



Office of Defense Nuclear Nonproliferation Research & Development

**Nuclear Weapons and Material Security
(WMS) Team Program Review
WMS2013**

**Intrinsically Tamper Indicating Ceramic Seal
(Ceramic Seal)**

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- **Participating Labs – Sandia National Laboratories (SNL) and Savannah River National Laboratory (SRNL)**
- **SNL PI: Juan Romero, SNL PM: Heidi Smartt**
- **Multi-disciplined team (SNL):**
 - **Software and Electronics**
 - **Maikael Thomas, Ross Hymel and Alfie Johnson**
 - **LTCC**
 - **Steve Dai and Billy Cunningham**
 - **VR team with material science, mechanical, software, and electronics expertise**

- **Goal is to develop prototype next generation seal as replacement for metal cup seal**
- **Objective is to advance seal security and improve efficiency**
 - **Improve ease of application w/ self-securing wire feature**
 - **Create multiple levels of tamper indication**
 - **Frangible seal body**
 - **Surface coatings – SRNL**
 - **Active detection of state including tamper planes**
 - **Create unique identification with an electronic ID**
- **Technical approach involves systems view and iteration with VR team for improved design**
- **Deliverable – at least 2 prototype seals available for field testing**



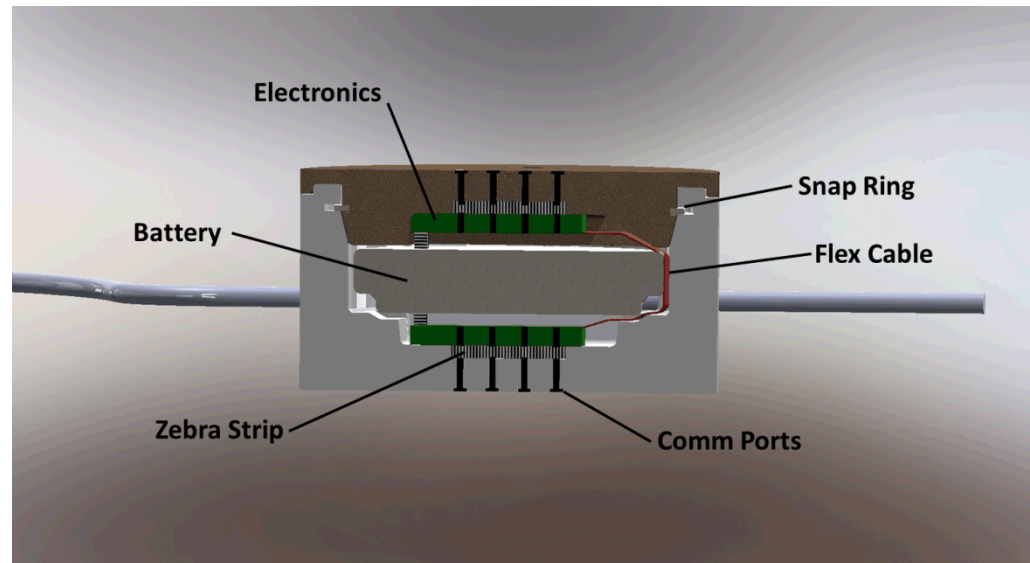
- **Seals ensure continuity of knowledge in treaty verification regimes**
- **Require continuous improvement as:**
 - **Adversary advances**
 - **Advances in technology not previously available can be implemented (security and efficiency)**
- **Ceramic Seal improves**
 - **Security features**
 - **Tamper indication**
 - **Unique identification**
 - **Efficiency**
 - **In-situ verification**
 - **Ease of application**
- **Innovation is advanced capabilities in small footprint**

Ceramic Seal Gen I

- Tamper indication via frangible seal body
- Electronic tamper (seal separation) bench top tested
- Unique ID incorporated electronically
- VR team tested individual components
- VR recommended change in wire-securing mechanism – caused application tool to be dropped



