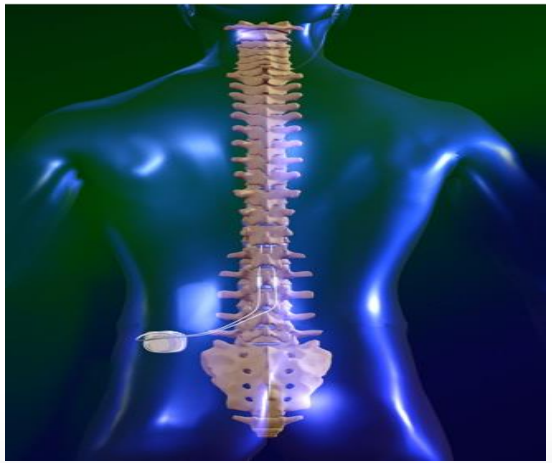
The Use of Advanced Microelectronic Packaging Techniques to Miniaturize an Implantable Neuromodulator

Jim Ohneck
AEMtec, Berlin Germany

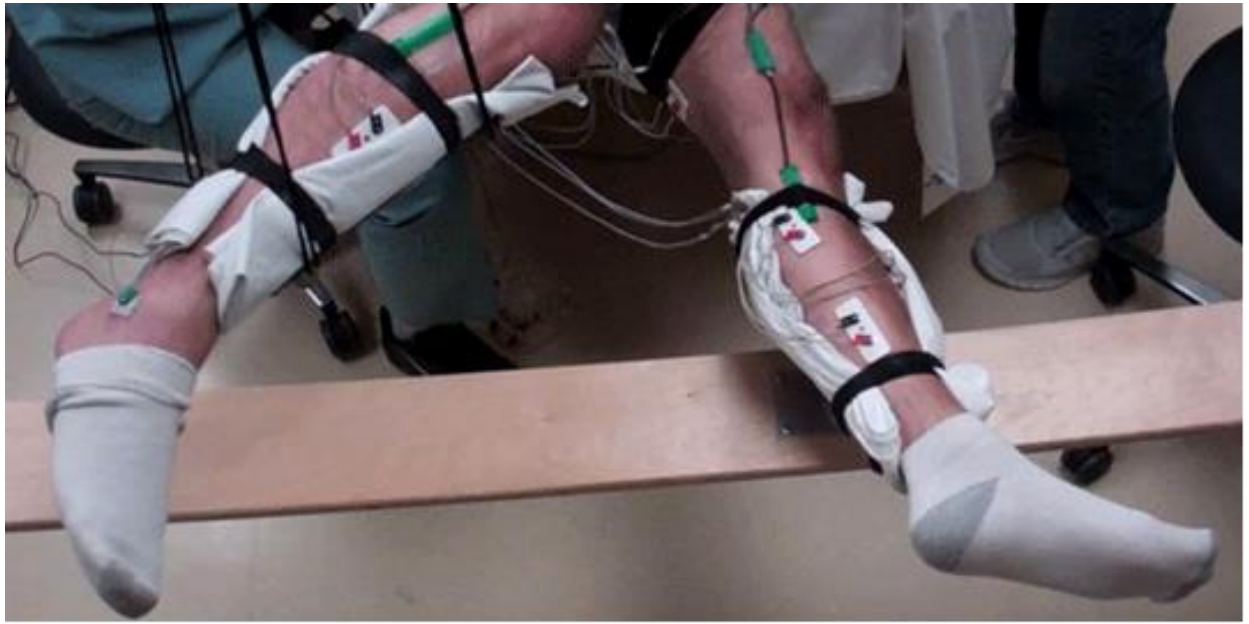
Implantable Neuromodulator

Neuromodulation refers to an emerging class of technologies that apply magnetic or electrical energy to the spinal cord or brain

- Chronic Pain using SCS Approach
- Deep Brain Stimulation (DBS) for Epilepsy
- Parkinson's Disease
- Urinary Incontinence



