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Sandia National Laboratories

Development of an Advanced Ceramic Seal for Maintaining Continuity of Knowledge in Treaty Verification and Safeguards Applications

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SAND

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- Savannah River National Laboratory (SRNL)
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Outline

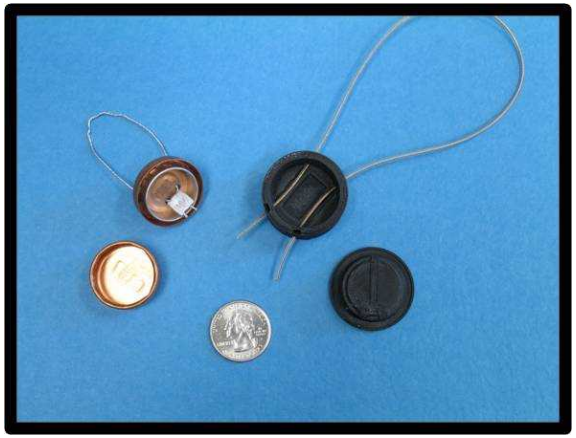
- Introduction
- Advanced security
- Improved efficiency
- Next steps

Seals and lifecycle

- Seals provide Continuity of Knowledge (CoK) in treaty verification regimes
- Require continuous improvement as:
  - Adversary advances
  - Requirements change
  - Technology advances, providing new options
- Ceramic Seal improves
  - Security features
    - Tamper indication
    - Unique identification
  - Efficiency
    - In-situ verification
    - Self-securing wire

Goals and objectives

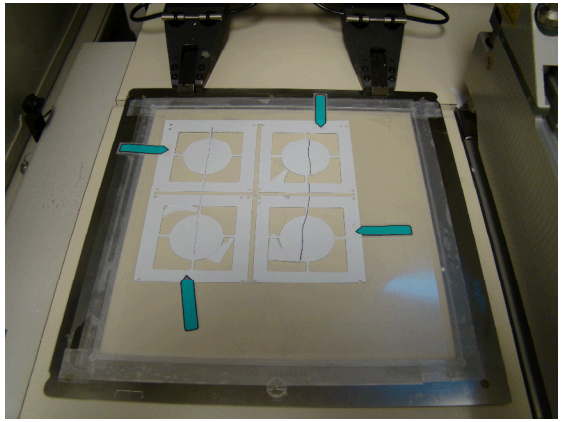
- Integrate multiple advanced technologies into prototype next generation loop seal
- Advance seal capabilities
  - Improve efficiency
    - In-situ verification
    - Self-securing wire
  - Create multiple levels of tamper indication
    - Frangible seal body
    - Surface coatings
    - Active detection of state
  - Create unique identification
    - Electronic ID
    - Non-reproducible surface features
- Innovation of Ceramic Seal is advanced capabilities in small volume



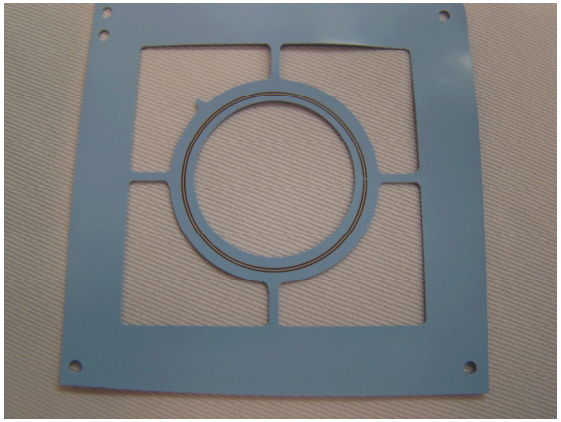
Picture courtesy SNL

Advanced security: seal body

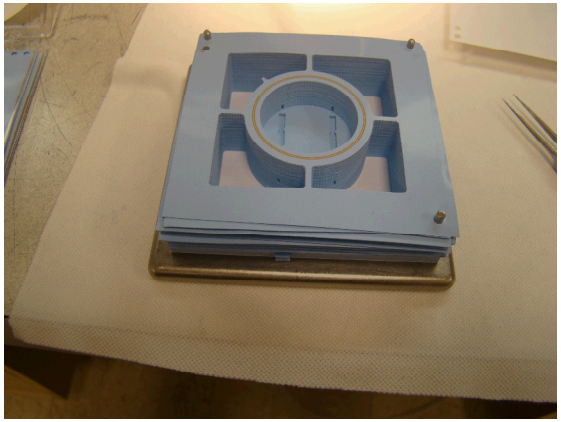
- Low-temperature co-fired ceramic (LTCC)
  - Meets frangibility requirements
  - Allows integration of electronic components/line traces



