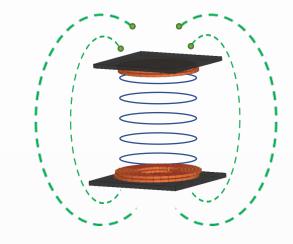






Wireless Power Transmission (WPT) for Smart Home and Mobile Applications







Dr Haimeng Wu July 2024

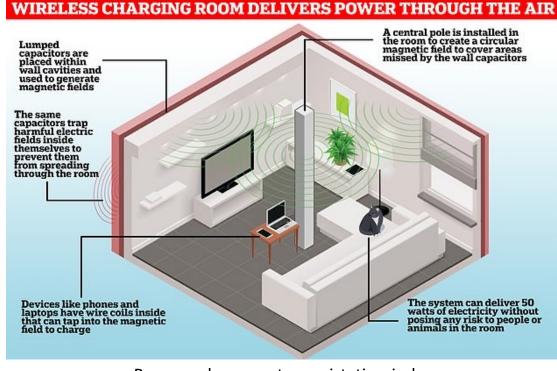
WPT Techniques for Smart Homes/Mobile Devices



Powering the devices wirelessly as transferring the WIFI signals



Conceptional WPT for Household Electronic Devices (credit: WiTricity)



Room-scale magnetoquasistatic wireless power transfer (credit: Nature Electronics)

Introduction - Overview





(a) WPT for consumable electronics https://dietlovemk.best/

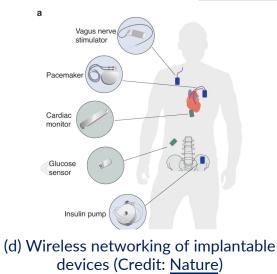


(c) WPT for Warehouse Robotics (Credit: <u>Plugless Power</u>)

Fig.1 Applications of WPT techniques



(b) WPT for EV charging (Credit: <u>Plugless Power</u>)



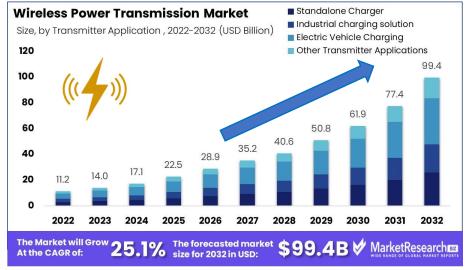
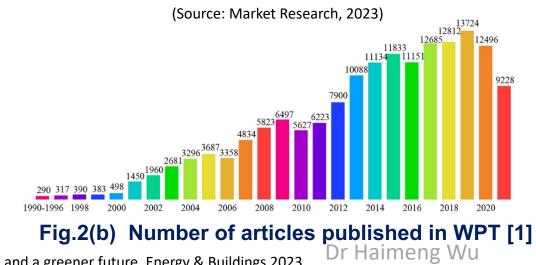