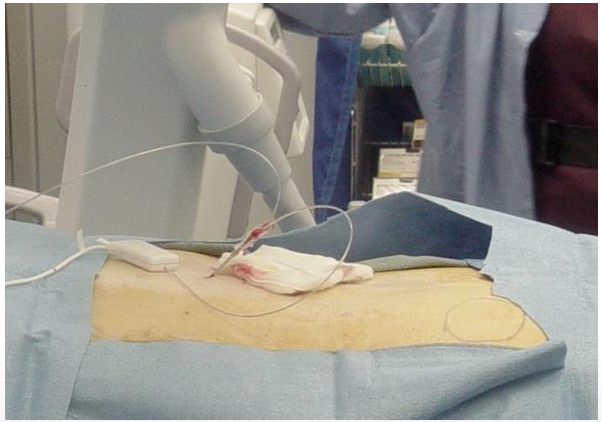
External Neuromodulators



Picture courtesy of UCLA

Barriers to Technology Adoption

- Physician Training
- Patient Acceptance
  - » Discomfort due to physical size
  - » Complexity of use
  - » Battery Life/Recharging process
- Physician Acceptance
  - » Complexity of Implant
  - » Concerns with patient acceptance/physical size
  - » Cost of device and surgery



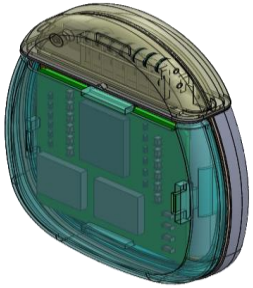
Desirable Features

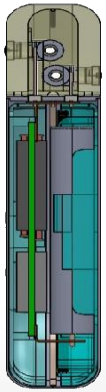
- Reduction in physical size
  - » Improve patient comfort and acceptance
  - » Reduce complexity of Surgery
- Closed Loop Stimulation
  - » Sense onset of undesirable condition
  - » Analyze Signals
  - » Assume autonomous actions to counteract effect
- Reduced Cost

Neuromodulation Device for Parkinson's

Newronika SRL

- Employs a closed loop design
- Final Implant package Volumes of 22cc's & 32cc's for increasingly capable devices
- Telemetry for communication with external controllers
- Fast, easy to use re-charging and data collection system



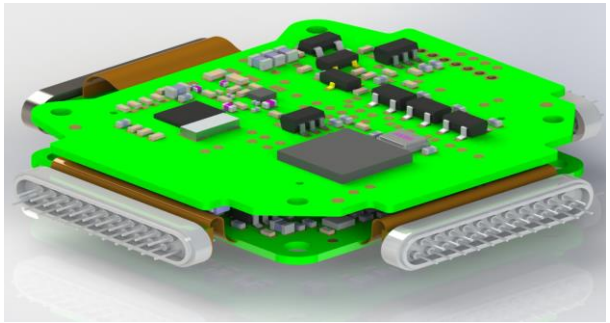


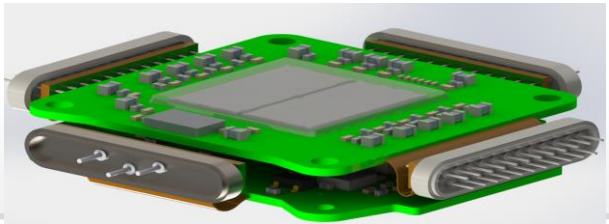
Product Challenges

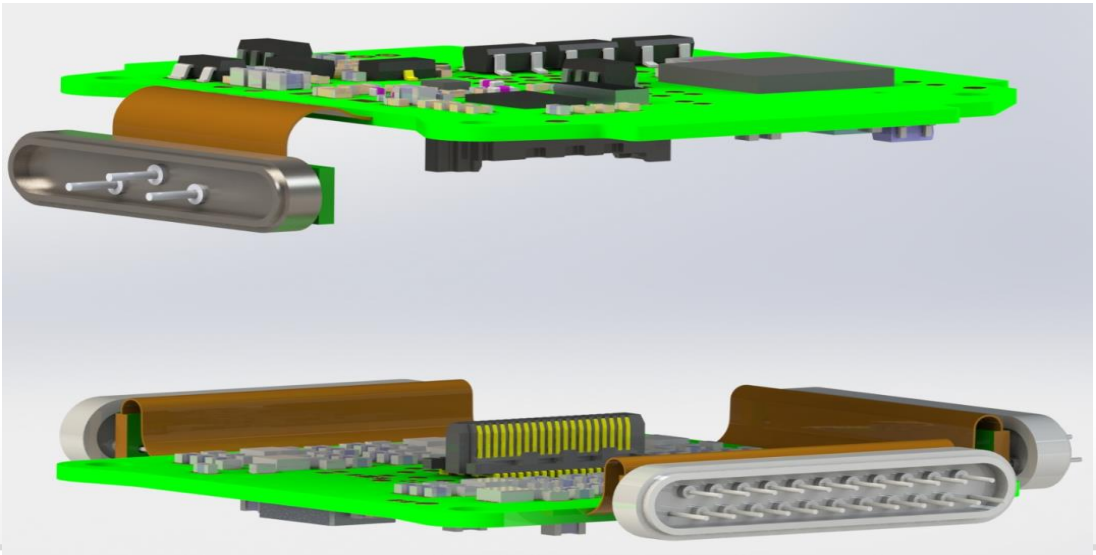
- Evaluating how to package the considerable amount of circuitry into the specified volume requirements
  - » What if any Advanced Packaging Techniques are required
  - » Implications of PCB design
  - » RF and Charging circuitry design
  - » Reliability
  - » Cost Factors