LTCC Green Tape™ punching process



Conductive trace screen printing



Green Tape™ stacking prior to lamination

Pictures courtesy SNL

Advanced security: tamper planes

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- Conductive line traces integrated into LTCC
- Tamper planes throughout body walls, cap, and base
  - Connected to electronics
  - If disrupted, seal performance affected

Advanced security: active tamper

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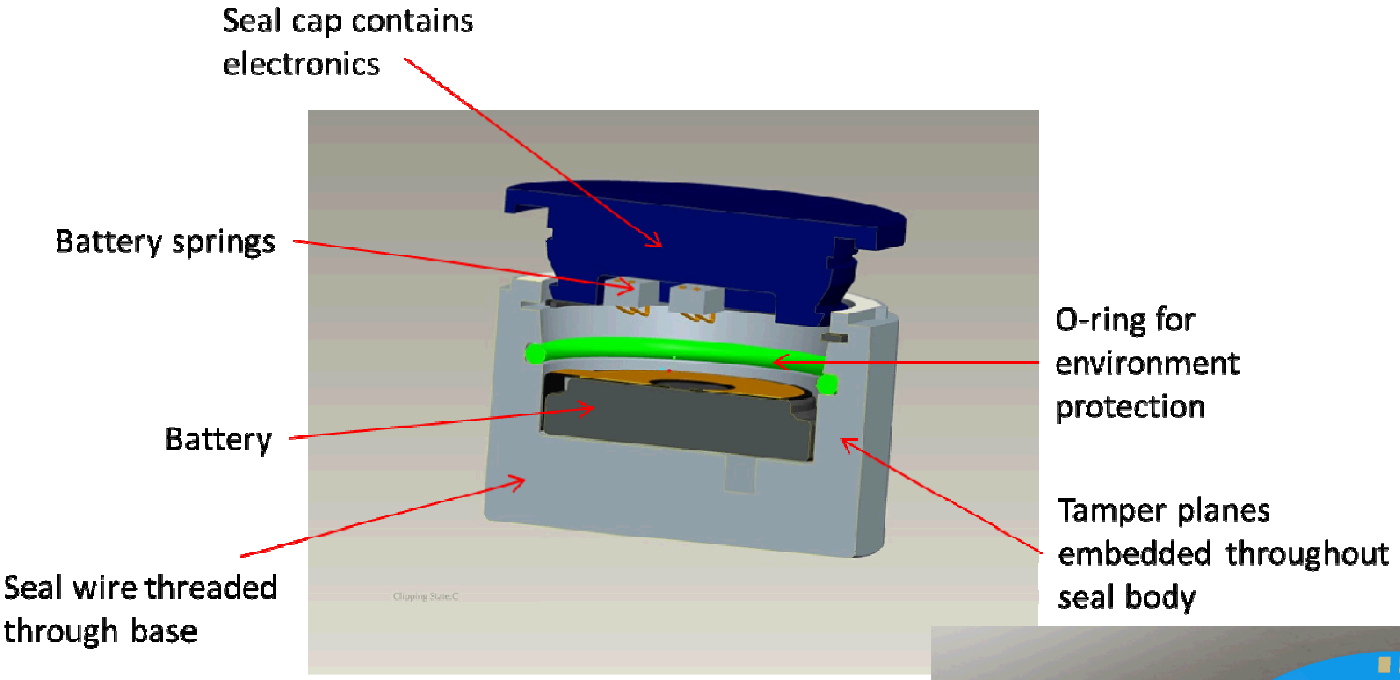
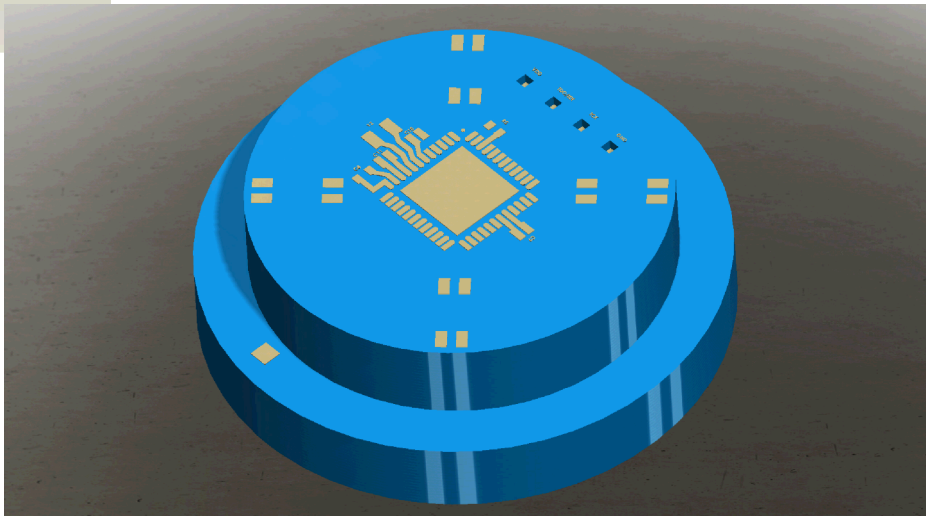
- Electronics recessed underneath seal cap
  - Attached to embedded line traces in LTCC
- Single microcontroller
- One-time personality programming in-situ
  - Loads secret keys onto seal, sets message creation interval and absolute time
- Messages
  - State-of-health, anomalous events, seal interrogation history
  - Stored in flash memory
  - Message authentication code (MAC) appended to messages using 128-bit CMAC algorithm with AES cipher
    - Based on secret key, 8 byte ID, non-repeating message count, clock