Fig.2(a) Wireless Power Transmission (WPT) Market Revenue from 2022 to 2032



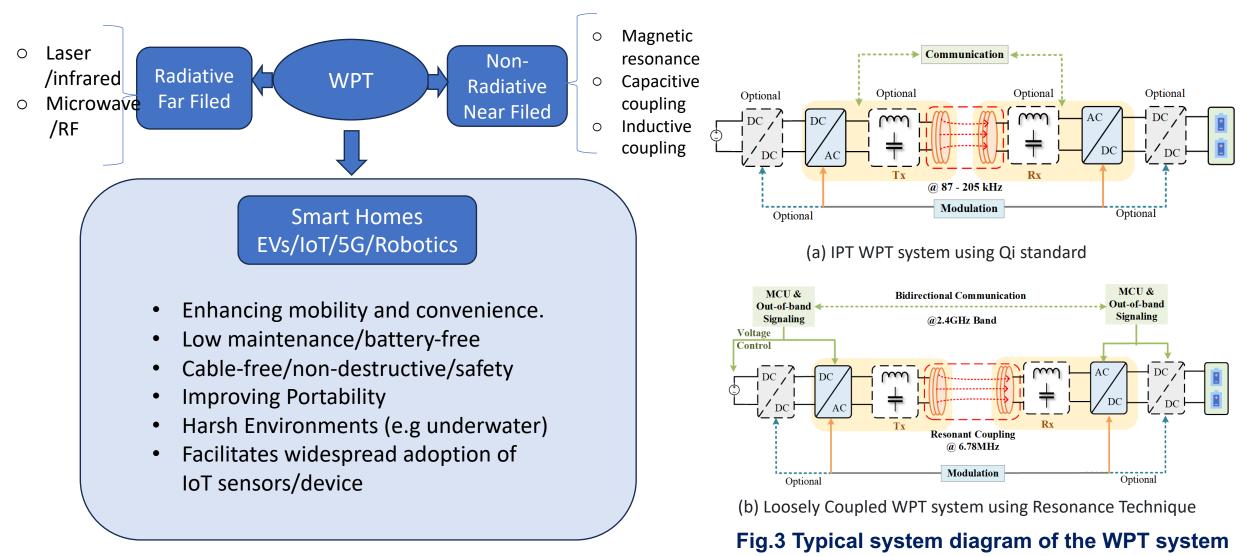
[1] Wireless energy: Paving the way for smart cities and a greener future, Energy & Buildings 2023

bn (USD)

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Introduction - Overview





Introduction – WPT Technologies



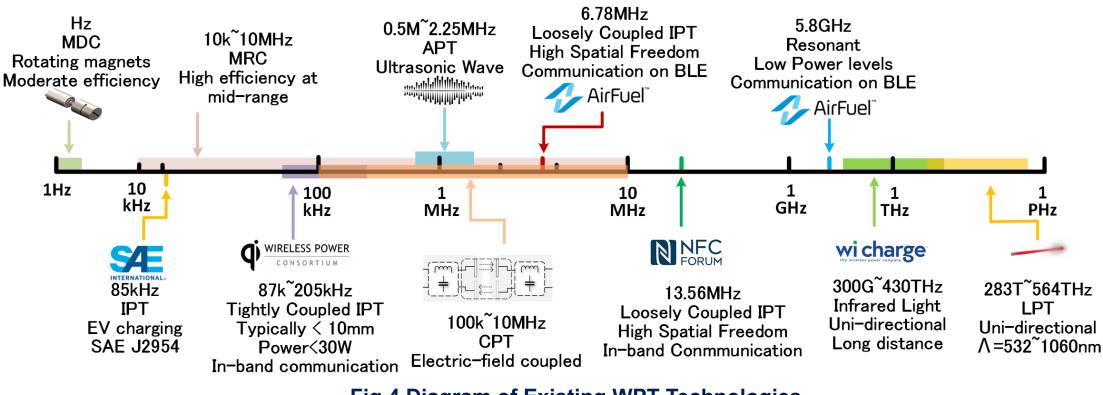


Fig.4 Diagram of Existing WPT Technologies

Techniques

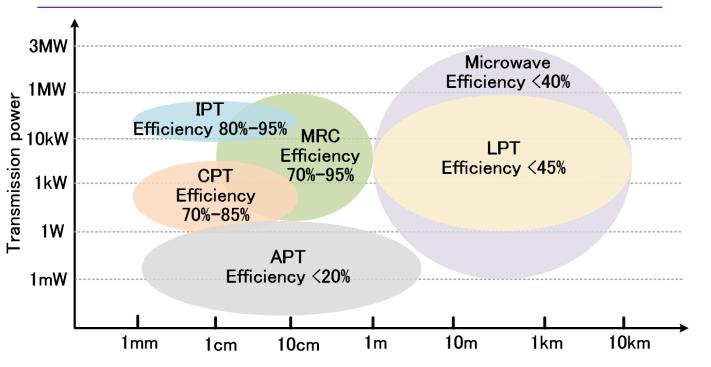
- Inductive power transfer (IPT)
- Capacitive power transfer (CPT)
- Microwave power transfer (MPT)
- Laser power transfer (LPT)
- Acoustic power transfer (APT)

