IEEE ECTC May 2015
San Diego

Challenges and advancement of battery technology for medical device applications

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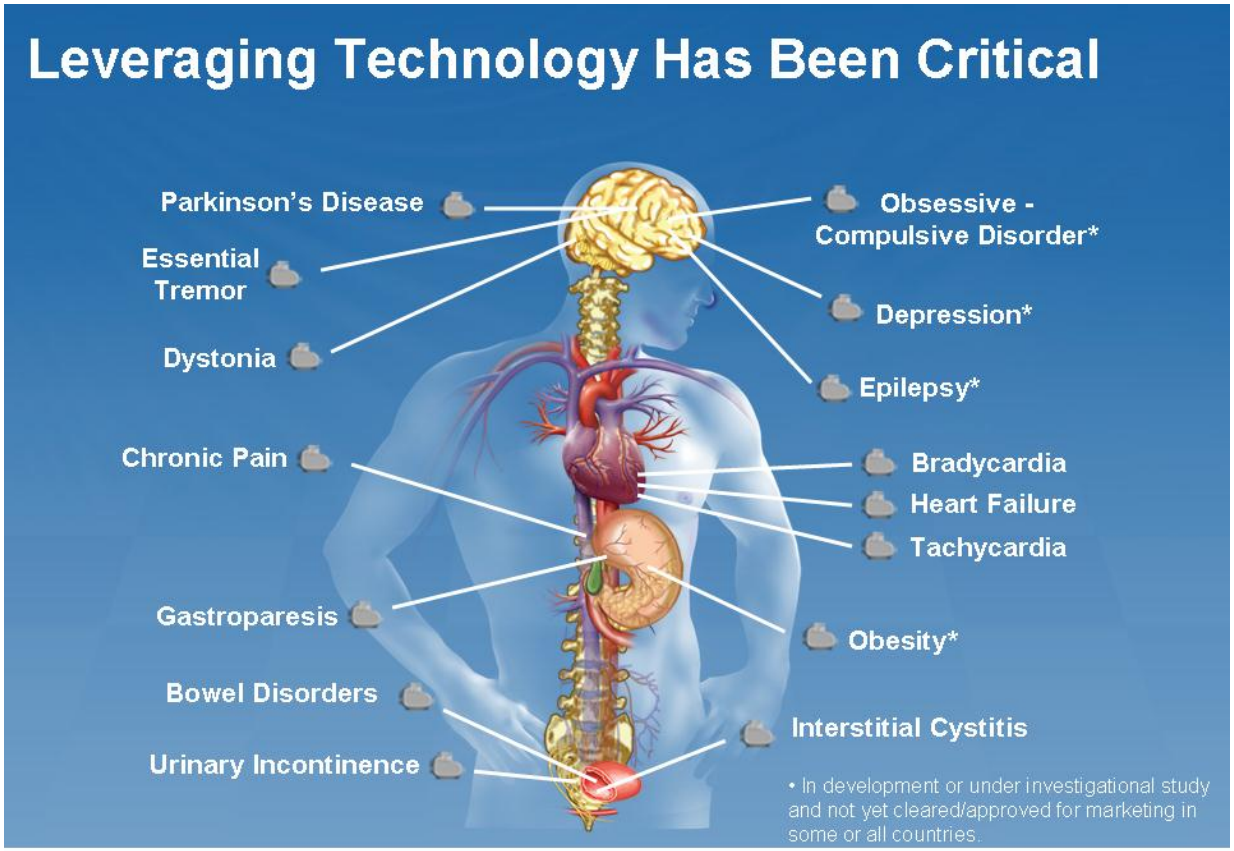
Acknowledgements:
Craig Schmidt, Erik Scott,
Hui Ye, Prabhakar Tamirisa

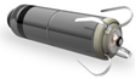
Variety of active implant applications..




