



# **Topology in Image Analysis for Distinguishing Tampering from Environmental Degradation of Unique Tags**

## **Combinatorial Algebraic Topology**

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**We protect critical materials by placing them in sealed containers.**

**How do we verify that unattended seals have not been tampered with?**

**What if the host organization or facility is uncooperative?**

**What if industrial processes and hazards are present?**



# Nuclear Fuel Reprocessing Storage Containers & Shipping Cask



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# UF6 Cylinders & Transport



<http://www.westermancompanies.com/Products/UF6Cylinders.aspx>

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## Canister containing an attribute measurement system used in disarmament



Credit: Los  
Alamos National  
Laboratory

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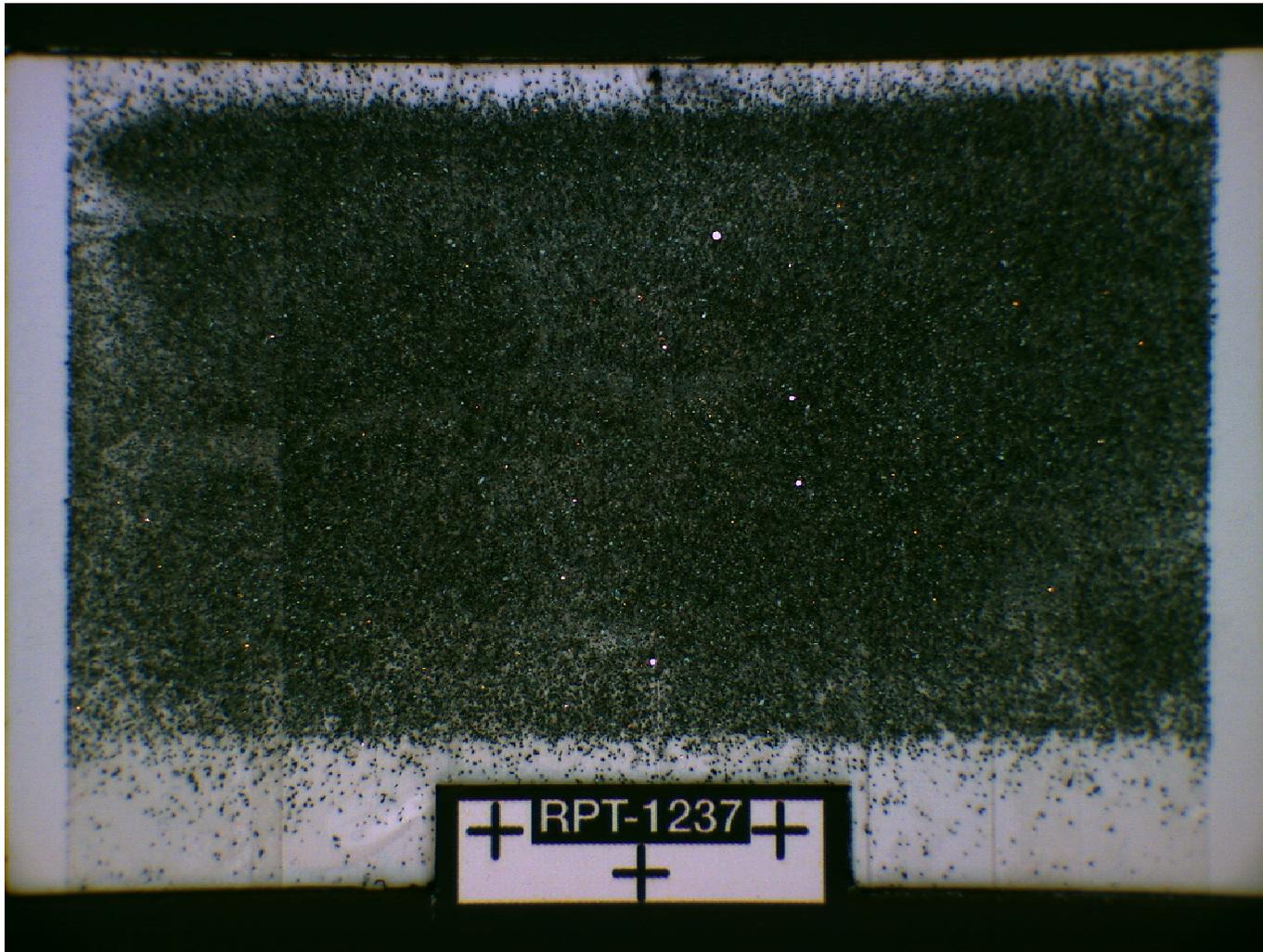
# Arms Control Information Barrier (Trusted Radiation Information System)