Organisations

- Wireless Power Consortium (WPC)
- AirFuel Alliance (AFA)
- Society of Automotive Engineers (SAE)
- Near Field Communication (NFC)

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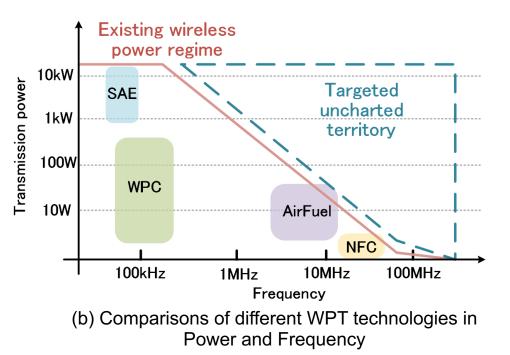
Comparisons of different WPT Technologies



Distance that power is transferred

(a) Comparisons of different WPT technologies in Power and Distance* Fig.5 Comparisons of different WPT technologies

- Magnetic Inductive/Resonance have the highest power efficiency
- The microwave technique can transfer the highest power in the record
- Microwave/Laser WPT can transfer power the longest



Magnetic resonance WPT technique is the best candidate for smart home applications according to the capability of power, frequency and transfer distance

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NEWCASTLE

Challenges and Opportunities for WPT System