ICDs, CRTDs


Drug pumps


Pacemakers

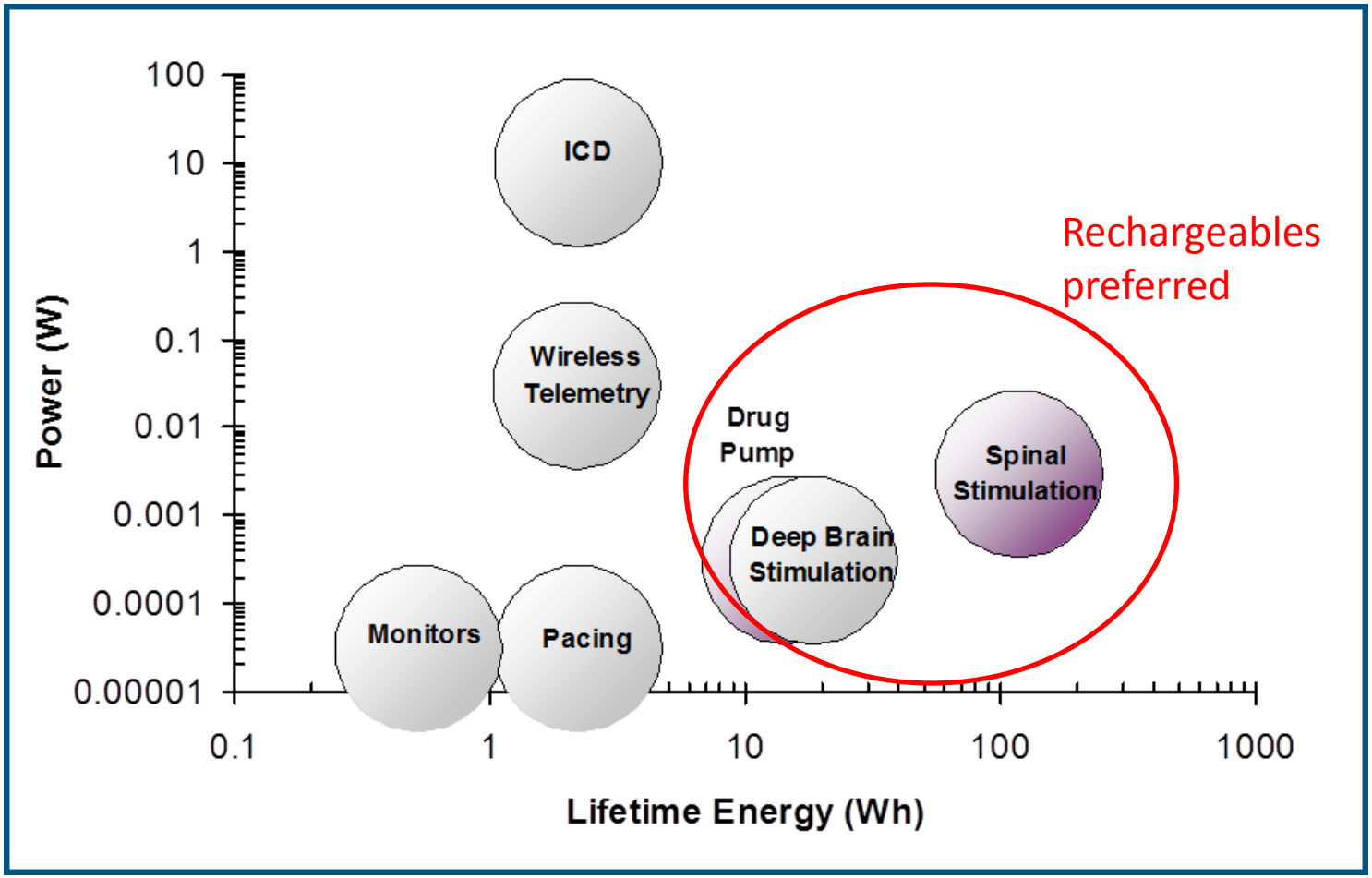



Neurostims


Diagnostic

..variety of power source needs

Power source needs & requirements

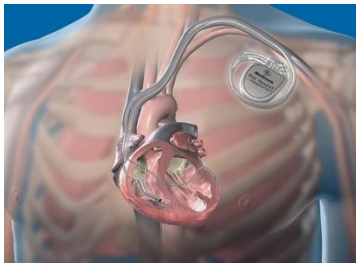


- Safety / Predictability / Reliability
- Mechanical / Materials compatibility
- Patient experience / Business & regulatory goals

