無線デバイス材料 RF wireless device materials

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2001年同志社大学工学部電子工学科卒業、2003年同大学院工学研究科電気電子工学専攻博士前期課程修了、2006年同博士後期課程修了、博士（工学）。産総研関西産学連携センター特別研究員、東北大学大学院工学研究科電気・通信工学専攻知的電磁系計測分野（日本学術振興会特別研究員PD）、産総研ナノテクノロジー部門ナノ機能合成グループ（日本学術振興会特別研究員PD）を経て、2008年名古屋工業大学機械工学科計測分野共通教育コアメンバー（旧教養部物理学教室）助教（任期あり）、2012年同助教（任期なし）。2015年より早稲田大学理工学術院先進理工学部電気・情報生命工学科准教授。2022年同教授。2016年科学技術振興機構さきがけ研究員（兼任）。2016年度早稲田大学リサーチアワード（国際発信力）受賞。2018年文部科学大臣表彰ほか、受賞歴多数。

Graduated from the Department of Electronics, Faculty of Science and Engineering, Doshisha University (2001); completed the first semester of the doctoral program in the Department of Electrical and Electronic Engineering, Faculty of Science and Engineering, Graduate School of Science and Engineering, Doshisha University (2003); completed the last semester of the doctoral program in the Department of Electrical and Electronic Engineering, Faculty of Science and Engineering, Graduate School of Science and Engineering, Doshisha University (2006); awarded a doctoral degree in engineering. Worked for the AIST Kansai, National Institute of Advanced Industrial Science and Technology (AIST) (special researcher); the Electromagnetic Instrumentation Course, the Department of Communications Engineering, School of Engineering, Tohoku University (special researcher (PD) of the Japan Society for the Promotion of Science); the Nano-Function Synthesis Group, Nano Technology Department, the National Institute of Advanced Industrial Science and Technology (AIST) (special researcher (PD) of the Japan Society for the Promotion of Science). In 2008, became an Assistant Professor in the ‘Core Member’ of Common Education for the Measurement Group (formerly, Physics Course in the Faculty of Liberal Arts), Nagoya Institute of Technology, Department of Electrical and Mechanical Engineering (without tenure); and in 2012, assumed the same role, but with tenure. In 2015, became an Associate Professor in the Department of Electrical Engineering and Bioscience, Faculty of Science and Engineering, Waseda University. In 2016, became a researcher at Presto (Sakigake), Japan Science and Technology Agency (part time). In 2016, won the Waseda Research Award (High-Impact Publication). (He has received numerous awards.)

圧電薄膜を用いた無線通信デバイスや電波のエネルギーハーベスティングの研究を行っている。現在、スマートフォンには欲しい無線周波数帯を送受信するためのフィルタが搭載されている。これらのフィルタには超音波が使われ、圧電効果を持つ材料から構成されている。スマートフォンはそのデータ量の多さから超高周波で通信するため、GHz帯で音波共鳴させる必要がある。固有振動数を上げるために圧電材料を薄膜化させるが、なかなか良い材料がないのが現状である。例えば、圧電材料の王様のチタン酸ジルコン酸鉛（PZT）などは誘電損失と音響減衰が大きく、GHz帯で使えない。そんな中、本研究室では、高圧電性、低誘電損失、低音響減衰の三拍子が揃った、窒化物新圧電材料を発見し、企業共同研究を多数行っている。スマートフォンに搭載される部品のほとんどが１個あたり数円程度なのに対して、無線フィルタはその何十倍もの値がつき、大きなビジネスになっている。国際ローミングの影響で、１台の携帯電話に搭載されるフィルタの数は50個程度にもおよび、各々の無線規格に対応できる圧電材料がますます要求されている。

さらに本研究室では、周囲の地上デジタル波や2.45GHz工業周波数帯の微小電波環境のエネルギーを直流に変換し、発電する研究を行っている。この無線給電技術は将来の電池レスのトリリオンセンサ社会に有望である。研究室独自の圧電トランス薄膜共振子を用いて、電波を増幅させ、直流電圧変換効率の飛躍的向上を目指している。圧電デバイス分野では開発に必要な技術水準が高く、人件費と物価の安い他国に真似されにくいのも大きな特長である。

Our laboratory is conducting a study on wireless communication devices using piezoelectric thin films and wave energy harvesting from radio waves. Currently, smartphones are equipped with filters to transmit and receive desired wireless frequency bands. These filters use ultra sonic wave and consist of piezoelectric materials. Since smartphones communicate at ultra-high frequencies to handle large quantities of data, it is necessary to resonate the ultra sonic wave in the GHz band. To increase the resonant frequency, thinned piezoelectric materials should be used; however, it is difficult to find appropriate material. For example, lead zirconate titanate (PZT), which is often called the king of piezoelectric materials, has large dielectric loss and acoustic attenuation; thus, it is not suitable for use in the GHz band. In light of this, our laboratory has found an ideal, new nitrides-based piezoelectric material, which has high piezoelectricity, low dielectric loss, and low acoustic attenuation features; and we have been conducting various forms of cooperative research with several companies. While most smartphone parts cost only a few yen each, the wireless filters typically cost 10 times as much, and have become a big business. Moreover, with the expansion of the international roaming system, the number of filters in a single smartphone has increased to about 50, and the demand for piezoelectric material corresponding to the various wireless standards is significantly increasing.

Our laboratory also conducts studies on power generation through the conversion of the energy in micro-electric wave environments (such as surrounding terrestrial digital waves), and an industrial frequency of 2.45 GHz, into direct current. Such wireless power-supply technology is promising for the ‘trillium sensor’ society of the future. We aim to dramatically improve the DC voltage conversion efficiency by amplifying the waves, using our unique piezoelectric transformer thin-film resonator. Another feature of this area is that the development of piezoelectric devices requires a high level of technical expertise, making such development difficult to reproduce in countries with low labor costs and prices.

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