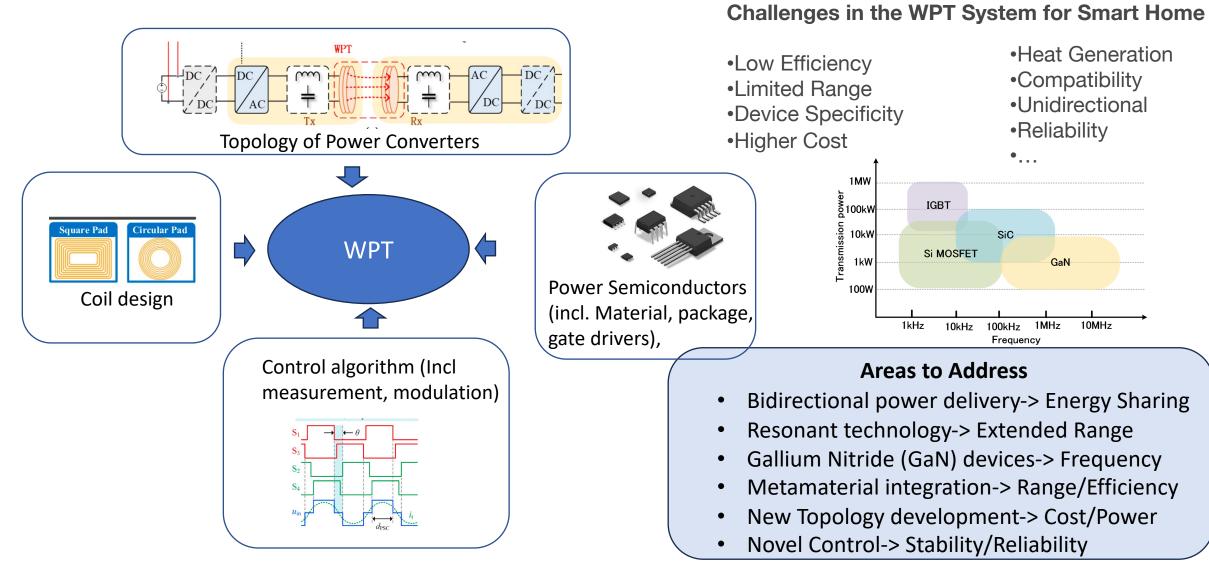


Fig.5 How Power Electronics Techniques contribute to WPT

Research Focus – MRC WPT



HIGH EFFICIENT, LONG-DISTANCE, ALIGNMENT-FREE WPT TECHNIQUES

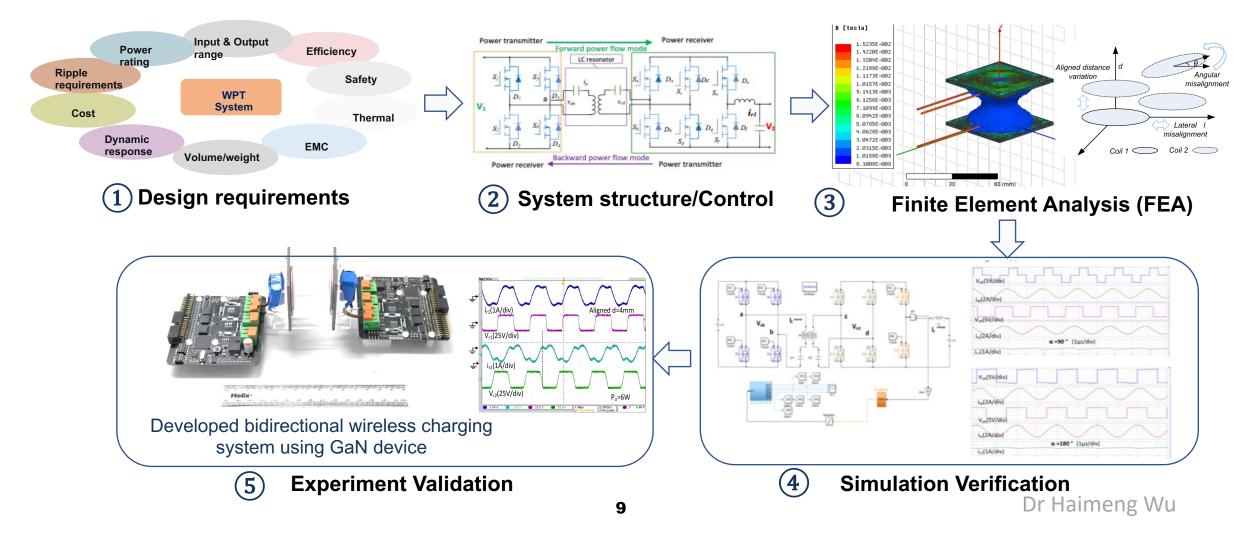


- WPT for mobile and IoT devices
- WPT for EV and Robotics
- WPT with Renewable energy
- ...

WPT System Design



Case Study: Bidirectional compact wireless charging system using GaN device



Research Case Study – Siemens project



Award-winning Research in Bidirectional wireless power transfer system Winner of Siemens European Competition in Power Electronics 2018

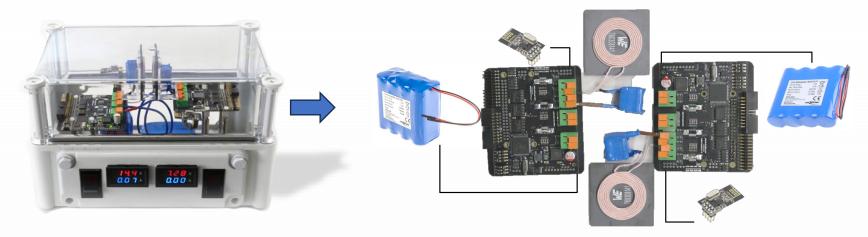


Fig. 6 Prototype of the proposed bidirectional wireless charging system

- **Features**
- Wireless power transfer
- Bidirectional power flow
- High switching frequency: 500kHz
- Close loop control via wireless communication
- High power transfer ability: Laptop application
 - Dr Haimeng Wu

