（報告様式４）

【課題管理番号：16hm0102022h0004】

平成２９年５月３１日

平 成 ２ ８ 年 度　委 託 研 究 開 発 成 果 報 告 書

I. 基本情報

事　業　名：（日本語）医療分野研究成果展開事業【先端計測分析技術・機器開発プログラム】
ライフイノベーション領域　要素技術開発タイプ
（英　語）Advanced Research and Development for Medical Innovation
Development of Advanced Measurement and Analysis Systems
Life Innovation　Element Technology Development

研究開発課題名：（日本語）乳がん検査用複素誘電率分布計測技術
（英　語）Measurement system of complex permittivity distribution
for breast cancer detection

研究開発担当者　（日本語）広島大学 ナノデバイス・バイオ融合科学研究所　教授　吉川公麿
所属 役職 氏名：（英　語）Hiroshima University Research Institute for Nanodevice and Bio Systems
Professor Takamaro Kikkawa

実 施 期 間：平成２８年４月１日 ～ 平成２９年３月３１日

分担研究　　（日本語）小型プロトタイプシステムの研究開発
開発課題名：　（英　語）Development of compact prototype system
研究開発分担者　（日本語）シャープ株式会社　電子デバイス事業本部　部長　染井　潤一
所属 役職 氏名：（英　語））SHARP　Corporation,　Division Manager,　　Jun-ichi Somei

分担研究　　（日本語）3-10GHz 帯 4 x 4UWB アンテナアレーの開発
開発課題名：　（英　語）Development of 4x4 UWB antenna array in 3-10 GHz
研究開発分担者　（日本語）東京工業大学 環境・社会理工学院　助教　平野　拓一
所属 役職 氏名：（英　語））Tokyo Institute of Technology, Assistant Professor, Taku-ichi Hirano

分担研究　　（日本語）等価時間サンプリング回路の開発
開発課題名：　（英　語）Development of equivalent time sampling circuits
研究開発分担者　（日本語）　国立高等専門学校機構 呉工業高等専門学校　助教　外谷 昭洋
所属 役職 氏名：（英　語））Kure Technical College, Assistant Professor, Akihiro Toya

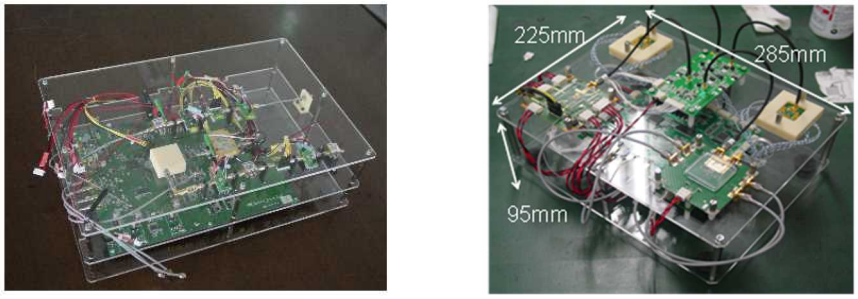
分担研究　　（日本語）乳がん検査用複素誘電率分布計測の臨床的実践
開発課題名：　（英　語）Clinical examination for breast cancer detection system
研究開発分担者　（日本語）広島大学　原爆放射線医科学研究所 教授　岡田　守人
所属 役職 氏名：（英　語）Hiroshima University Research Institute for Radiation Biology and Medicine,
Professor Morihito Okada

II. 成果の概要（総括研究報告）

（日本語）

吉川公麿教授（広島大学ナノデバイス・バイオ融合科学研究所）をチームリーダーとし、染井潤一サブリーダー（シャープ株式会社）らのグループとともに、乳がん検査用複素誘電率分布計測技術を開発し、岡田守人教授（広島大学原爆放射線医科学研究所、広島大学病院）らのグループとともに、乳がん検出能を臨床試験により評価した。

独自開発の 65nm テクノロジー半導体集積回路である CMOS（complementary metal oxide semiconductor）スイッチングマトリクス（1 入力 8 出力 : SP8T）、CMOS 送受信機（GMP : Gaussian monocycle pulse 信号、パルス幅 100-200ps）、CMOS 等価時間サンプリング（100G サンプル/秒）、アンテナアレー（4 x 4＝16 個）、について、当初の数値目標値を達成した。これらの要素技術をシステムに基板実装し、プロトタイプ I（高周波部品実装による原理実証機、マニュアル測定、寸法 450mm x 300mm x 121mm）、プロトタイプ II（高機能 FPGA の採用とソフトウェアにより自動測定を実現、寸法 95mm x 225mm x 285mm）、プロトタイプ III（高精度化と自動測定と時間短縮）をそれぞれ開発した。図 1(a)にプロトタイプ I を示す。図 1(b)にプロトタイプ II を示す。プロトタイプ III は寸法 188mm x 177mm x 191mm、重量 2kg の小型携帯化を実現した。



(a) (b)

図 1. 乳がん検出システムの外観写真. (a)プロトタイプ I. (b) プロトタイプ II.

