



Technologies to Products – on the Leading edge

Explosive Bonding Technology

Explosively-Clad, Refractory Barrel Liners for Small Caliber Machine Guns

Douglas Taylor, Ph.D.

Senior Scientist
TPL, Inc.

505-342-4428

dtaylor@tplinc.com

NDIA Small Arms Symposium

25 May 2011



Project Objective

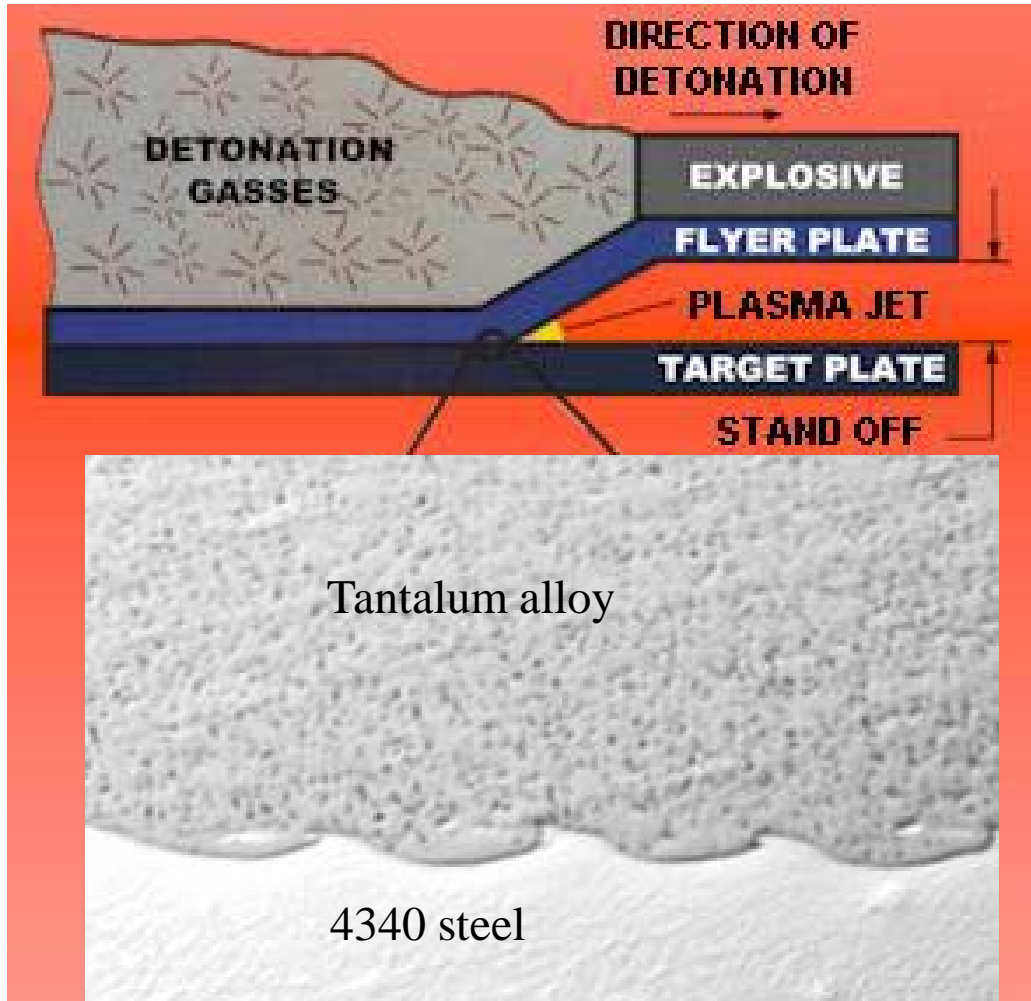
Replace monolithic steel barrels with bi-metallic barrels using explosive bonding

- Increase barrel performance
 - lifespan (number of rounds)
 - increase rates of fire and sustainability
 - increase muzzle energy/range
- Reduce soldier's load/decrease weight



Explosive Bonding

- A solid state joining process that creates a metallurgical bond between dis/similar metals
- High energy impact from a controlled detonation produces atomic-level bonding
- A cold-welding process (no heat affected zone) for similar and dissimilar metals that produces a strong bond and small interface



Variables:

- Explosive
 - Type
 - Amount
 - Arrangement
- Impact Velocity
- Impact Angle



Cladding vs. Coating

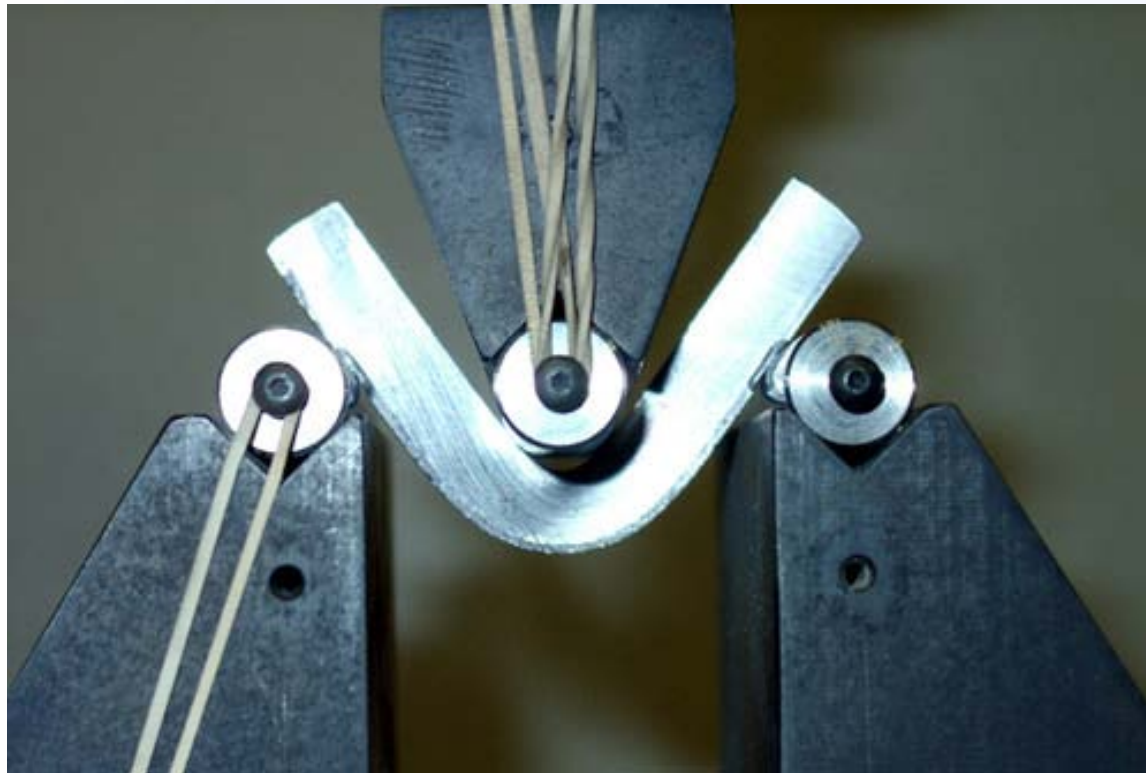
- Cladding bonds two solid metal parts together
- Coatings are deposited atomically from the liquid or vapor phase (including plasma)
- Solid clad layers do not flake, chip, peel or delaminate like most coatings in the harsh environment of a gun barrel



Technologies to Products – on the Leading edge

Explosive Bonding Technology

Interfacial Bond Strength: 3-pt Bend (Ta/steel)





Cladding vs. Coating

- Clad layers can be 0.010-0.120” thick
- CVD and PVD coatings are typically measured in microns
- Chrome coatings are 0.003-0.007” thick
- Clad layers prevent hot gas erosion and subsequent hydrogen embrittlement as well as insulating the barrel material



Clad Gun Barrels

- **A solid-state, bi-metallic tube**

Steel

- Hard
- Strong
- Tough

Tantalum/Stellite

- Refractory
- Tough
- Corrosion-resistant

Tailored barrel mat'l

- Steel: proven
- Inconel: high temp.
- Al, Ti: light weight, corrosion-resistant



Technologies to Products – on the Leading edge

Explosive Bonding Technology

TPL-Clad Gun Barrels



5" Navy Gun Breech



45mm test section



Firing Tests

- 25mm Bushmaster w/ XM919 (APFSDS-T) DU rounds (3692K flame temperature)
- Baseline (non-clad) barrel
 - Unserviceable after 229 rounds
 - Destroyed at 375 rounds
- TPL-clad barrel
 - Serviceable after 1385 rounds (no more ammo)
- TPL-clad and rifled barrel
 - Serviceable after 600 rounds (removed)
- 8800 accelerated rounds (~25k rounds) —still serviceable (2010)





Application to Small Arms

- Adapt Barrel Cladding technology to small caliber tubes (5.56mm, 7.62mm, .50 cal)
 - Tailored explosives to reduce critical diameter
- New possibilities with small size
 - Steel barrels will last longer
 - High temperature alloys are possible (*e.g.* Inconel)
 - Low density alloys (*e.g.* aluminum)
- Adapt machining technology, especially rifling



Technologies to Products – on the Leading edge

Explosive Bonding Technology

TPL-Clad Gun Barrels





Conclusions

- Refractory lined barrels have demonstrated large increases in longevity
- Explosive bonding is preferred to other methods to line gun barrels (solid metal liner)
- TPL has demonstrated the ability to clad small caliber barrels (Ta/steel M249)
- Potential to eliminate carrying extra MG barrels and changing them in combat
- Results to date indicate longer life, and possibly lighter weight small caliber barrels are possible