

Bioelectrical Energy Harvesting and Human Tissue Stimulation

Dr.-Ing. Gerd Teepe

CEO and Co-Founder of Celtro Inc.

14. November 2024

The Team



Gerd Teepe PhD, Co-Founder, CEO



Thomas Gaspar MD, Co-Founder
Cardiac EP – Pre-Clinical Lead



Paul Reidy, Esq.
M&A and Licensing



Manu Viswambharan M. Sc
IC Design, Principal Engineer



Niko Joram PhD, System
Design, Principal Engineer



Judith Piorkowski, MD, Co-Founder
Cardiac EP Lead



Jarek Budny, MBA, Co-Founder
Finance & Business Development



Forrest Pape MSEE
Implantable Architect



Andres Belalcazar, PhD
Scientific Advisor



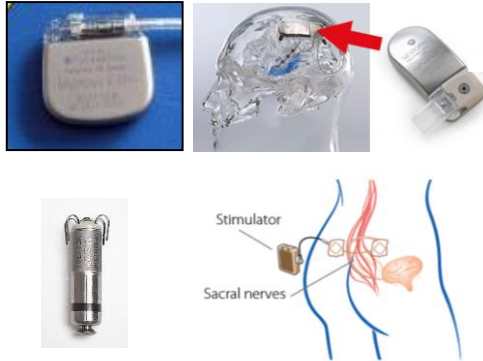
Tom Drechsel, PhD, Tissue
Interface, Principal Engineer



Problems with current implantable devices

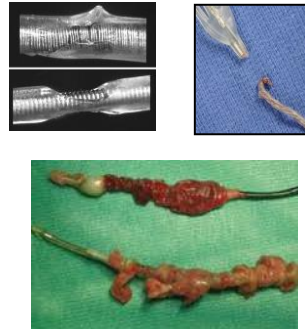
Batteries

- drain, fail, infect -



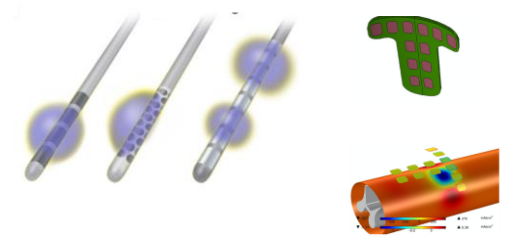
Leads

- integrity, infection, obstruction -



Tissue Interface

- access & stability -



Complex Implantation & Maintenance, Therapy Failures, Complications, Frequent Surgeries

The Idea - Deep Miniaturization

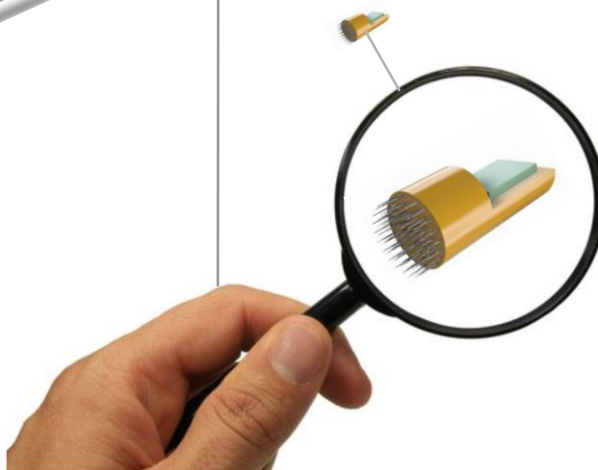
Yesterday



Today



CELTRO



CELTRO - Features

Implant for Life

Pacing site flexibility
(e.g., left heart)

Vascular access flexibility
(e.g., radial access)

Faster, simpler, less invasive, outpatient procedure

Broaden implanter base

Widen geographic penetration
(underserved countries)