Foundational Attributes

Examples of Current Applications

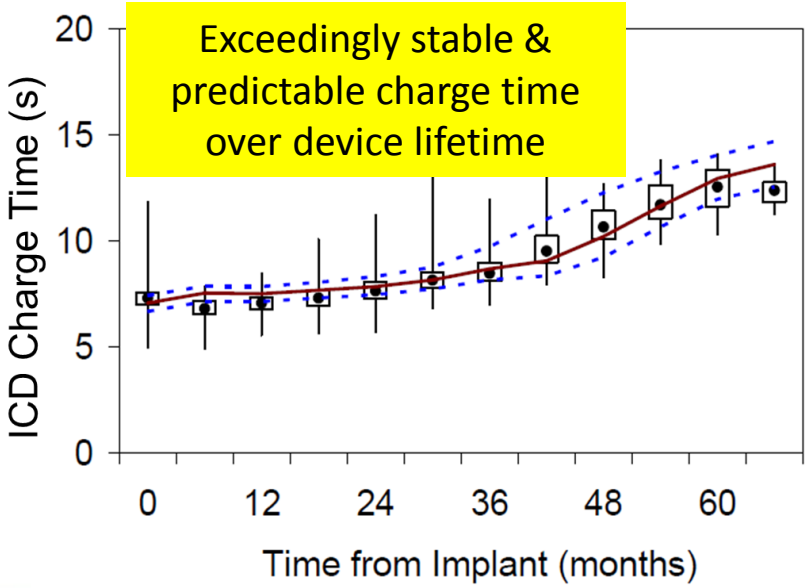
ICDs & CRT-Ds

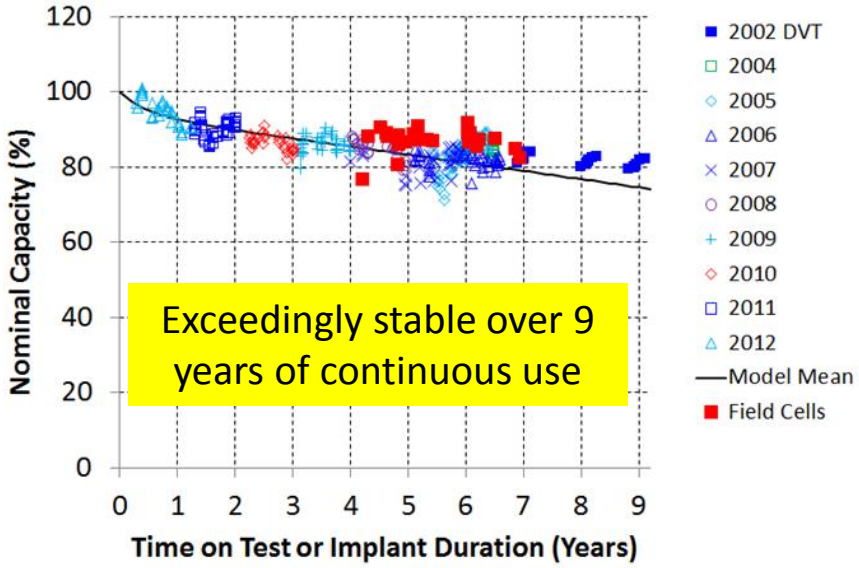


Pacing and Defibrillation
