

LIGHTWEIGHT HIGH PERFORMANCE GUN BARRELS

ARMY SBIR CONTRACT W15QKN-04-C-1028
USMC SBIR CONTRACT NO: M67854-03-C-1011

M249 BARRELS

May 17, 2005

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PRESENTATION OUTLINE

- Statement of the Problem
- Fabrication Technologies Utilized
- Approaches/Solutions to the Problem
- Refractory Metal Composite Liners
- Ceramic Matrix Composite Liners
- Future Work

STATEMENT OF THE PROBLEM

- Standard gun steel and chromium plated gun steel barrels suffer from:
 - High weight
 - Excessive wear and erosion
 - Poor thermal management

- Micro-cracks and porosity in electrodeposited Cr allow hot propellant gases to reach and degrade the steel

- Executive order D013148 requires the usage reduction of hexavalent chrome by 50% by 31 December 2006.

- Approximately 80% of per year sustainment cost is due to barrel replacements.

APPROACHES/SOLUTIONS TO THE PROBLEM

- Fabricate two-component gun barrels, i.e., liner + overwrap, such that there is no abrupt interface between the two components

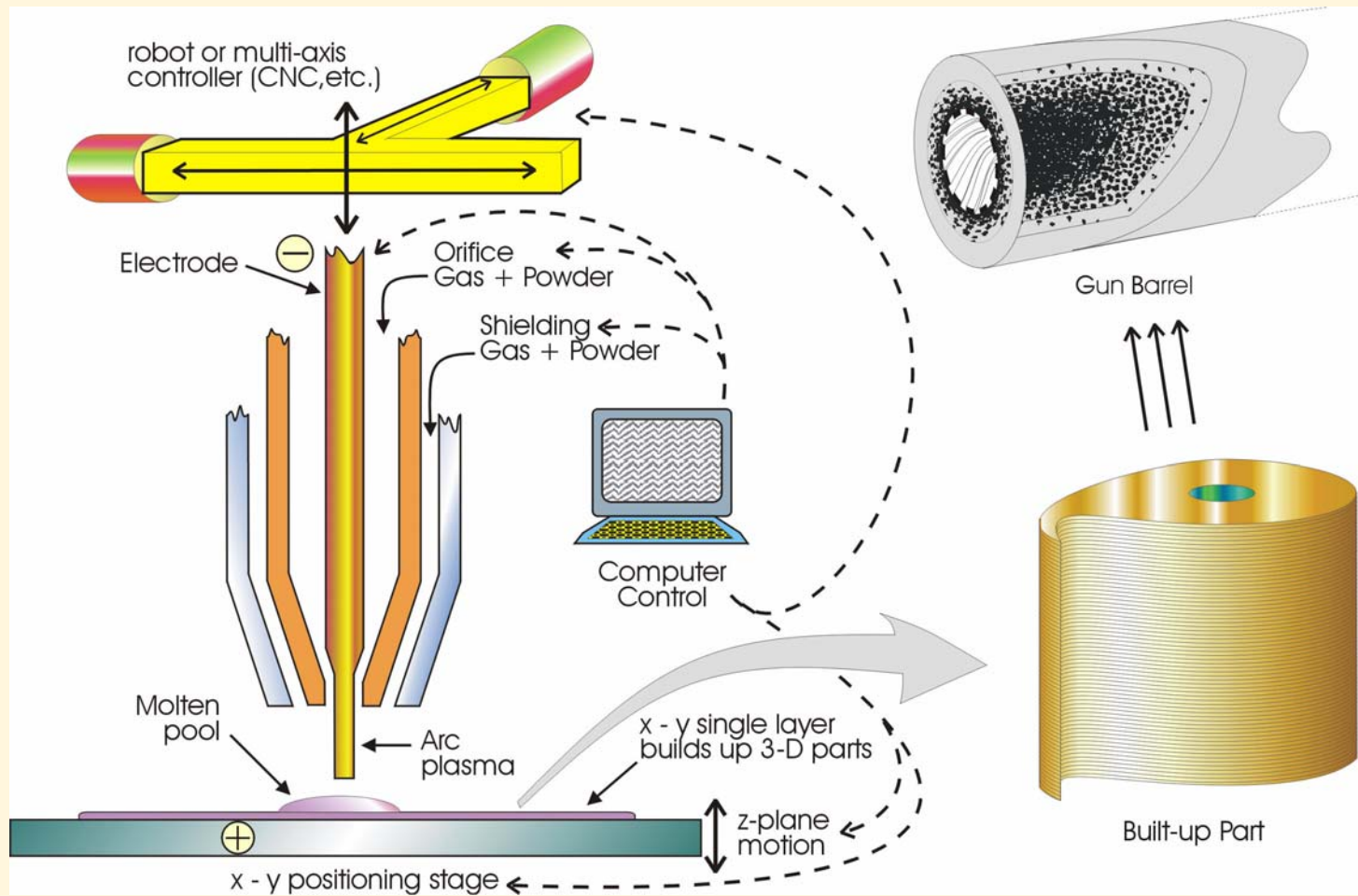
- Investigate bore liner materials that eliminate bore erosion and corrosion:
 - ❑ Ceramic matrix composites (CMCs)
 - ❑ Refractory metal composites (RMCs)