Smaller is better – Conceptual View

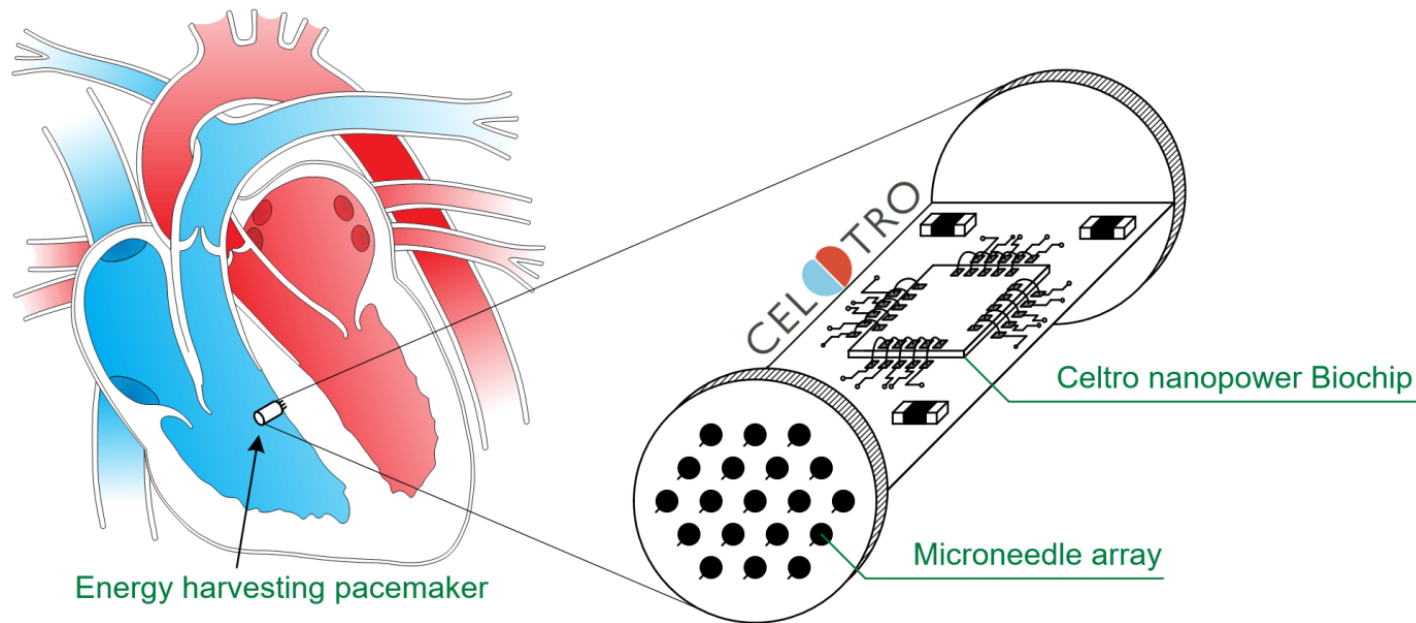
**Deep Miniaturization =
precise anatomy
placement**

RV First solution for
leadless conduction
system pacing

LV Optimized
resynchronization via
endocardial LV access

RA Flexible right atrial
leadless positioning
options

LA Easy left atrial
pacing access to
suppress AF



Energy-Harvesting for Biomedical Devices

Hannan et al. *BioMedical Engineering OnLine* 2014, **13**:79
<http://www.biomedical-engineering-online.com/content/13/1/79>



