Microsystems and Wireless Power Components

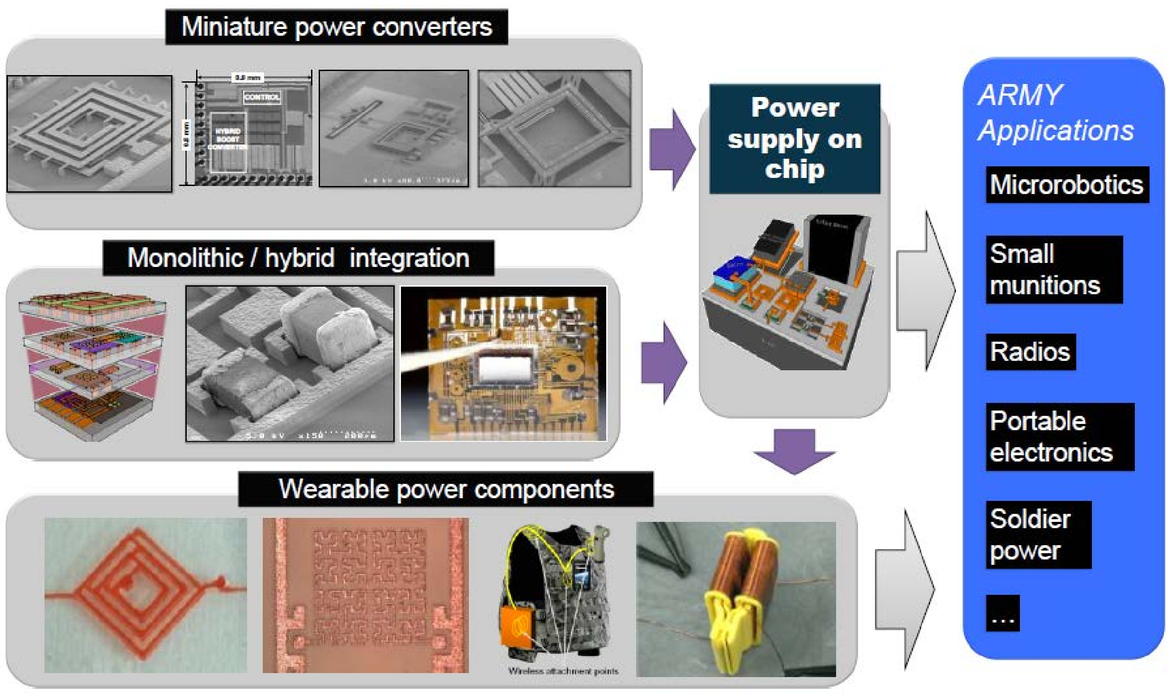
S&T Campaign: Materials Research
Electronics
Energy Efficient

Sarah Bedair, (301) 394-0021
sarah.s.bedair.civ@mail.mil
Nathan Lazarus, (301) 394-1421
nathan.lazarus2.civ@mail.mil

Iain Kierzewski, (301) 394-3516
iain.m.kierzewski.ctr@mail.mil

Research Objective

- **Develop components and topologies to tightly integrate power management at the individual points of load in handheld and smaller electronic devices**
- **Enable loosely coupled, wireless power distribution amongst multiple, freely moving devices**



Establishing innovative microfabrication and integration/assembly processes to create high performance integrated power components

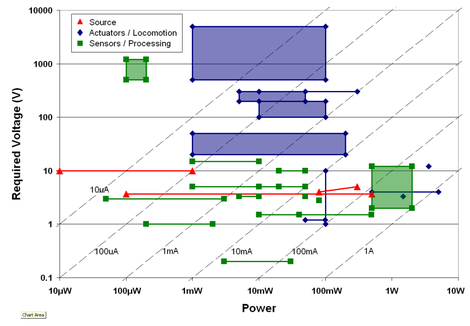
Challenges

Chip-scale Components for Power Management:

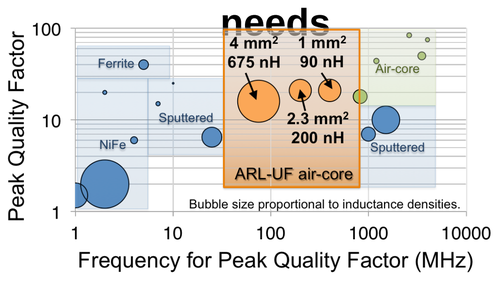
- **Parasitic capacitances and inductances comprise sizeable portion of switched impedance at very high frequencies**
- **Fabrication of power components with tight (<1 µm) tolerances requires precise characterization and control of equipment**