Previous Approaches for Neuromodulators

Cortical implant - 3D simulation







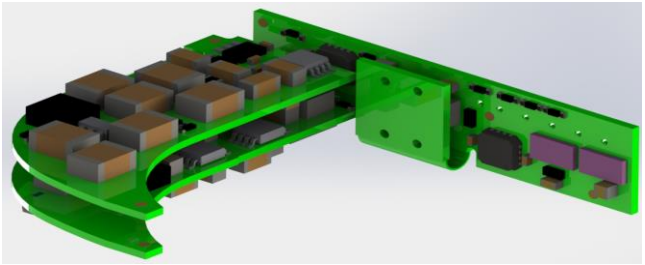
Previous Approaches for Neuromodulators

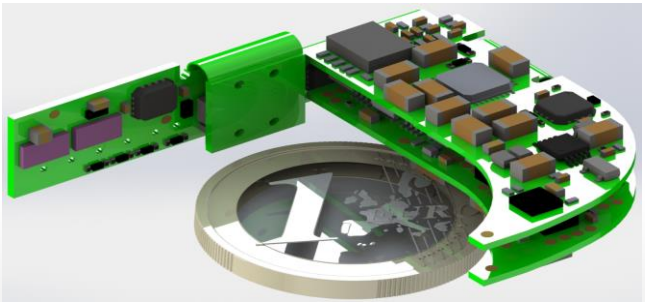
Cortical implant - Technical Features:

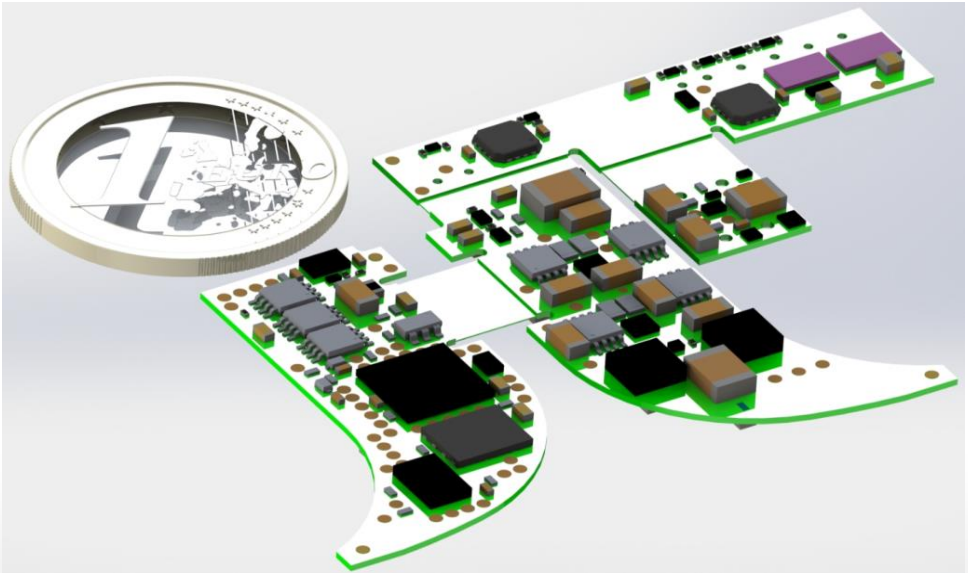
- PCB Features
  - » Type – HDI, Rigid-Flex
  - » Layers – 8 Rigid/2 Flex
  - » Via's – blind/buried/blind
  - » Line spacing 0.1mm/0.1mm
- Assembly Features
  - » Component size SMD 0201
  - » Core assembly technology SMD/Chip on board
  - » Two dies, 102 gold wires, pad size .2x0.15 on PCB, pitch for die 0.15mm