プロトタイプ III を用いて乳がん検出能の試験を行った。図 2 に乳房ファントム（シリコーン）中の乳がんファントム（ベーコン）の共焦点画像を示す。均一媒体中の乳がんファントム（最小サイズ : 5mm）の検出性能を実証した。広島大学病院にて全摘手術後の乳房サンプルの共焦点画像も確認した。これにより、正常乳腺を含む乳房中の複雑な組織中の乳がんを識別できる性能を実証した。

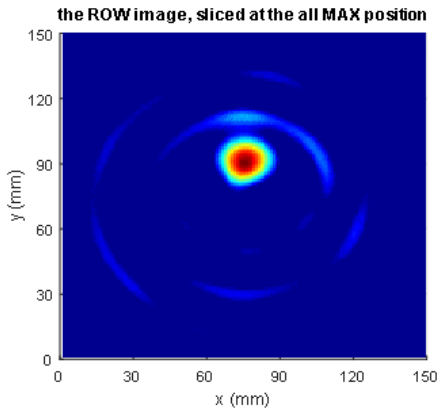


図 2. 乳房ファントム中の乳がんファントムの共焦点画像.

（英語）

Professor Takamaro Kikkawa, team leader, Research Institute for Nanodevice and Bio Systems, Hiroshima University, Japan and his group together with Mr. Jun-ichi Somei, sub-leader, Sharp Corporation, Japan and his group developed a measurement system of complex permittivity distribution for breast cancer detection. Professor Morihito Okada, Research Institute for Radiation Biology and Medicine, Hiroshima University, Japan and his group confirmed the detectability of malignant breast tumors in the clinical test.

The 65 nm technology silicon complementary-metal-oxide-semiconductor (CMOS) integrated circuits for breast cancer detection were developed such as switching matrix (single-pole eight throw), transmitter and receiver (Gaussian monocycle pulse (GMP) pulse width 100-200 ps) and equivalent time sampling (100G sample/sec) as well as antenna arrays (4x4=16). The target performances of all developed modules were achieved. These modules were implemented in the systems such as Prototype-I (450mm x 300mm x 121mm), which is a proof of concept and manual operation, Prototype- II (95mm x 225mm x 285mm), which is fabricated with high-performance FPGA and enables automatic measurement by a software, and Prototype-III, which makes possible high precision, automatic and short-time measurement. Fig.1 shows photographs of Prototype-I and Prototype-II. A portable system of Prototype-III with the size of 188mm x177mm x 191mm and the weight of 2kg was realized.

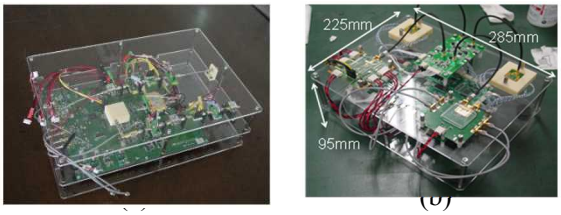


Fig. 1. Prototypes for breast cancer detection.
(a) Prototype-I. (b) Prototype-II.

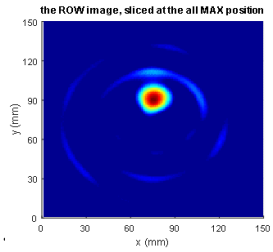


Fig. 2. ge of a breast cancer phantom in a breast phantom.

Examination for breast cancer detection was performed by the use of a Prototype-III. Fig. 2 shows a confocal image of a breast cancer phantom (bacon) in a breast phantom (silicone). It is confirmed that a cancer phantom target with the size of 5mm was detected in the homogeneous medium. It is also confirmed that a malignant tumor tissue could be detected in an inhomogeneous breast tissue including the normal gland tissues in a total mastectomy sample at Hiroshima University Hospital.

III. 成果の外部への発表

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（３）「国民との科学・技術対話社会」に対する取り組み

1. 半導体を用いた乳がんの検査機器で人々の生命を救う、吉川公麿、http://shochou-kaigi.org/interview/interview_34/ 、2017/04/19、国内

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