Wireless Power for Power Distribution:

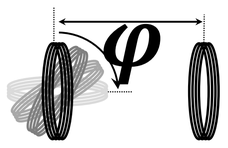
- **Varying coupling coefficient between transmitter and receiver pair requires adaptable impedance matching to maintain high efficiency and levels of power transfer**

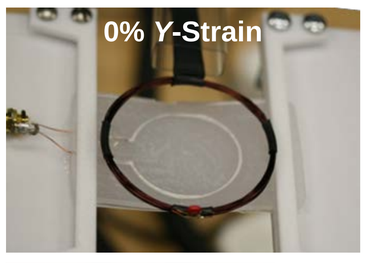


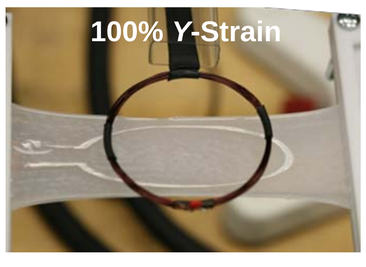
Survey of microsystem power needs



Microinductor performance state-of-art



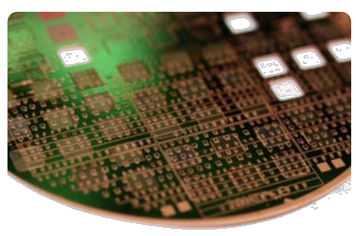




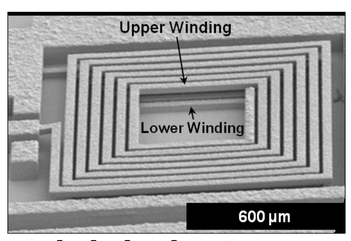
Wireless power in dynamic systems

ARL Facilities and Capabilities Available to Support Collaborative Research

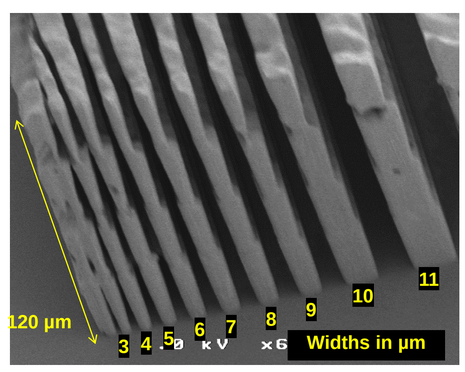
- **3D multilayer metallization process with thick films (up to 30 µm) and high aspect ratios (up to 10:1) in copper**
- **Thin film sol-gel PZT & multi-layer metal integrated process for novel MEMS devices**
- **Thin-film electroplating processes and characterization**
- **Broad spectrum (5 Hz – 3 GHz) network analysis of wireless power topologies and high frequency, integrated passive power components**
- **Liquid metal, stretchable, conductive traces and inductors in embedded in multilayer silicone elastomer channels**
- **High accuracy pick-and-place tools for heterogeneous electronic integration**
- **N Lazarus, et al., "Multilayer liquid metal stretchable inductors," Smart Materials and Structures, 2014**
- **SS Bedair, et al., "High-performance micromachined inductors tunable by lead zirconate titanate actuators," IEEE Electron Device Letters, 2012**
- **CD Meyer, et al., "High-Inductance-Density, Air-Core Power Inductors and Transformers Designed for Operation at 100-500 MHz," IEEE Trans. Magn., 2010**



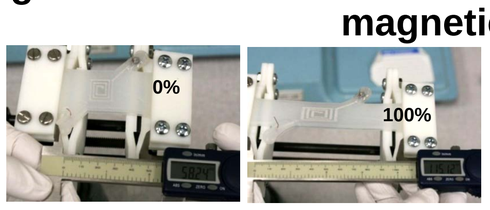
Wafer level MEMS integration



High inductance density air core magnetics



High-aspect-ratio multilayer metal power electronics



Liquid metal stretchable

Complementary Expertise/ Facilities/ Capabilities Sought in Collaboration

- **Synthesis, processing, and characterization of high frequency (>100 MHz) magnetic materials with high quality factor (μ_r vs μ_i) as well as high-k dielectric materials with high Q for power components**
- **Expertise in CMOS power circuit architectures, controls electronics, and MEMS interface electronics**
- **MEMS packaging / processing for 3D electronics**
- **Chip-scale energy harvesters with high power densities**
- **Electromagnetic meta-material development for enhanced wireless power transfer**