Previous Approaches for Neuromodulators

Anti-epilepsy stimulation implant - 3D simulation







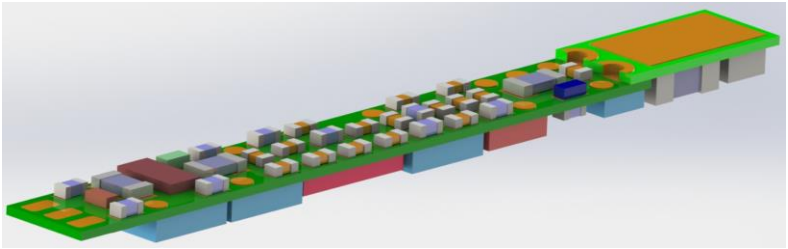
Previous Approaches for Neuromodulators

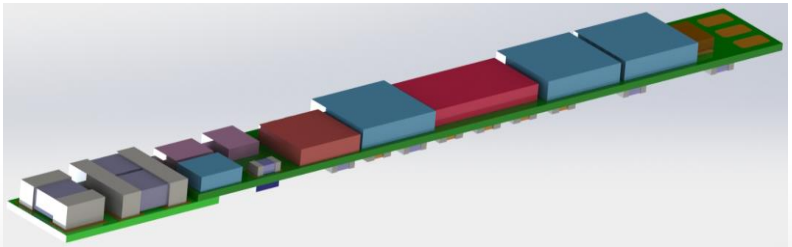
Anti-epilepsy stimulation implant - Technical Features:

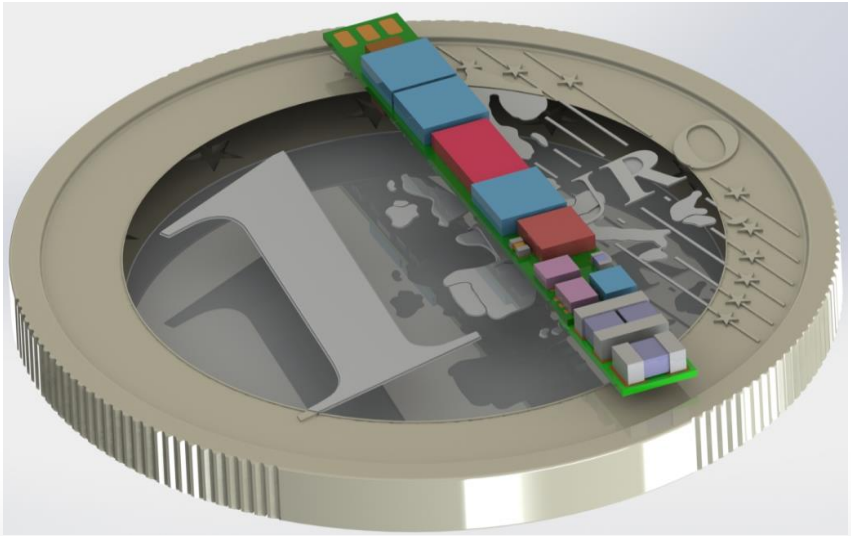
- PCB Features
  - » Type – HDI, Rigid-Flex
  - » Layers –8 Rigid/2 Flex
  - » Via's – blind/buried/blind
  - » Line spacing 0.1mm/0.1mm
- Assembly features
  - » Component size SMD 0201
  - » Core assembly technology SMD