- Investigate light weight titanium or metal matrix composites (MMCs) for the overwrap material to reduce barrel weight and provide structural integrity

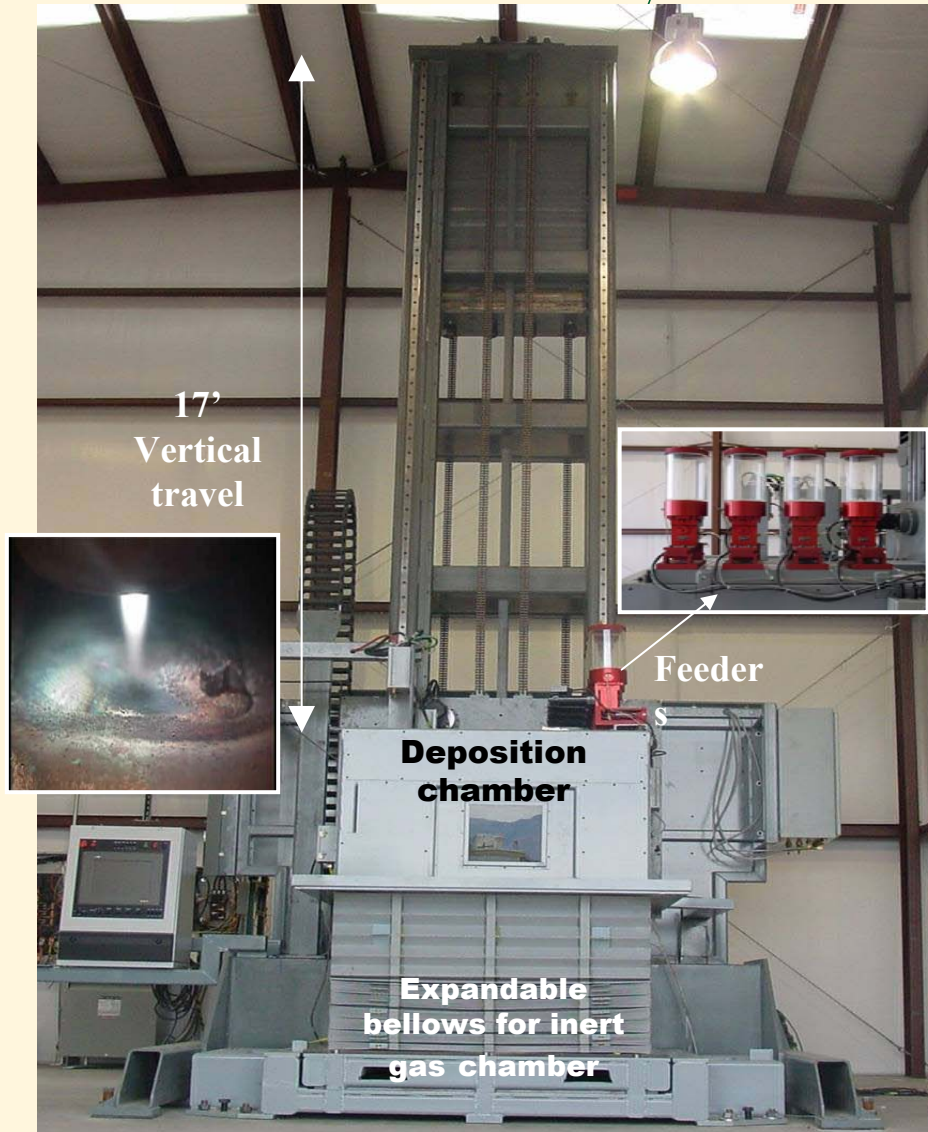
FABRICATION TECHNOLOGIES

- Ceramic Matrix Composite (CMC)
 - ❑ Liners with in situ rifling
- (EDM) Electrical Discharge Machining
 - ❑ Deep hole drilling
 - ❑ Chamber fabrication
- Electrochemical Machining (ECM)
 - ❑ Refractory metal liner rifling
 - ❑ Developing in-house process for Ta rifling
- Plasma Transfer Arc (PTA)
 - ❑ Barrel overwrap fabrication
- Metal Matrix Composites (MMC)
 - ❑ Nextel 610 alumina fiber with Al matrix
 - ❑ Barrel overwrap fabrication