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# Reflective Particle Tag



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## Reflective Particle Tag Facts

- **Finely ground crystalline material in a tough resin**
- **Have a complex appearance that is critically dependent on illumination and observation parameters**
- **Unique, irreproducible, and unmovable**



Sample A  
Mid focus (no EDF)  
Single light source fiber bundle  
Better Geometry  
CFD Acquired 8-Aug-2009  
CFD Processed 8-Aug-2009

Credit: Carl Deigert, Sandia National Laboratories

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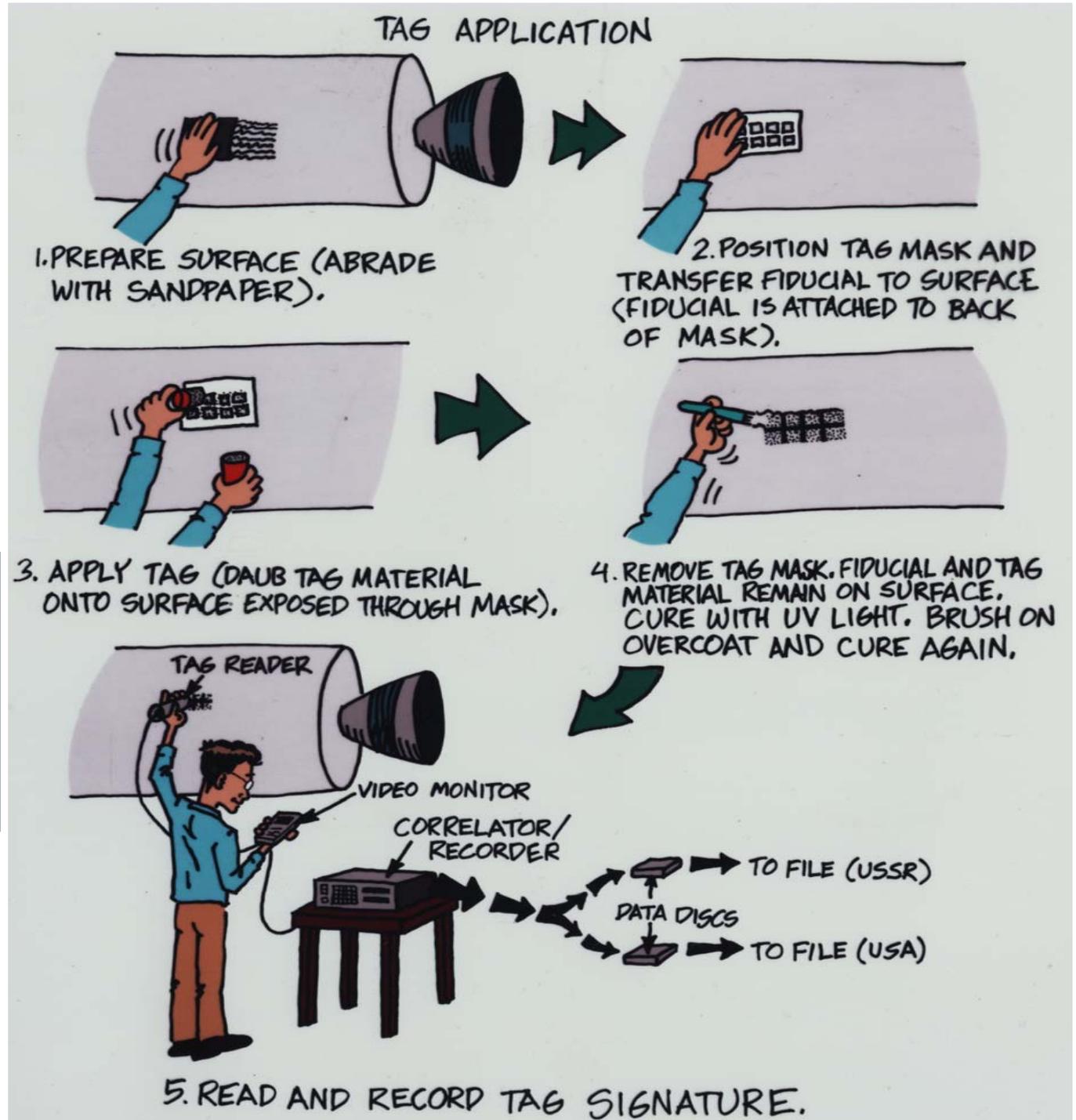