Bidirectional WPT system - Simulation



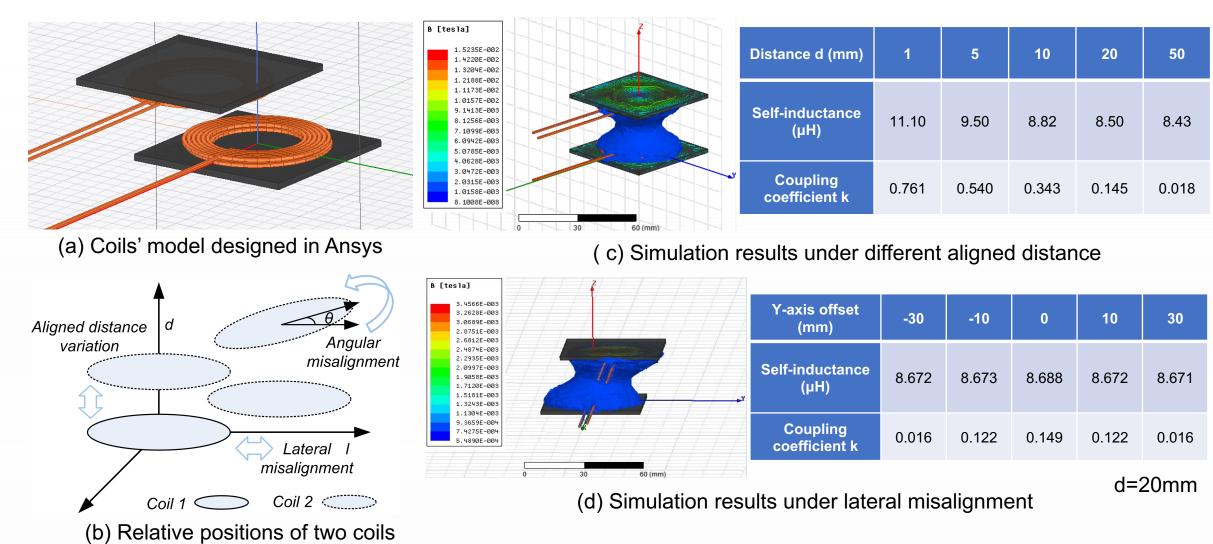
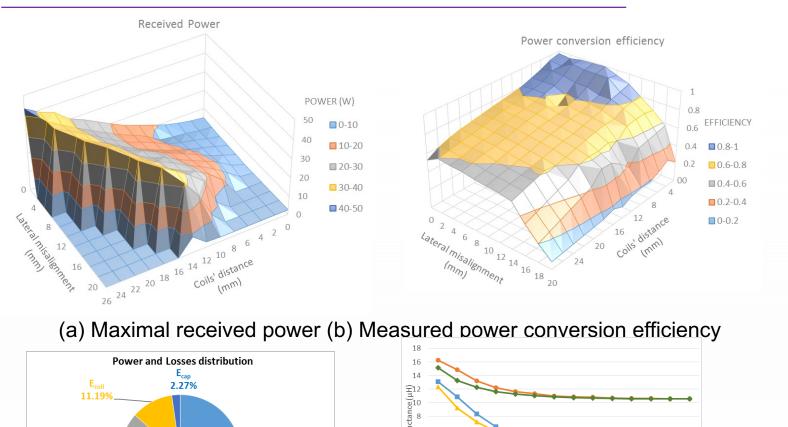
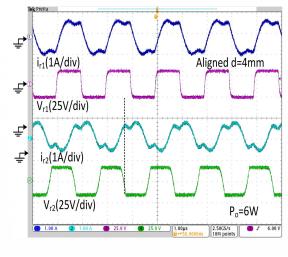


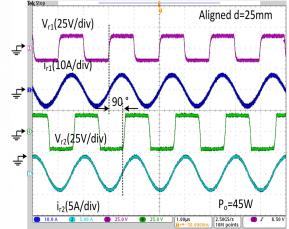
Fig. 7 FEA Analysis for Bidirectional WPT