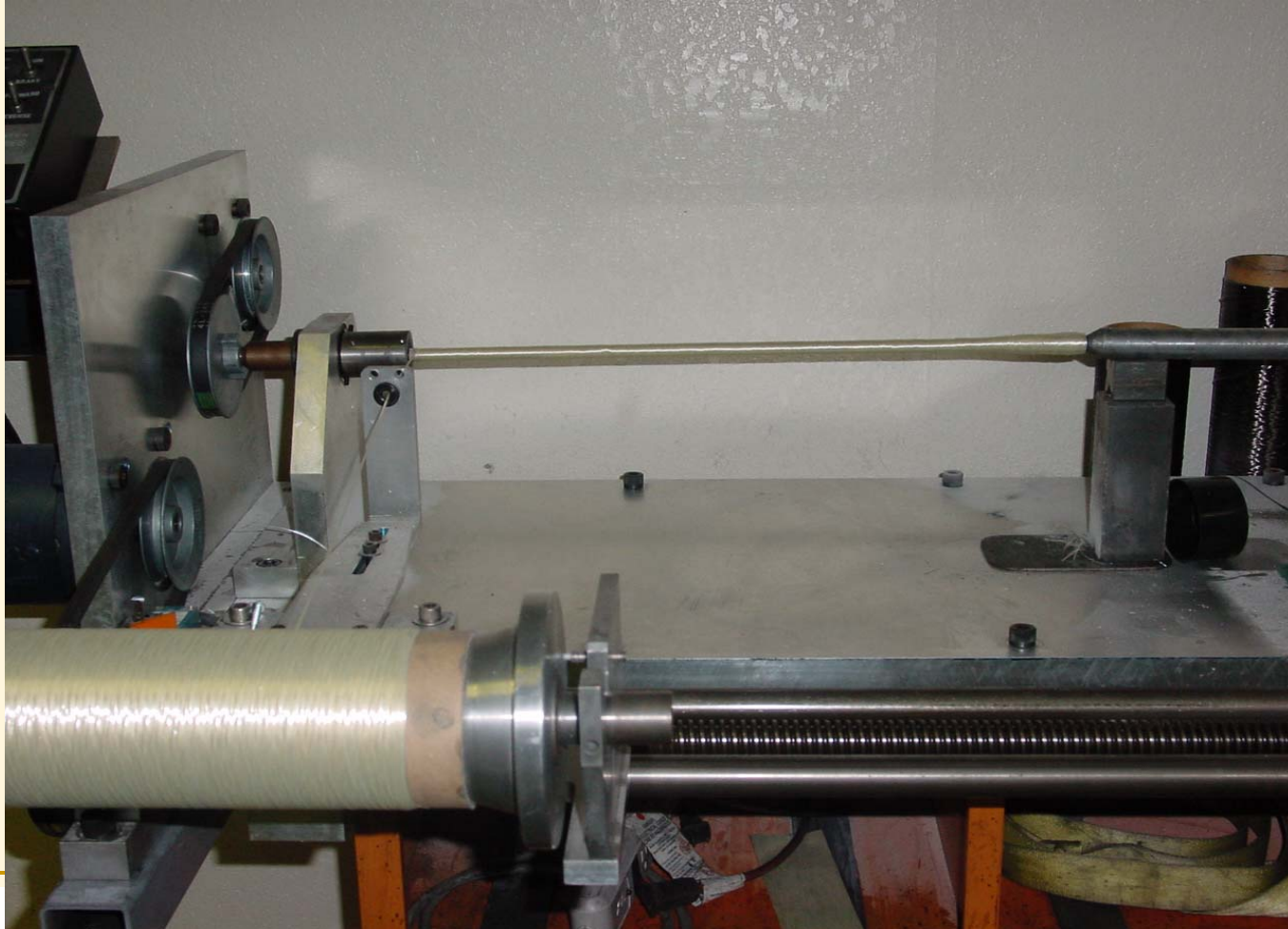
PTA SCHEMATIC



PTA SFFF System



FIBER WINDING CMC BARREL



REFRACTORY METAL COMPOSITE LINERS

- PTA Tantalum - Chromium Carbide (Ta-Cr₃C₂) Liner with PTA Ti Overwrap
 - ❑ ECM rifling was inconsistent
 - ❑ EDM rifling was unsuccessful
- Molybdenum-Rhenium (Mo-Re) Liner- Machined From Rod with MMC Overwrap
 - ❑ Drilled Mo-47.5%Re rods were used to prove material suitability
 - ❑ ECM rifling was successful
 - ❑ Barrel was live fire tested to about 600 rounds
 - 200 round at 5 round bursts; 200 rounds at 50 round bursts; and 200 round burst
 - ROF diminished gradually – gas port obstructed from hole misalignment
 - Surface temperature reached 601 °C

REFRACTORY METAL COMPOSITE LINERS