Uses primary cell devices

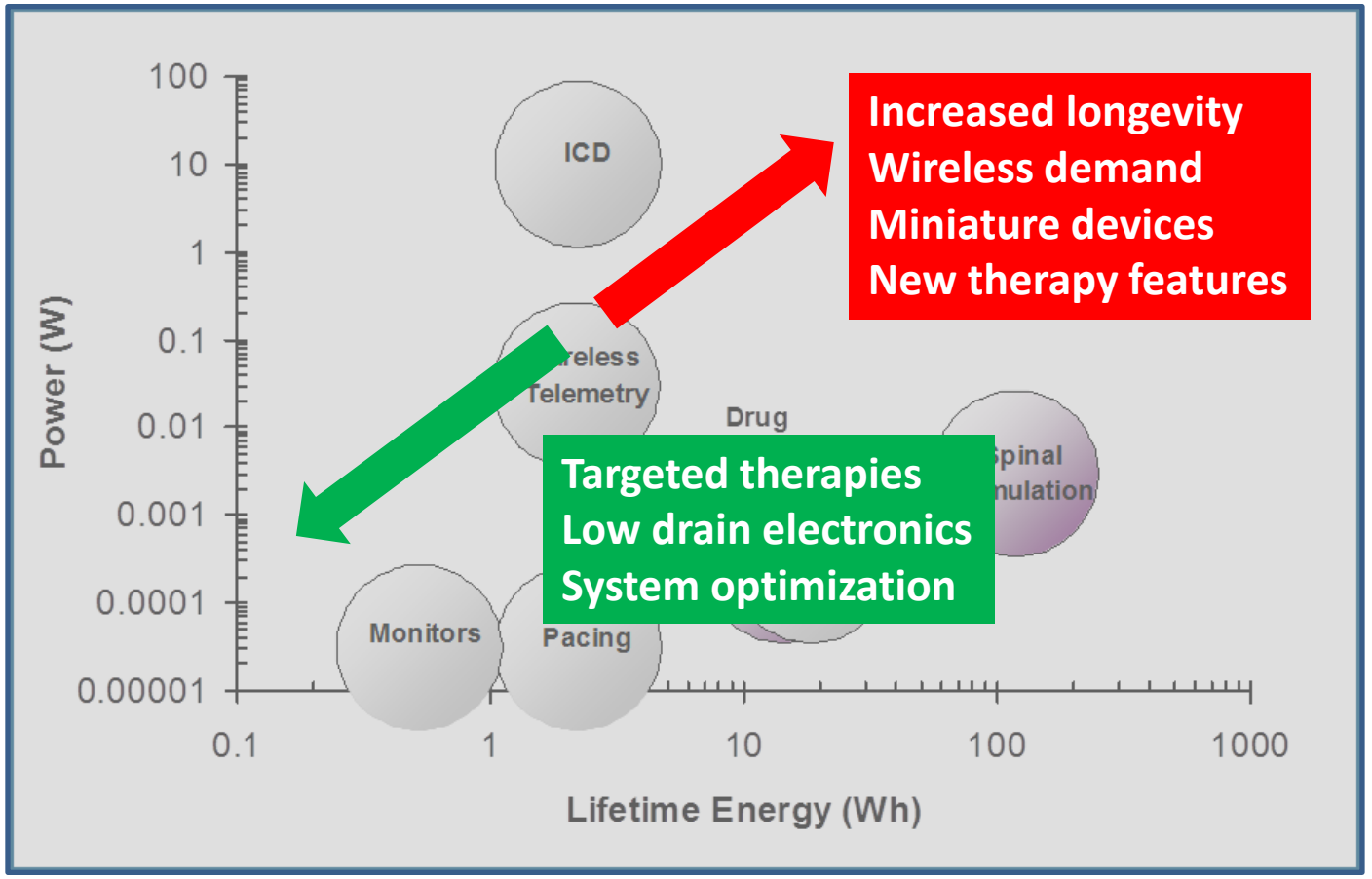
Neurostimulators

Deep brain, spinal cord stimulation
Uses Primary <u>or</u> Rechargeable cell devices