Previous Approaches for Neuromodulators

Intra-aortic stimulation implant - 3D simulation







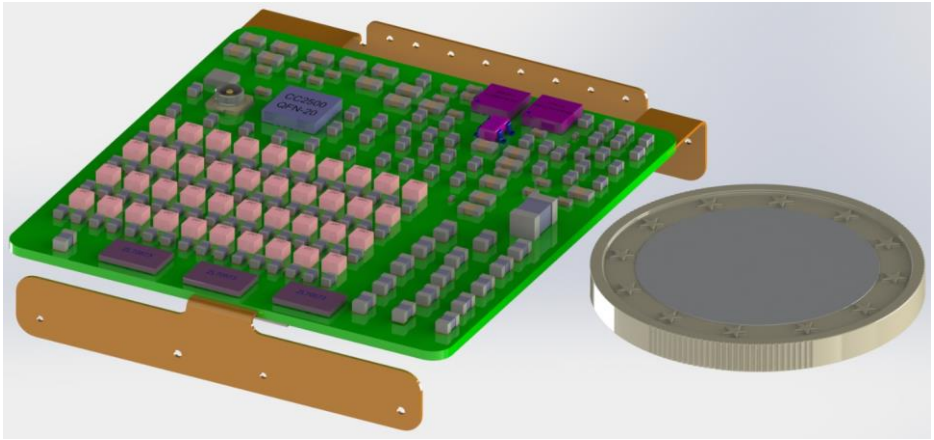
Previous Approaches for Neuromodulators

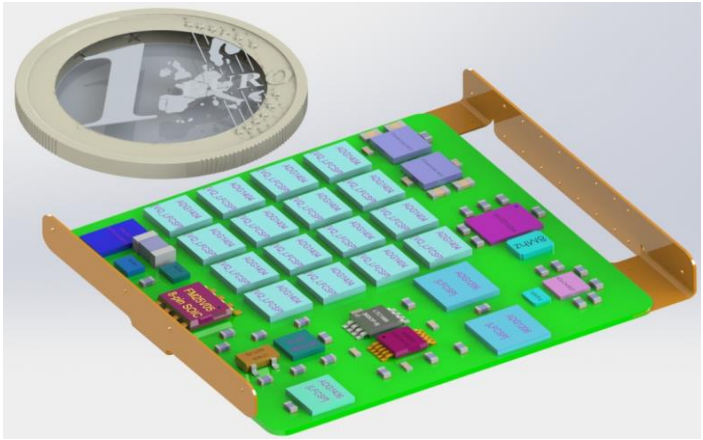
Intra-aortic stimulation implant - Technical Features:

- PCB Features
  - » Type – HDI, Flex (2.3mm x 16mm)
  - » Layers – 6
  - » Via's – blind/buried/blind
  - » Line spacing 0.075mm/0.075mm
- Assembly features
  - » Component size SMD 0201
  - » Core assembly technology SMD

Med-Ally LLC - Neuromodulators

3D Simulation*





** Ongoing project, shown is an intermediate output of the mechanical feasibility assessment*

Med-Ally LLC - neuromodulators

Technical Features:

- PCB Features
  - » Type – HDI, Rigid-Flex
  - » Layers – 8 rigid/2 flex
  - » Via's – blind/buried/blind
  - » Line spacing 0.1mm/0.1mm
- Assembly features
  - » Component Count approx. 300
  - » Component size SMD 0201
  - » Core assembly technology SMD/Chip on Board

Design Considerations

- Product Features
  - » Closed loop
  - » Interaction with other devices
  - » Microprocessor selection
- Final Package Requirement, dimensions, volume
- Telemetry, antenna scheme
- Charging Requirements
  - » Power budget critical to understand
  - » Batteries – drives physical size
  - » Coil design
  - » Charging Scheme and requirements

Design Considerations

- Type of Assembly Technology
  - » PCB Type, Rigid, Flex, Rigid-Flex
  - » SMD
  - » COB/CSP/FC
- Product Cost/Process Flow/Raw Material Cost
- Manufacturing Process Complexity
- Supply Chain complexity

Conclusions

- Select appropriate technology for purpose
  - » Is bare die technology a necessity ?
  - » If yes, use well proven techniques, not necessarily the latest cutting edge techniques
  - » PCB design is extremely important
  - » Clever PCB layout is usually a given as size requirements demand it

Contributions

- The author wishes to thank the following Companies for their contributions:
  - » Med-Ally, LLC – New York, USA
  - » Exceet Medtec Romania, Budapest, Romania
  - » Newronika SRL – Milan, Italy
  - » AEMtec – Berlin, Germany