- Molybdenum-Rhenium (Mo-Re) Liner- Machined From Rod with PTA Ti Overwrap
 - ❑ Drilled rods are used to prove material suitability
 - ❑ Three compositions investigated: 47.5%, 22%, and 14% Re
 - ❑ EDM is used for deep hole drilling
 - ❑ ECM is used for rifling
 - ❑ Mo-47.5%Re is ready to be live fire tested



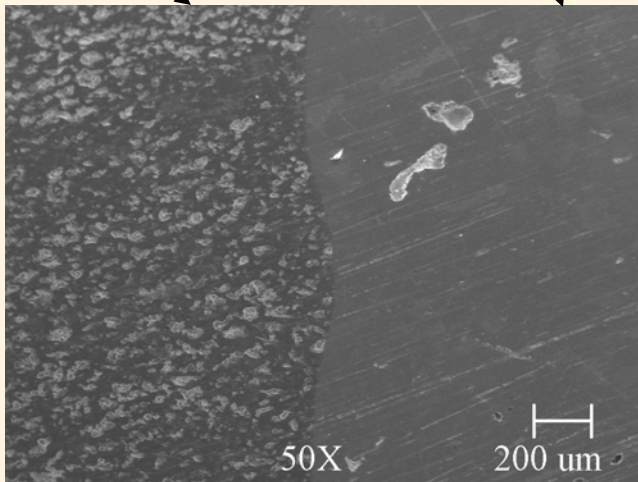
REFRACTORY METAL LINERS WITH PTA Ti OVERWRAP

As-produced



Ti

Mo-Re



After machining OD



CMC LINERS

- Prototype barrels with a CMC liner and Ti or MMC over wrap
 - Graphite mandrel is wrapped with Alumina fiber (Nextel 610)
 - Infiltrated with liquid ceramic (SiC) matrix
 - A CVD SiC interlayer is deposited to prevent metal infiltration to the bore during squeeze casting of MMC overwrap