Advanced security: active tamper



Picture courtesy SRNL

Picture courtesy SNL



Advanced security: ID

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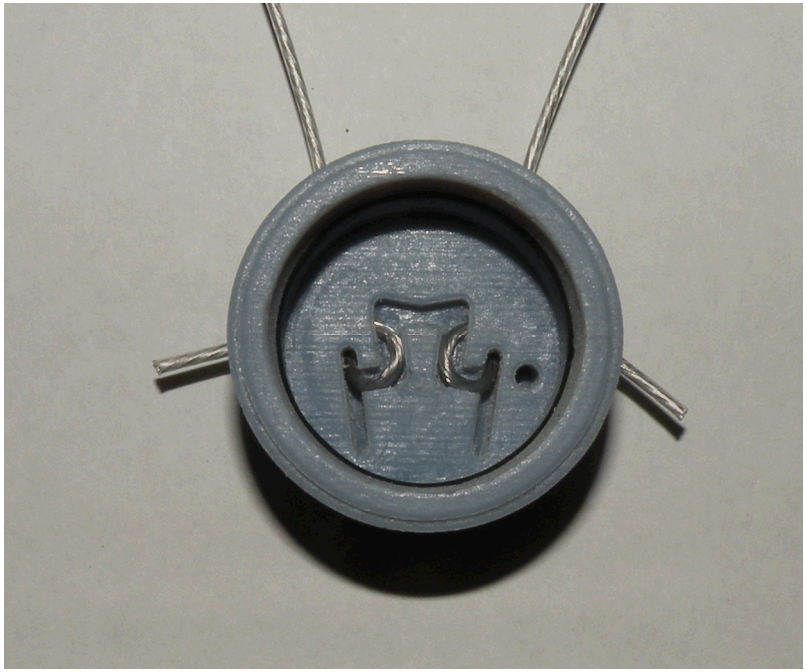
- 8 byte number
- Assigned when firmware programmed
- Ensuring unique ID number procedural
- Seal electronic uniqueness (authenticity) based on MAC

Improved efficiency: self-securing wire

- Wire follows tortuous path within seal body
- Design increases difficultly of removing wire
- Active research on wire
  - Commercial candidates identified

Picture courtesy SRNL



Improved efficiency: in-situ verification

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- Contact reader has same secret keys as seal
- Supports following authenticated commands over serial port:
  - Request latest sensor state-of-health
  - Request specific message number from seal
  - Request that seal send latest anomalous/tamper message
  - Request that seal send all anomalous/tamper messages
  - One-time personality programming
- Authenticates received messages
- Currently implemented as laptop

Next steps

- Complete software development
- Vulnerability review of electronics and software
- Fabrication of seal prototype with LTCC, tamper planes, electronics, battery, coatings
- Functional testing
- Comprehensive vulnerability review