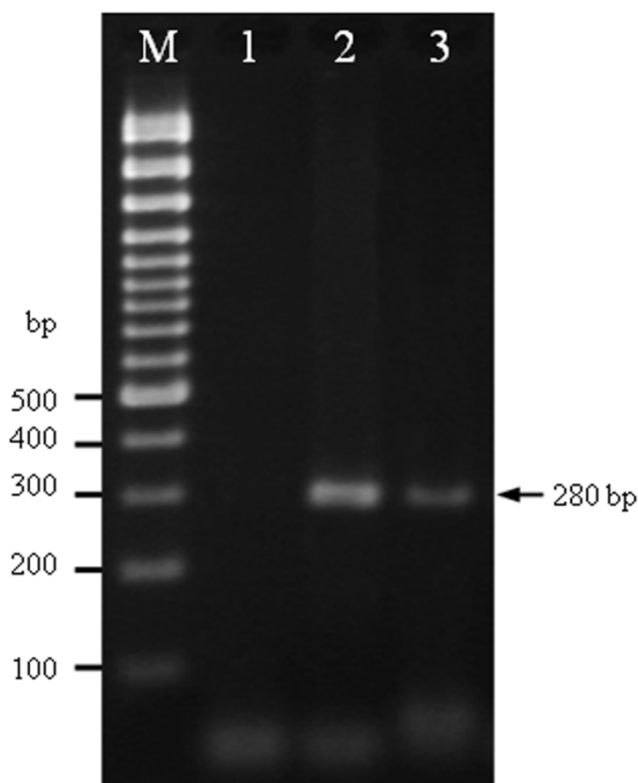


Fig. 2. Agarose gel electrophoresis pattern of HR region. The 280 bp in size were amplified from *Brugia*. Lane M represents 100 bp ladder plus marker, Lanes 1 negative control, Lanes 2 represent PCR products of HR region from *B. malayi*, Lanes 3 PCR products of HR region from *B. pahangi*.

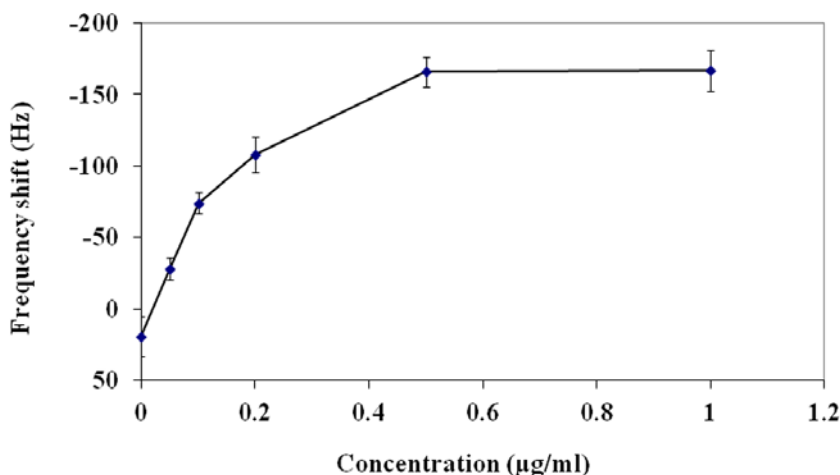


Fig. 3. The frequency shift of hybridization relationship between concentrations of DNA amplicon and probe. Error bars indicate the standard deviation (n=3).

3.3. The Specificity of Detection

The specificity was detected by using *B. malayi*, *B. pahangi* and negative control. The hybridization buffer was the negative control. All PCR products were hybridized with 1 µM of biotin-modified probe for 5 minutes at room temperature. The frequency shift of each DNA target (n=3) of denaturation methods was presented as mean ± S.D. as shown in Fig. 4. *B. malayi* gave frequency shift with higher frequency shift than of *B. pahangi* by no cross hybridization but, gel electrophoresis cannot differentiate *B. malayi* from *B. pahangi*.