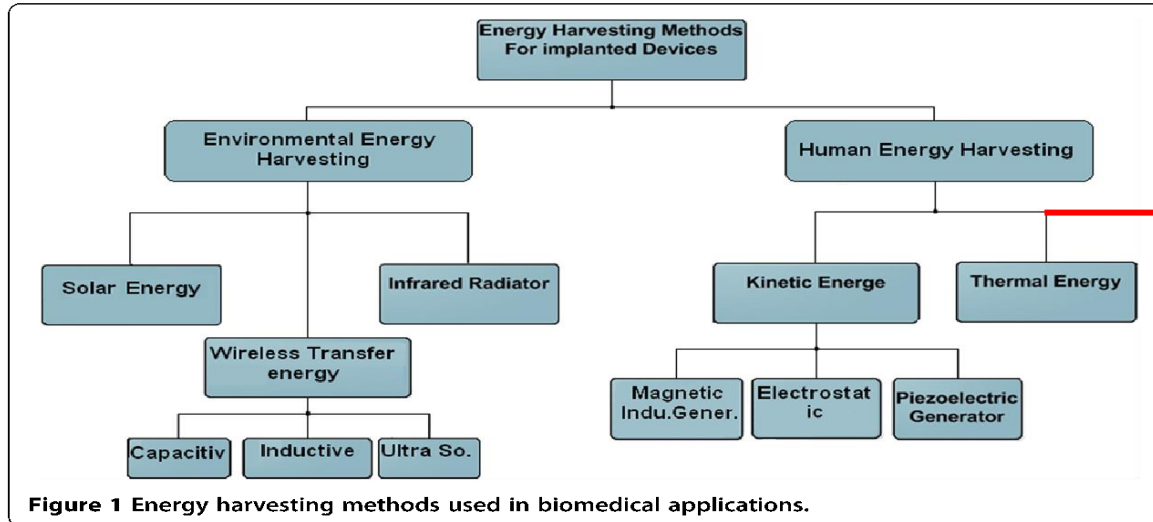
REVIEW

Open Access

Energy harvesting for the implantable biomedical devices: issues and challenges

Mahammad A Hannan¹, Saad Mutashar^{1,2*}, Salina A Samad¹ and Aini Hussain¹

Our technology uses electrical energy-harvesting to power implanted medical device functions.



Electrical Energy

The Value Proposition - Broad Application Platform

Beyond Cardiac Implants

Incontinence:

Tibial nerve stimulation
Sacral nerve stimulation

Hypertension:

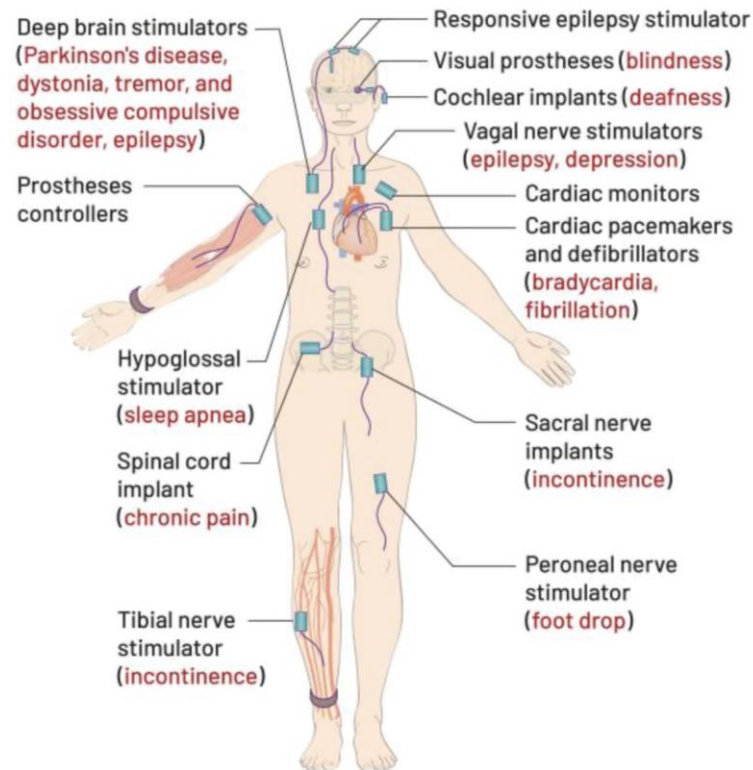
Baroreceptor stimulation

Sleep Apnea:

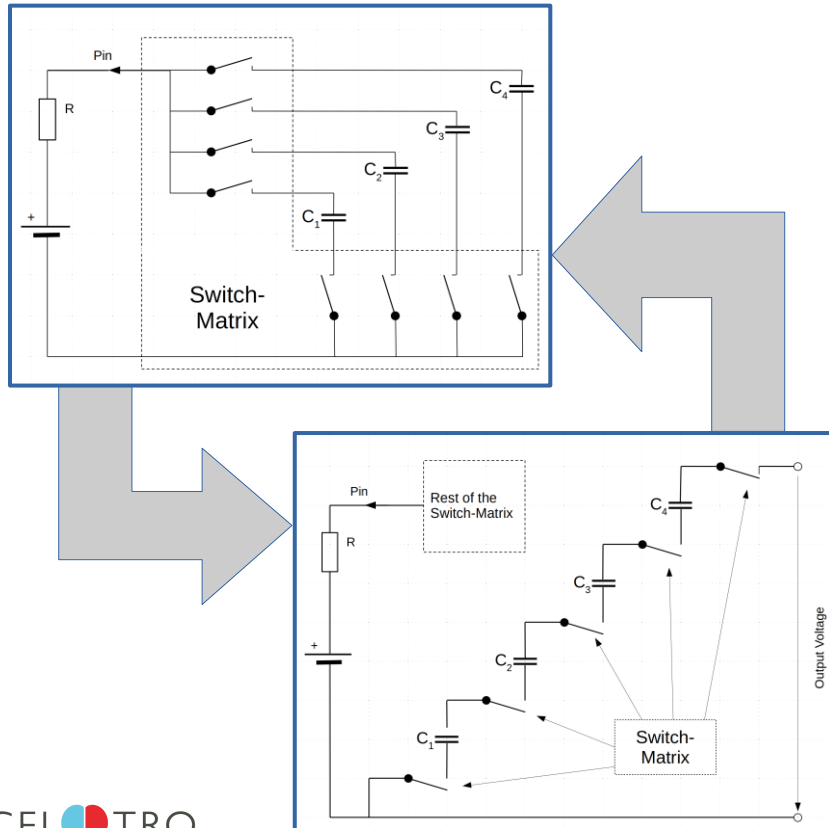
Phrenic nerve stimulation

Obesity:

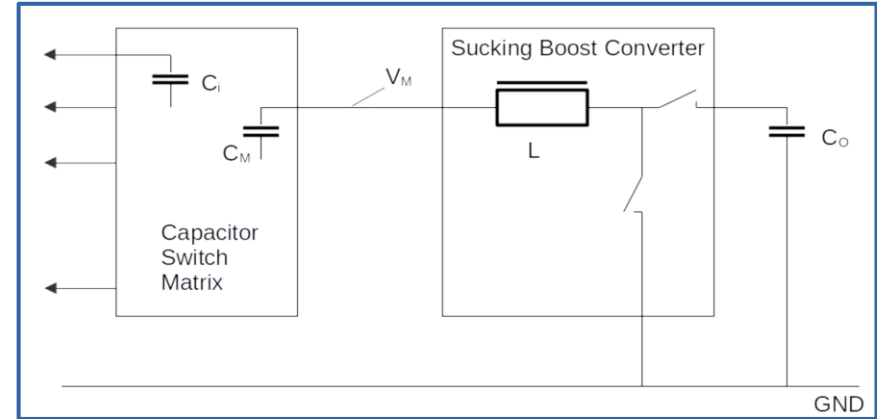
Gastric stimulation



Capacitive Voltage Conversion



Inductive Boost Conversion



Technology Advancements:

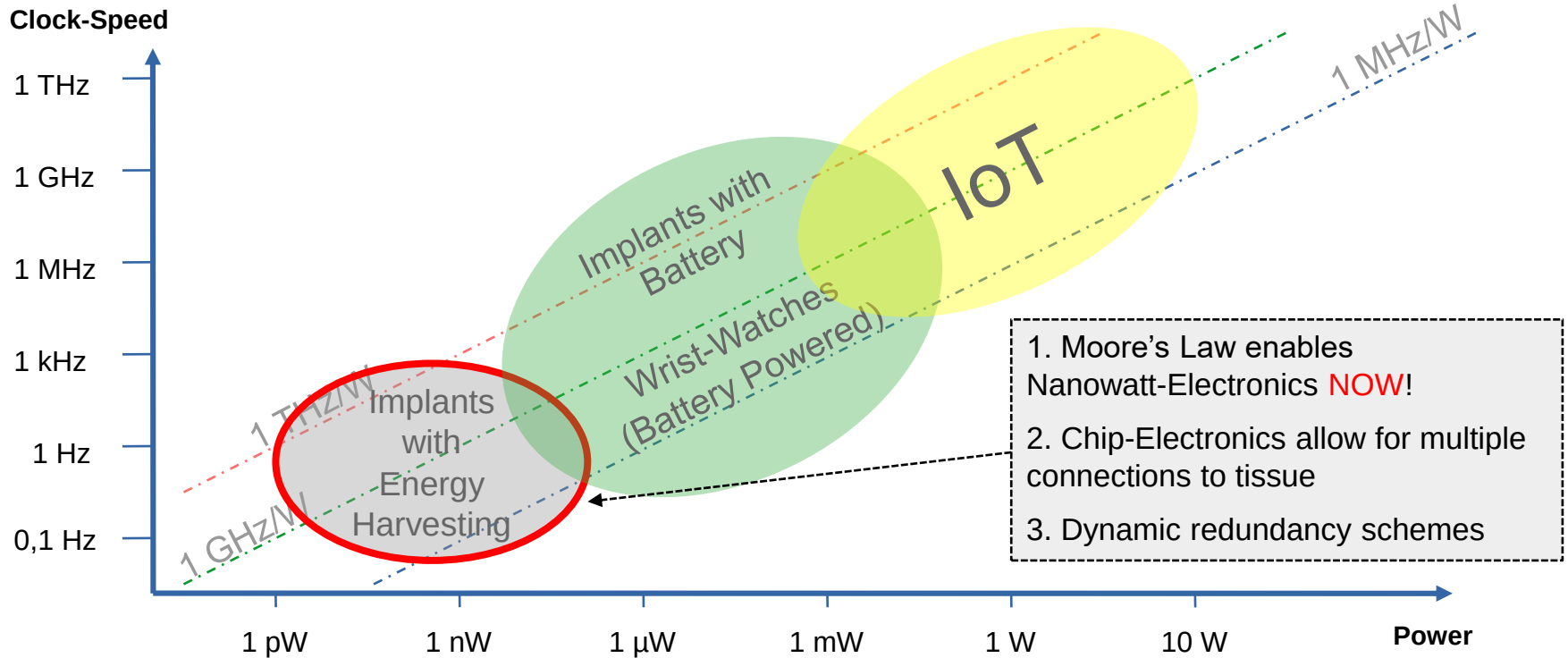
Better Transistor Performance → Reduction of Switching Losses