CMC LINERS (cont'd)

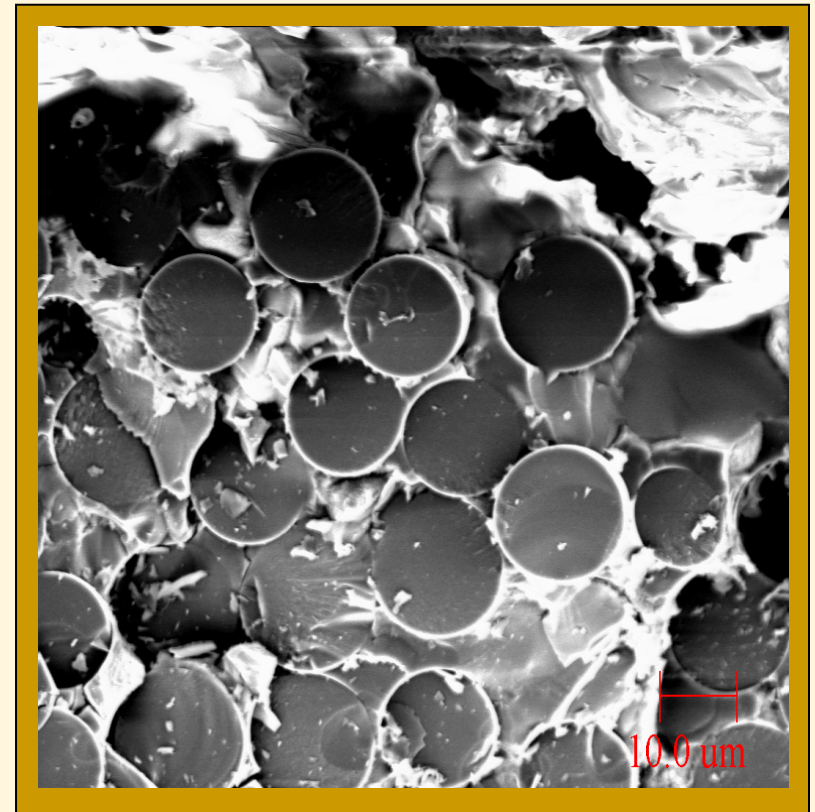
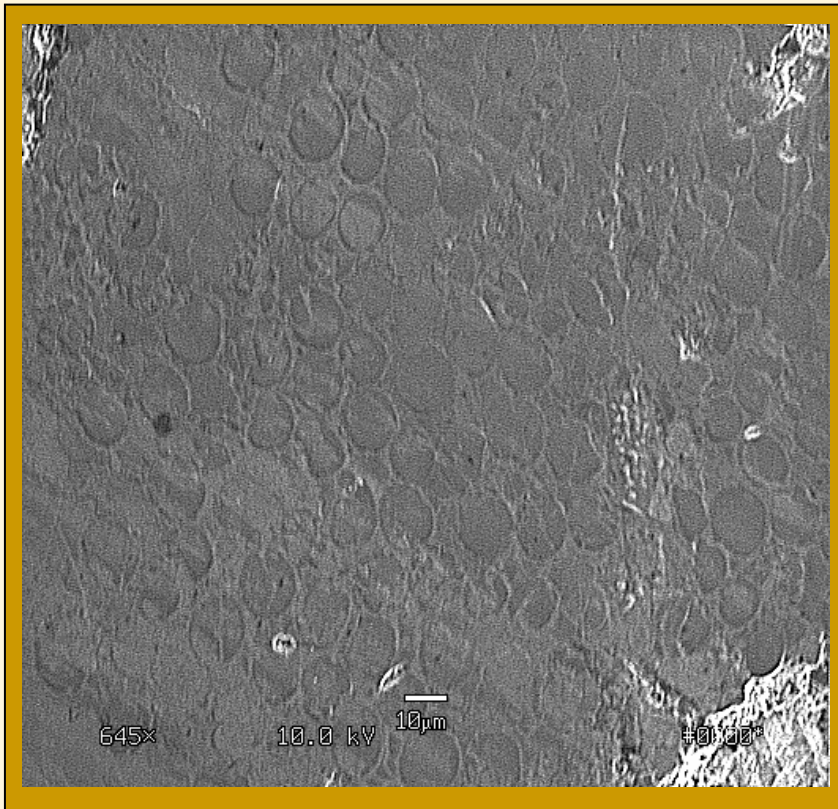
- Repeat infiltration to eliminate porosity. Continue fiber wrapping and infiltrating with ceramic precursor until desired liner thickness is achieved.