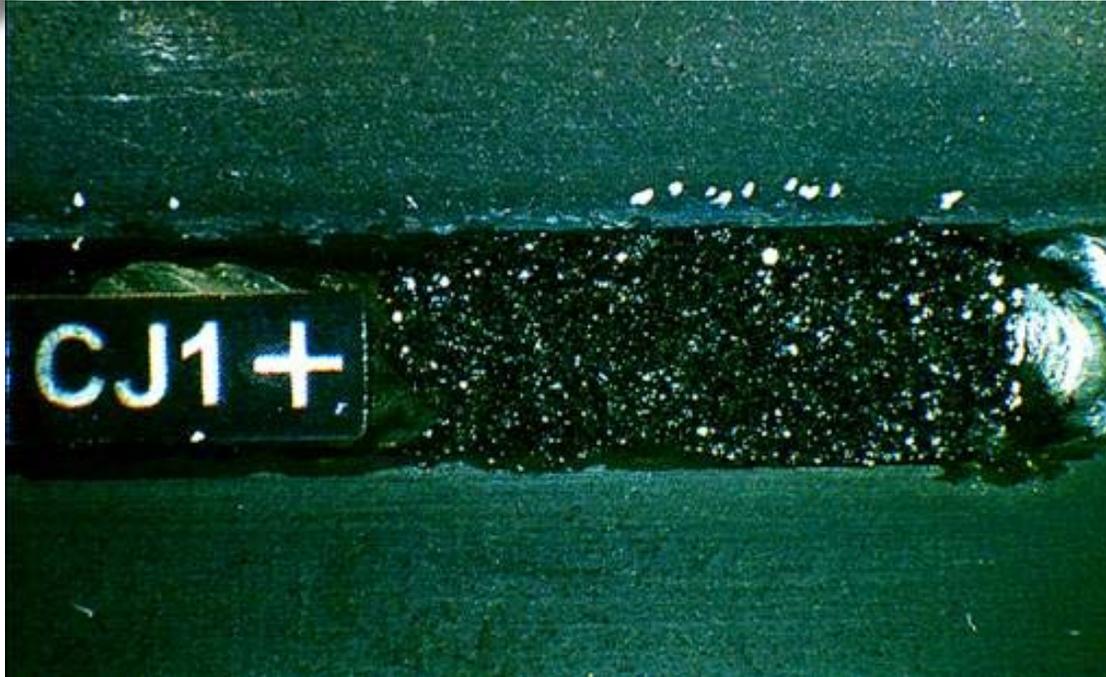
Apply RPT on:

- welds
- sealing points
- mounting points
- critical components in larger assemblies