Higher Switching Speeds → Better Integration Capabilities

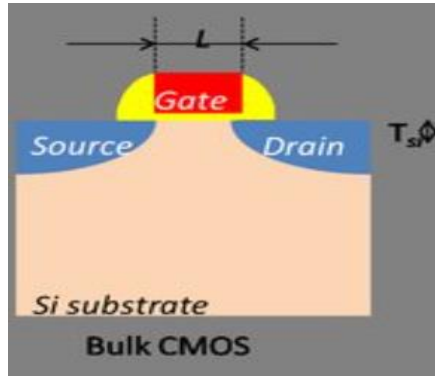
SOI-Technology → leakage reduction

Logic Power: 1TOPs @ 1 Watt → 1 kOPs @ 1nW

Moore's Law enables Nanowatt-Electronics



Semiconductor Technology breakthrough in Low Power

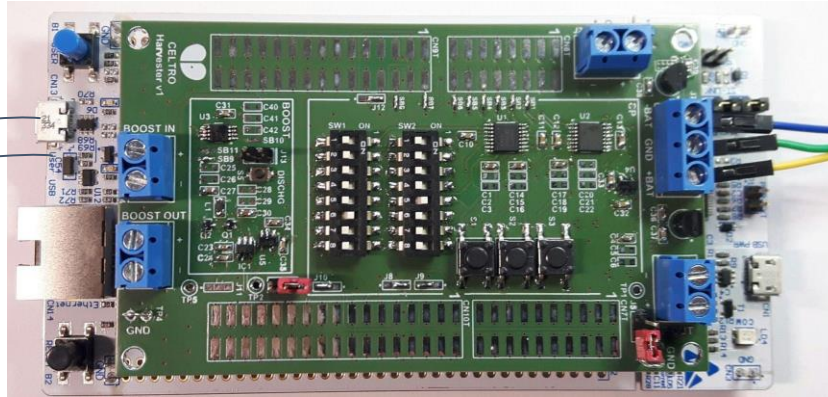
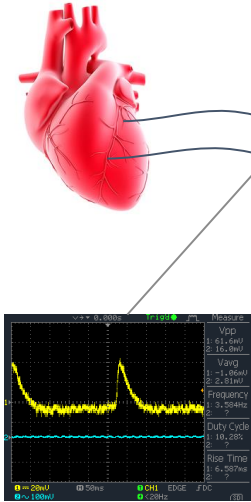


... up to
28 nm

Substrate Diodes

The Proof of Concept

Operational PCB-based Harvester (ex-silicon)



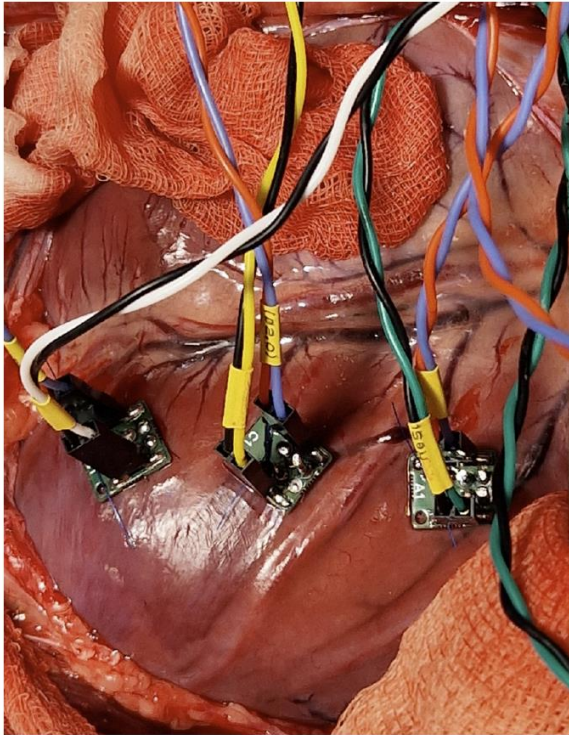
Used for:

- Tissue Characterization
- Validation of SC Harvesting & Stimulation Specifications
- Tissue Interface Design testing
- Feasibility Demonstration

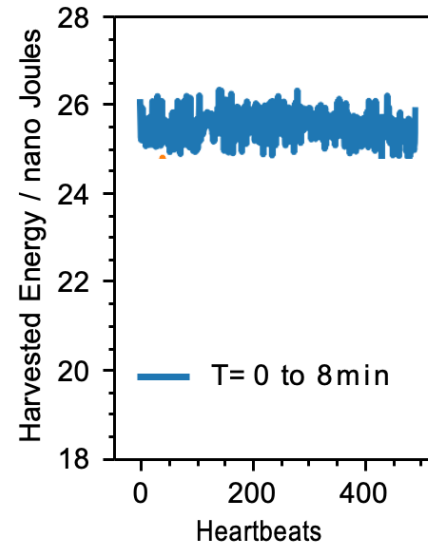
- Off-The-Shelf Components, Programmable Design
- Demonstrates ability to generate CMOS-Voltages from Myocardial Tissue
- Not usable to demonstrate autonomy

The Proof of Concept

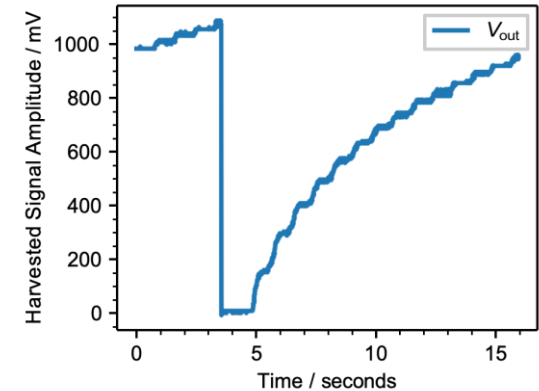
Harvesting from porcine hearts, performed 5/24-8/24