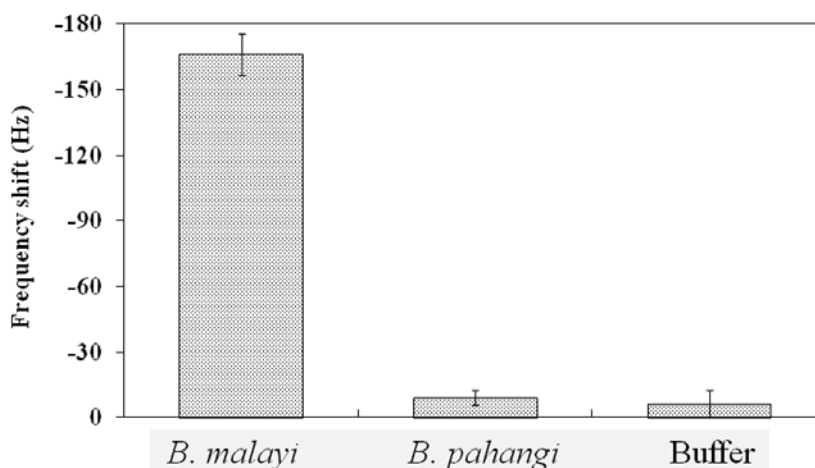


Fig. 4. Specificity test of QCM based DNA biosensor system on DNA amplicons of *B. malayi*, *B. pahangi*, and negative control as buffer. Error bars indicate the standard deviation (n = 3).

Basically, *B. malayi* and *B. pahangi* are genetically closely related. The sensitive PCR and gel electrophoresis cannot differentiate these two species. Moreover, the carryover contamination could affect the PCR amplification leading to the false-positive or false-negative interpretation. The use of antibody is costly and may lead to false positive diagnosis so that the control group for each single test is needed. Previously, the differentiation of these two filarial species was relied on nucleotide comparison of ITS regions [7-9] using PCR-based methods. This work provides the possibility of using QCM based DNA biosensor systems to detect rapid and specific of *B. malayi* DNA target

amplification of HR region by *B. malayi* and *B. pahangi* were a few differences in nucleotide sequence between the two *Brugia* species. The method demonstrated two step of the detection by biotin-modified probe immobilization via stepwise kept at 4 °C for use and DNA target hybridization to probe via liquid phase as rapid detection for 5 minutes. This QCM based sensor system detection limit as 0.05 µg/ml and was comparable to that of PCR-based detection. No cross hybridization was observed when the closely related species, *B. pahangi*, was used. This indicated that the DNA-based QCM could be applicable for detection of *B. malayi* in feline reservoirs and mosquito vectors where the co-infection with *B. pahangi* could be observed. Hence, the success in eradication of lymphatic *B. malayi* should rely on the controlling of transmission of the parasite. The powerful diagnostic tool such as DNA-based QCM methods permitted the accurate identification of infection that was essential for the rapid epidemiological assessment as well as genetic inspection of these two closely related species.

4. Conclusions

The QCM biosensor appears to be a suitable and convenient tool for monitoring hybridization of complementary strands of oligonucleotides compared to other biosensor methods. The method demonstrated the sensitivity and specificity of the detection. The sensitivity of limited detection of genomic DNA as 0.05 µg/ml. The specificity of sensor can be tested with *HhaI* repetitive region gene also for differentiation of *B. malayi* from *B. pahangi* by PCR-gel electrophoresis cannot detected. This study will help the selection of gene which is more suitable for detection of *B. malayi* in lymphatic filariasis.

Moreover, this biosensor system may be developed for diagnosis lymphatic filariasis in clinical samples

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References

- [1]. A. B. Laing, J. F. Edeson, R. H. Wharton, Studies on filariasis in Malaya: the vertebrate hosts of *Brugia malayi* and *Brugia pahangi*, *Ann Trop Med Parasitol*, Vol. 54, 1960, pp. 92–99.
- [2]. J. W. Mak, W. H. Cheong, P. K. Yen, P. K. Lim, W. C. Chan, Studies on the epidemiology of subperiodic *Brugia malayi* in Malaysia: problems in its control, *Acta Trop*, Vol. 39, 1982, pp. 237–245.
- [3]. J. W. Mak, Zoonotic filariasis in Malaysia, *Malays Vet J*, Vol. 8, 1984, pp. 9–12.
- [4]. J. W. Mak, P. K. Yen, K. C. Lim, N. Ramiah, Zoonotic implications of cats and dogs in filarial transmission in Peninsular Malaysia, *Trop Geogr Med*, Vol. 32, 1980, 259–264.
- [5]. J. F. Edeson, R. H. Wharton, The transmission of *Wuchereria malayi* from man to the domestic cat, *Trans R Soc Trop Med Hyg*, Vol. 51, 1957, pp. 366–370.
- [6]. K. Chansiri, T. Tejangkura, P. Kwaosak, N. Sarataphan, S. Phantana, W. Sukhumsirichart. PCR based method for identification of zoonotic *Brugia malayi* microfilariae in domestic cats, *Mol Cell Probes*, Vol. 16, 2002, pp. 129–135.
- [7]. S. Areekit, S. Khuchareontaworn, P. Kanjanavas, T. Sriyapai, A. Pakpitchareon, P. Khawsak, et al. Molecular genetics analysis for co-infection of *Brugia malayi* and *Brugia pahangi* in cat reservoirs based on internal transcribed spacer region 1, *Southeast Asian J Trop Med Public Health*, Vol. 40, 2009, pp. 30–34
- [8]. S. Areekit, P. Kanjanavas, A. Pakpitchareon, P. Khawsak, S. Khuchareontaworn, T. Sriyaphai, et al. High Resolution Melting Real-Time PCR for Rapid Discrimination between *Brugia malayi* and *Brugia pahangi*, *J Med Assoc Thai*, Vol. 92, Issue Suppl 3, pp. S24–28.