Bidirectional WPT System - Experiments









(e) Key operational waveforms at two distancesstance (a) d=4mm (b) d=25mm

(c) Power and losses distribution

Received power 68.03%

P=25W

E_{diode} 18.39%

0.12%

(d) Mutual inductance with varying distance

---- Measured Mutual inductance

Aligned coils' distance d (mm)

22

24

Fig. 8 Study on Influence of variation of coils' distance and lateral misalignment

Measured Self inductance

Simulated Self inductance

Research Project – 3D Testing Platform

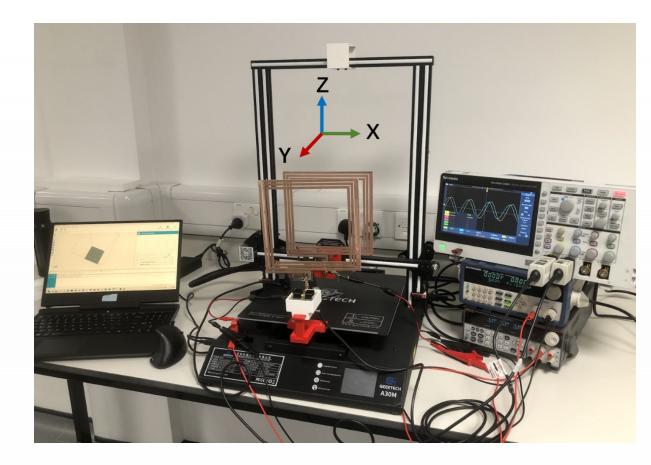
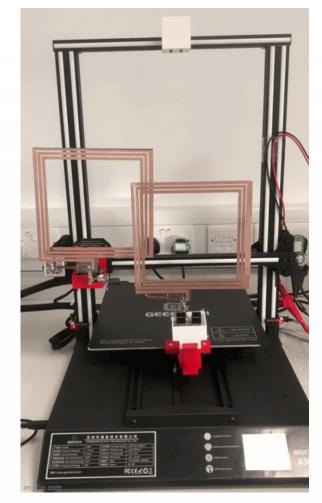


Fig. 10 Photo of 3D testing platform for WPT System



WPT Testing

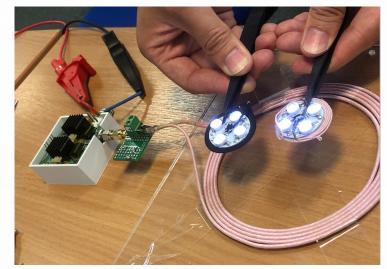
WPT – Demonstrations



(a)LED Matrix



(b) Smartwatch



(c) WPT for Multiple LEDs



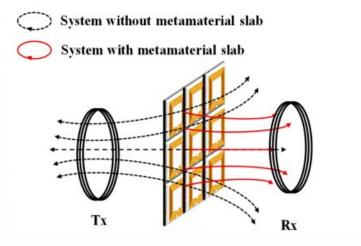
(d) WPT for Robotics

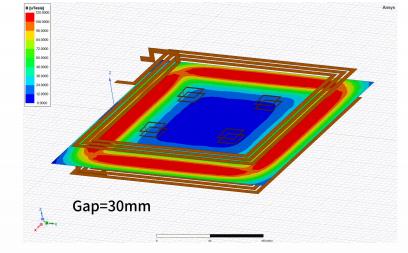
Dr Haimeng Wu

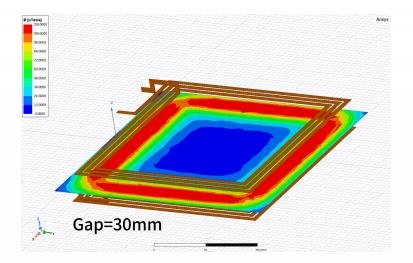
Fig. 13 WPT Demonstration in mobile devices/LEDs/Robotics