**Continuous Harvesting
1 microneedle**



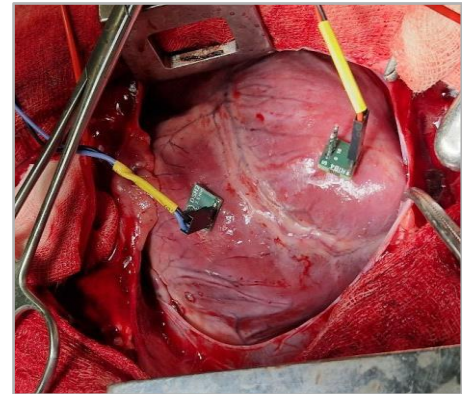
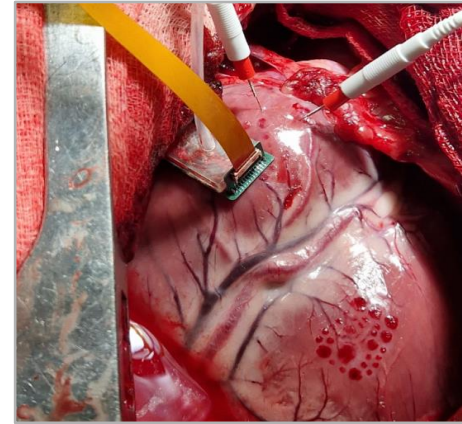
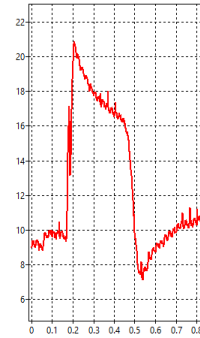
**Harvesting + Boost Conversion
1 microneedle**



The Proof of Concept

Energy harvesting from living hearts, performed 5/23-5/24

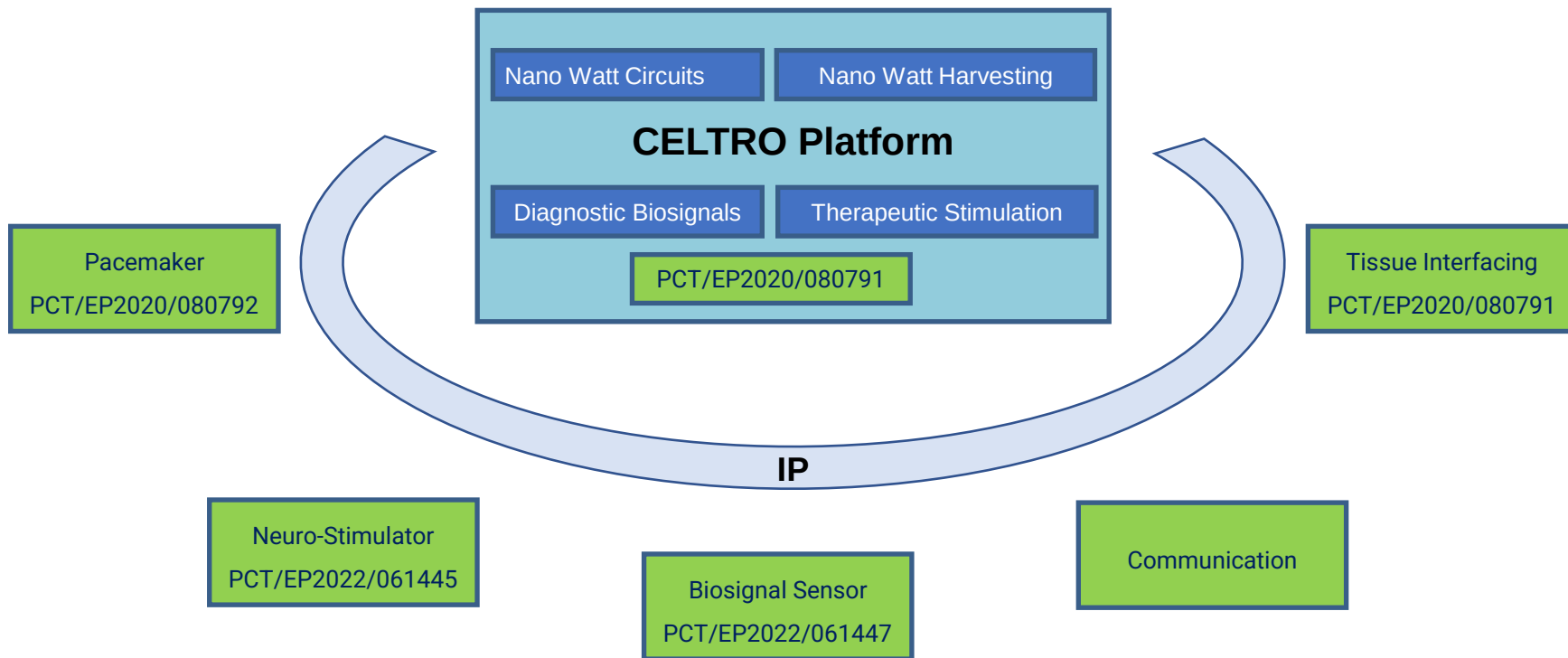
Waveform recorded from Tissue Interface (Needle)