Energy & power needs
Emerging trends



Examples of Emerging Applications

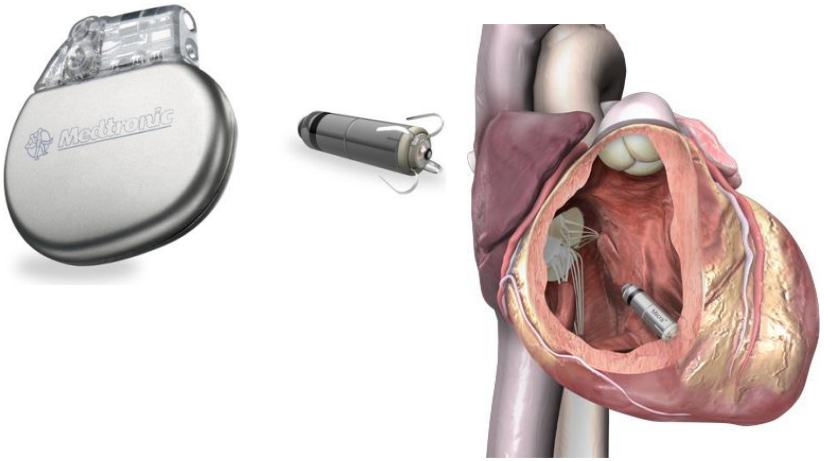
Reveal / LinQ Diagnostic

- Diagnose arrythmias
  - Unexplained syncope
  - Palpitations
  - Atrial fibrillation
  - Cryptogenic stroke
- Gather & automatically transmit signals
- Minimally invasive procedure
- Advanced sensors & algorithms
- Distance telemetry

Micra Transcatheter pacemaker

In Clinical in US

- Pacemaker in RV
- Single chamber
- No lead
- Reduced risk of infections
- 1/10th size of conventional pacemaker
- Therapy tailored to patient activity
- Minimally invasive procedure
- Estimated 10 year longevity



Power source – Technology trends

System-level packaging solutions (internal or external to battery)

Examples: Apple contoured battery cells

Offer limited gains in already optimized systems

Apple / PCWorld.com

Increased energy density: newer chemistries beyond lithium

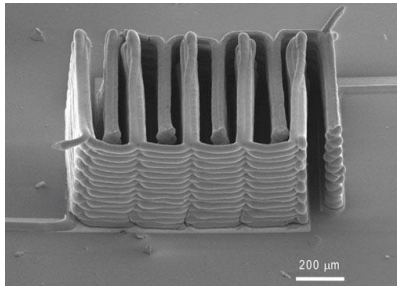
Examples: Mg ion, Al ion, Li air or Li sulfur

Need discovery to get to stable, reliable systems

Increased power density: 3D structures

Examples: 3D interdigitated structure, solid state, etc.

Significant design, manufacturability, materials challenges



J. Lewis, Harvard

Autonomous power sources

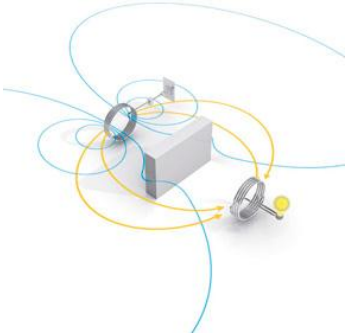
Example: Piezoelectrics, thermoelectrics, etc.

Need high power density to be viable

Wireless power transfer

Example: Resonant coupling inductive power

Power Transfer efficiency & significant infrastructure reqts.



Witricity

Summary

- Increased energy & power density are perpetual needs
- Batteries are an excellent solution & continue to improve
- Rechargeable Li ion have proven their longevity
- Need to understand longevity of other system components

- Near term - gains from better system integration both mechanical & electrical
- Longer term - several compelling technologies on the horizon

Thank you for your attention