Ongoing Research (1) – WPT with Metamaterial

Integration of Metamaterials structure for Mhz - WPT







- Unique Manipulation of Electromagnetic Fields
- Significant Increase in Transmission Distance
- Improve the efficiency of the power conversion
- Flexibility and Tunability

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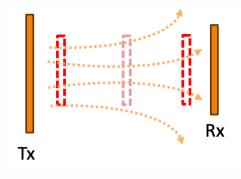
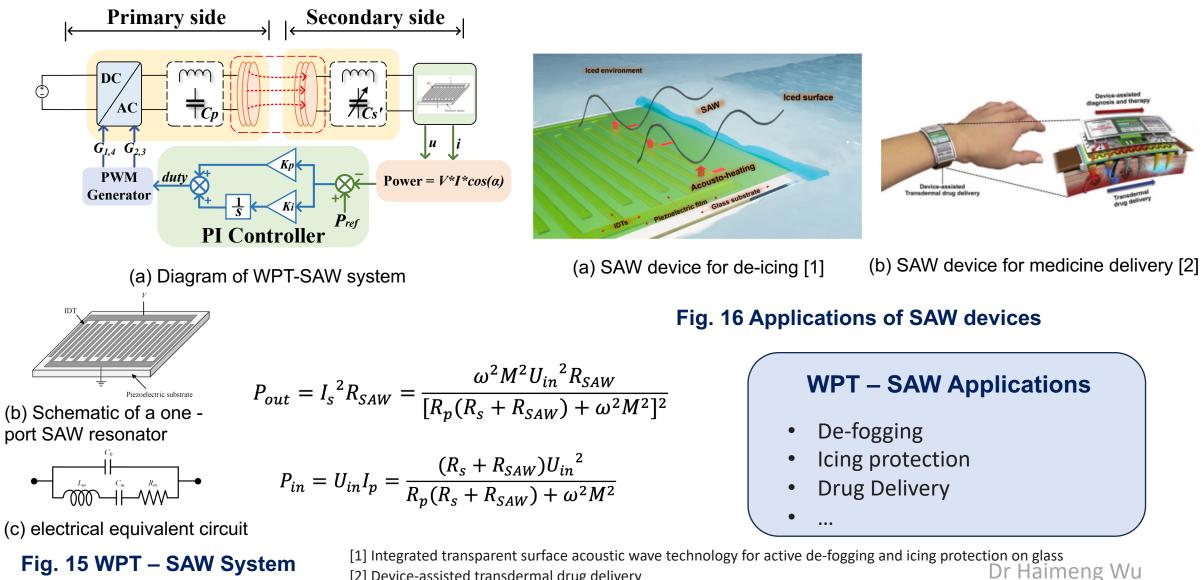




Fig. 14 WPT System with Metamaterial

Ongoing Research (2) – WPT for SAW Devices



[2] Device-assisted transdermal drug delivery

Conclusions

- **Rapid Development**: The global WPT market is booming, driven by applications in consumer electronics, EVs, robotics, and smart cities.
- **Diverse Technologies**: Various WPT methods, each with unique advantages, are paving the way for more efficient and long-range wireless power solutions.
- **Research and Innovation**: Ongoing research focuses on enhancing WPT efficiency, extending range, and integrating with advanced materials like metamaterials.
- **Challenges and Opportunities**: Addressing challenges such as efficiency, range, and cost can unlock new opportunities in bidirectional power delivery, advanced resonant technologies, and novel control algorithms. High-bandwidth Measurement Equipment tailored for WPT is required
- **Future Prospects**: High-efficiency, long-distance, alignment-free WPT techniques hold the promise of revolutionizing power delivery in smart homes and mobile applications, contributing to a greener and more connected future



Thank you



Powering the future wirelessly!

Figures are created by Copilot