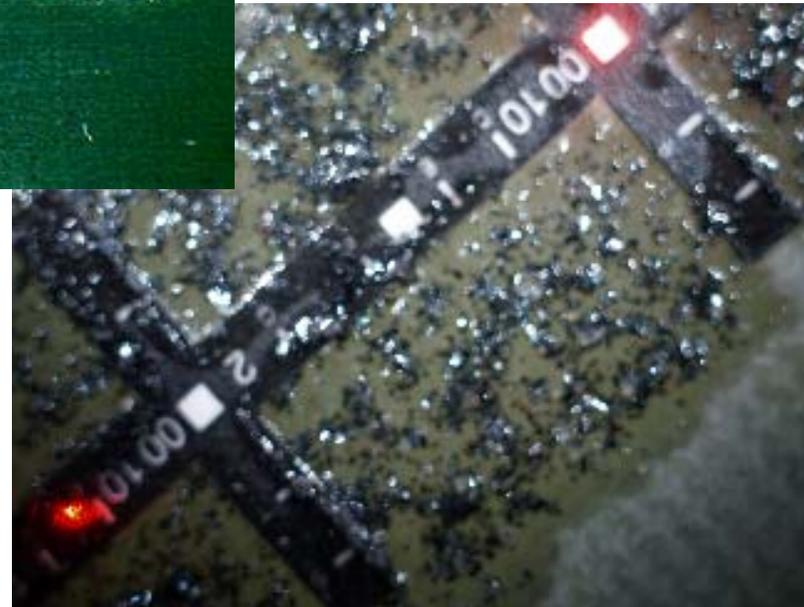


Credit:  
Keith Tolk,  
Sandia





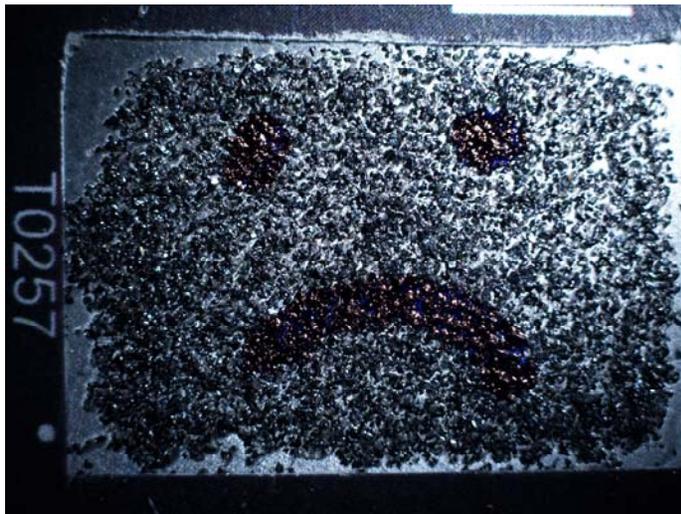
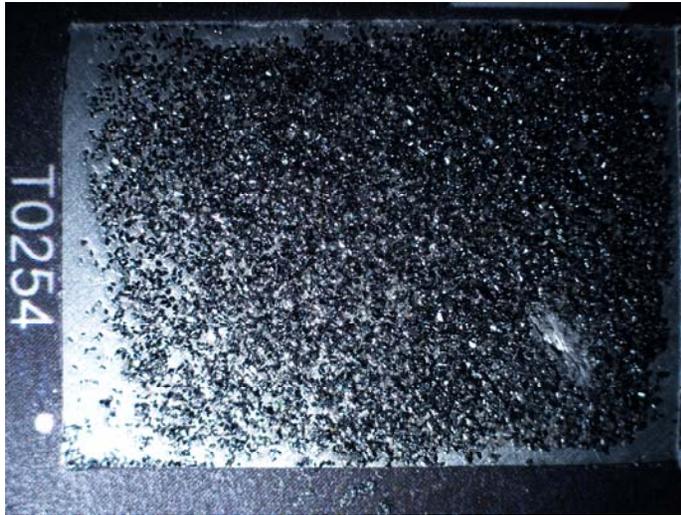
RPT on a weld



RPT on a circuit board



# Identity is Easy. What about Inadvertent Damage vs Malicious Tampering?



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## **Some Open Questions – Can Computational Algebraic Topology Help Out?**

- **What is the relationship between RPT match quality and confidence? What does it mean to say that a tag has integrity or has lost it? When is a tag “degraded”, “damaged”, “unreliable”, “tampered”?**
- **If we were to add micro-machined materials to the tags to complicate their imagery signature, what properties should they have?**