Picture courtesy SNL



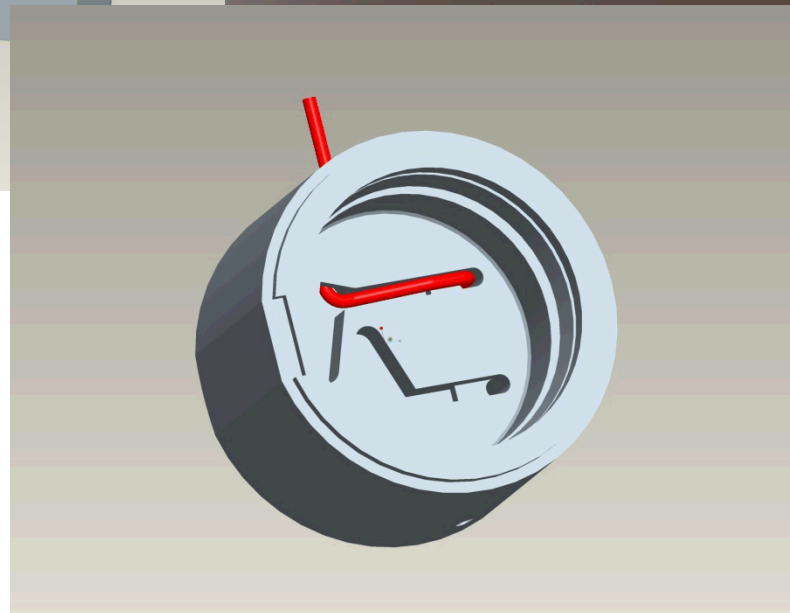
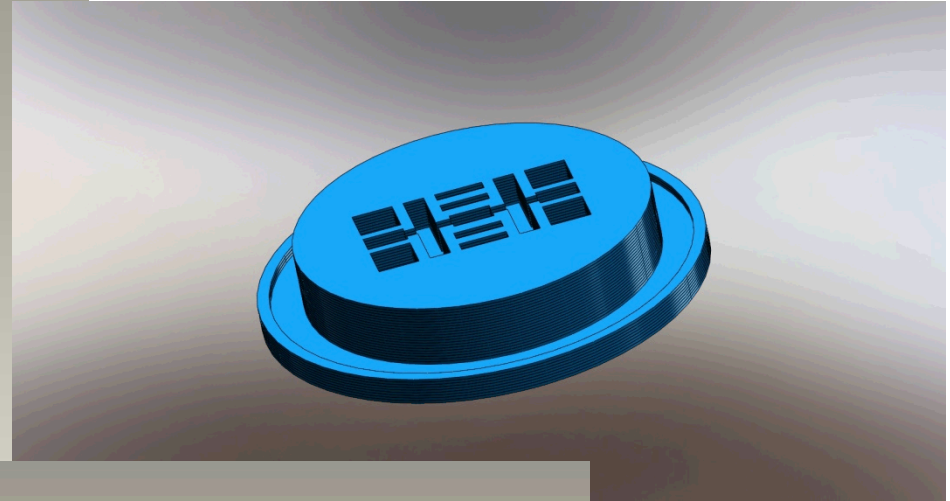
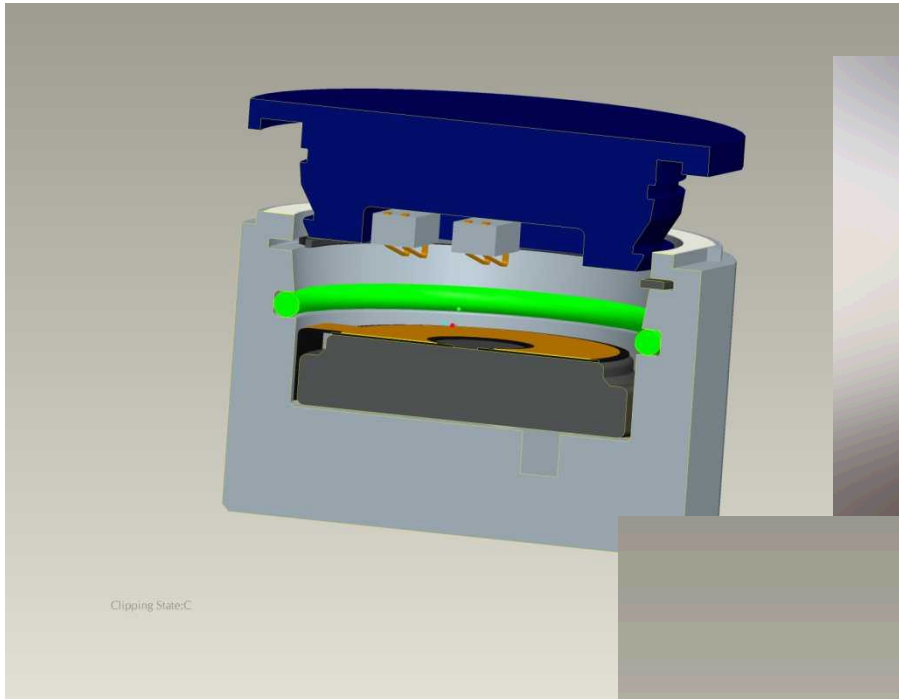
Picture courtesy SNL

- **Low-temperature co-fired ceramic (LTCC) fabrication**
 - Monolithic structure w/ embedded features
 - Completed prototype bodies
- **Conductive tamper planes embedded in body**
 - Completed prototype bodies
- **Electronics redesigned (single microcontroller), integrated into seal cap**
 - Secret keys destroyed upon disassembly of seal or interruption of tamper planes
 - Completed electronics redesign
 - Software in development
- **Fluorescent coatings**
 - Passive measures sensitive to surface modifications of seal body
 - In development at SRNL

- **Redesign of wire-routing/securing mechanism**
 - VR guidance
 - Indirectly affected application tool use
 - Operation change
 - Close seal by hand
 - Cut wire with standard tool
- **Research into wire types**



Ceramic Seal Gen II



Pictures courtesy SNL and
SRNL

- **Possible replacement for metal cup seal/EOSS (electronic seal)**
 - Replacement of both seals have been discussed in community
- **Applicable in situations requiring high-security, small form factor, in-situ readout loop seals**
 - IAEA Safeguards, Chain-of-Custody, HEU Transparency Program, Cargo Monitoring
- **Presented to ESARDA Containment and Surveillance Working Group, 2012**
- **Paper accepted for presentation at INMM 2013**
- **Paper accepted for presentation at ESARDA 2013**

Ceramic Seal Technical Challenges

- **Wire routing and securing mechanism**
- **Wire**
- **LTCC fabrication**
 - **High-aspect devices more difficult**
- **HTCC fabrication**
 - **Lack of manufacturers experienced with high-aspect devices**
- **Trade-space between small form factor and capabilities**

- **Complete software development**
- **VR on electronics and software**
- **Modifications to software and electronics based on VR review**
- **Fabricate and assemble LTCC prototype with tamper planes, electronics, battery, coatings**
- **Test**
- **Comprehensive VR on prototype**
- **Final modifications to prototype based on VR review**