Harvestable Energy Content / Tissue Interface
Pacing Threshold Assumption
Energy Needed for Pacing
Number of Tissue Interfaces Needed to Harvest Pacing Energy

23nJ
0.3V / 0.4ms
30nJ
2-3

Intellectual Property Rights



Financing: Sources and Conditions

Sources

- Private Financing from Founders and Investors
- R&D Project Funding from the Free State of Saxony / Germany
- Venture Capital

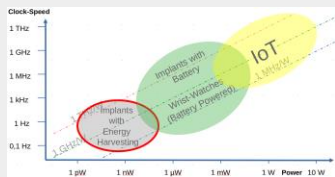
Criteria

- SME-Criteria (<50 Mio€ Sales, <25% ownership of a „large“ Company)
- No CID (Company in Difficulties) → implies fundamentally no debt

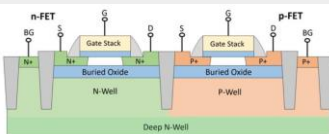
Summary

The Time is Now – Technology & Business Readiness

Semiconductor Technology



Moore's Law



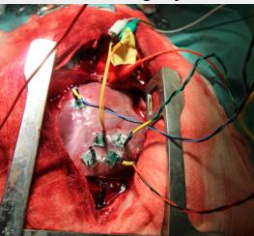
FDSOI from Globalfoundries (Dresden)

Advances in Moore's Law
Parallelism&Redundancies
FDSOI Leakage reduction

Electrode Miniaturization / Tissue Interface



Electrode Mfg by Laser



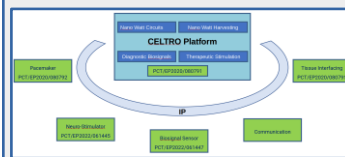
Tissue Interface

Entering the Intracellular Space
to access the electrochemical
potentials of the cell action
potentials

Battery removal & Size Reduction



Celtro Patents for Energy Harvesting and Stimulation



Patents for foundation of the
Celtro-Platform

Celtro Patents & Trademarks

3 Patents granted

1 Patent pending

Nationalizations underway for

- USA / Canada
- Germany/France/GB
- Japan/Korea

Obtained Trademark for Celtro™

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Sacral nerve stimulation

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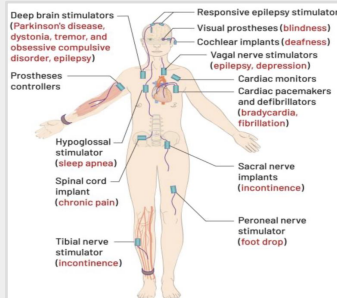
Baroreceptor stimulation

Sleep Apnea:

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Gastric stimulation



CELOTRO