- Squeeze cast molten aluminum into fiber over wrap

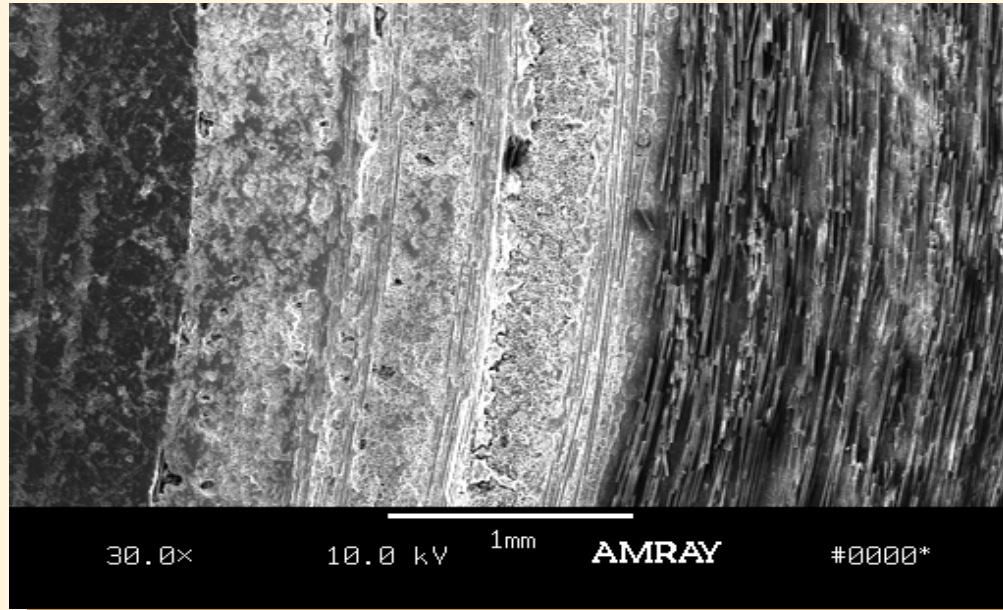


MICROSTRUCTURES OF CMC LINERS



BARREL CROSS SECTION

Graphite
Mandrel ← CMC → MMC →



CMC LINERS (CONTINUED)

- ❑ Graphite mandrel removal
 - Gun drill a small hole into the mandrel
 - Oxidize graphite with a cal rod
 - Sand blast to remove remaining graphite
- ❑ Barrel contains both rifling and chamber
- ❑ Barrel weighs 56% less than a steel barrel

FUTURE WORK

- ❑ Evaluate the Mo-Re barrels
- ❑ Complete the ECM rifling process for Ta-W
- ❑ Fabricate Ta-W barrels and evaluate
- ❑ Complete the CMC lined barrels and evaluate