- [9]. S. Areekit, P. Singhaphan, S. Khuchareontaworn, P. Kanjanavas, T. Sriyaphai, A. Pakpitchareon, et al. Intraspecies variation of *Brugia spp.* in cat reservoirs using complete ITS sequences, *Parasitol Res*, Vol. 104, Issue 6, 2009, pp. 1465–1469.
- [10]. K. K. Kanasawa, J. G. Gordon, A liquid phase piezoelectric detector, *Anal Chem*, Vol. 57, 1985, pp. 1771–1775.
- [11]. C. Yao, T. Zhu, J. Tang, R. Wu, Q. Chen, M. Chen, et al. Hybridization assay of hepatitis B virus by QCM peptide nucleic acid biosensor, *Biosens Bioelectron*, Vol. 23, Issue 6, 2008, pp. 879–885.
- [12]. H. Xia, F. Wang, Q. Huang, J. Huang, M. Chen, J. Wang, Detection of *Staphylococcus epidermidis* by a quartz crystal microbalance nucleic acid biosensor array using Au nanoparticle signal amplification, *Sensors*, Vol. 8, 2008, 6453–6470.
- [13]. X. T. Mo, Y. P. Zhou, H. Lei, L. Deng, Microbalance-DNA probe method for the detection of specific bacteria in water, *Enz Microbial Techno*, Vol. 30, 2002, pp. 583–589.
- [14]. F. He, S. Liu, Detection of *P. aeruginosa* using nano-structured electrode separated piezoelectric DNA biosensor, *Talanta*, Vol. 62, 2004, pp. 271–277.
- [15]. Kaewphinit T, Santiwatanakul S, Promptmas C, Chansiri K., Development of piezoelectric DNA-based biosensor for direct detection of *Mycobacterium tuberculosis* in Clinical Specimens, *Sensors & Transducers*, Vol. 113, Issue 2, 2010, pp. 115–126.

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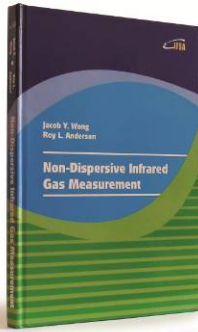
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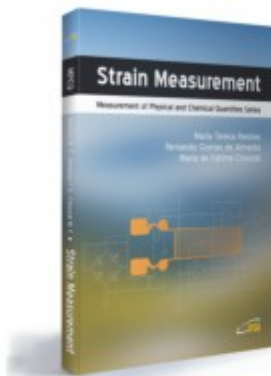
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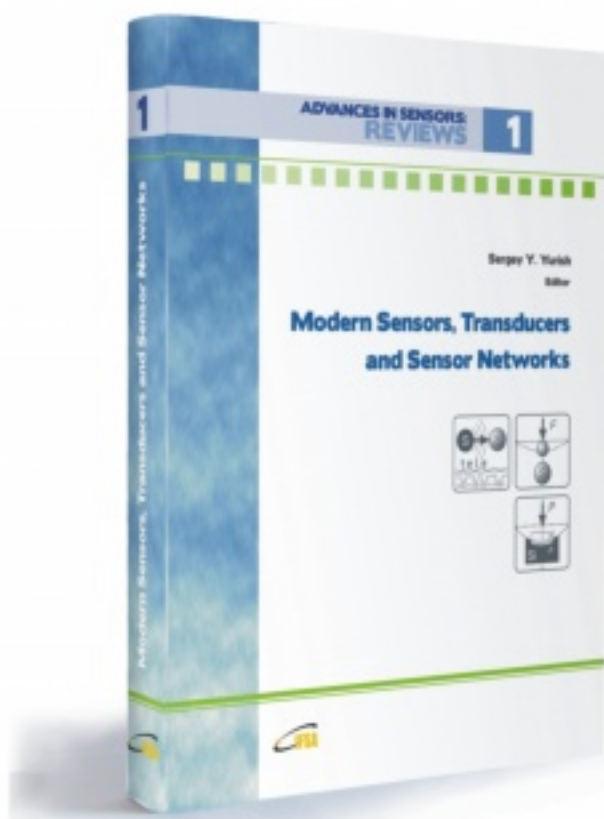
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