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Application of Powder Tantalum Material for Explosively Formed Penetrator (EFP) Warhead

U.S. Army ARDEC

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Acknowledgment

Textron Systems Inc.

Aerojet Corporation

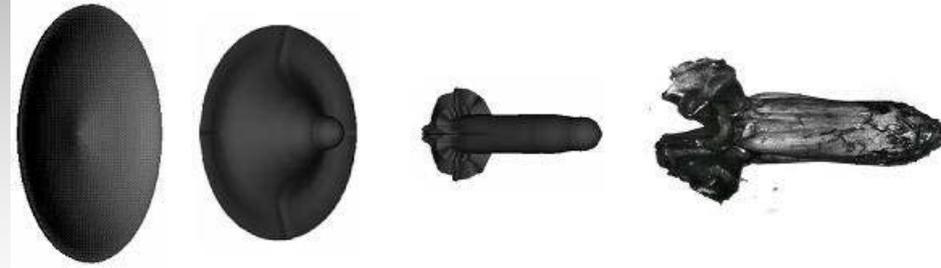


Outline

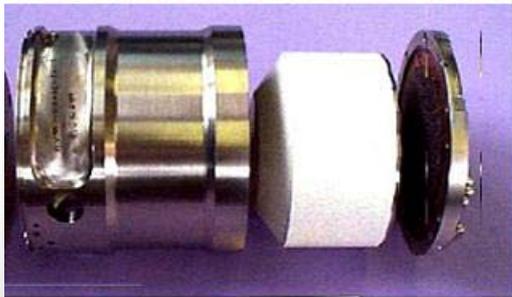
- Background
- Consolidation processes
 - Hot Isostatic Press
 - Extrusion
 - Resistance Sintered
- Near Net Process
- Material Evaluation
- Summary

Explosively Formed Penetrator (EFP) Warheads

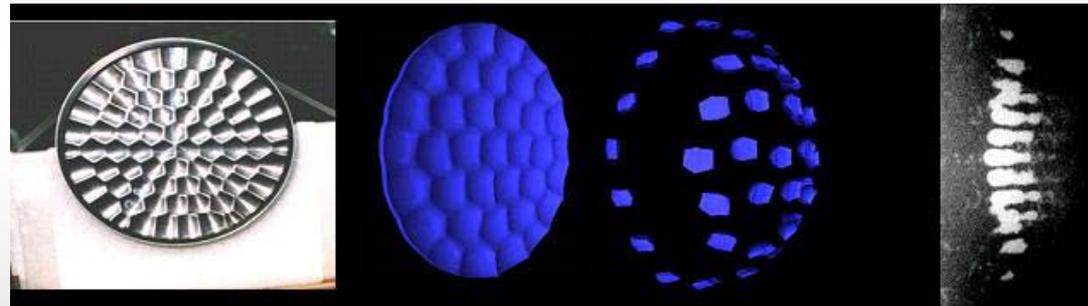
Single EFP



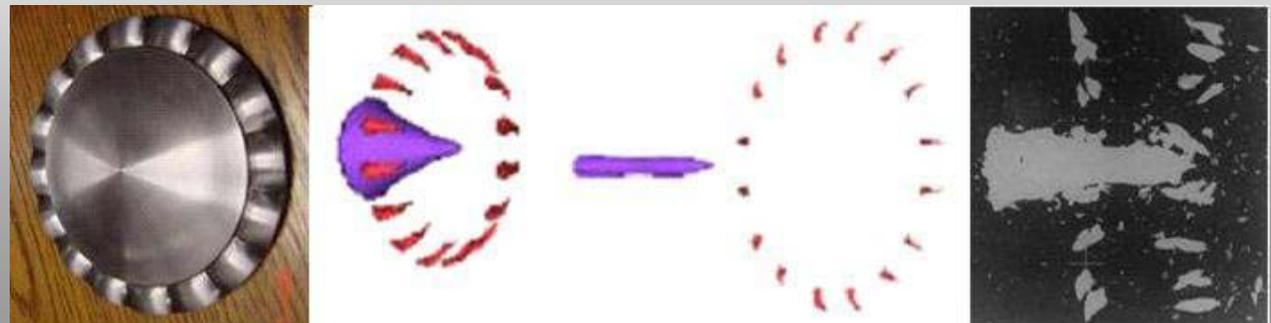
Warhead hardware



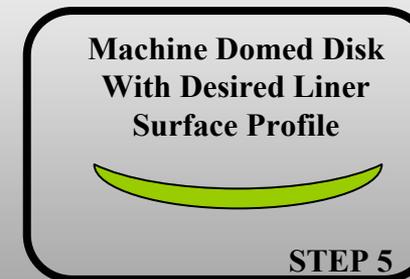
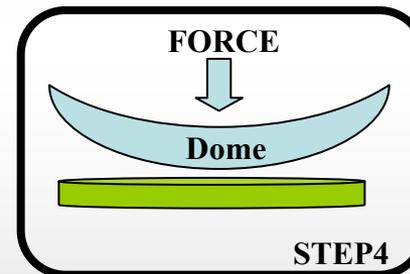
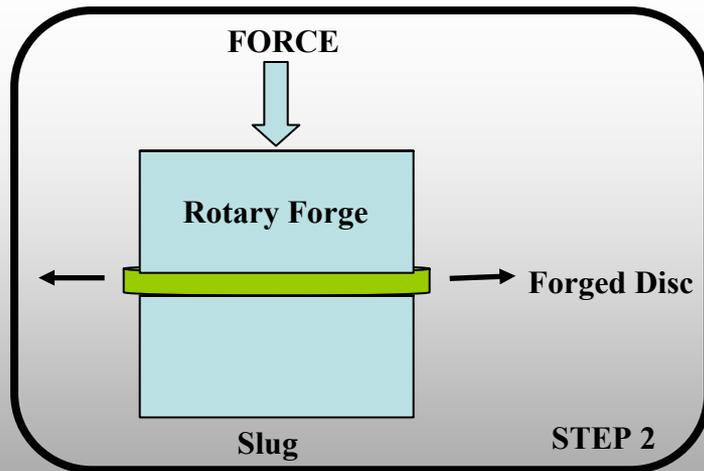
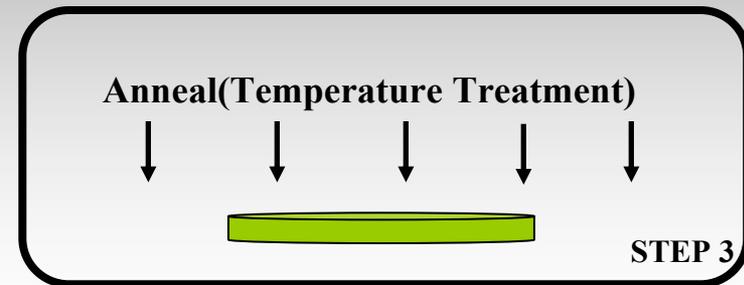
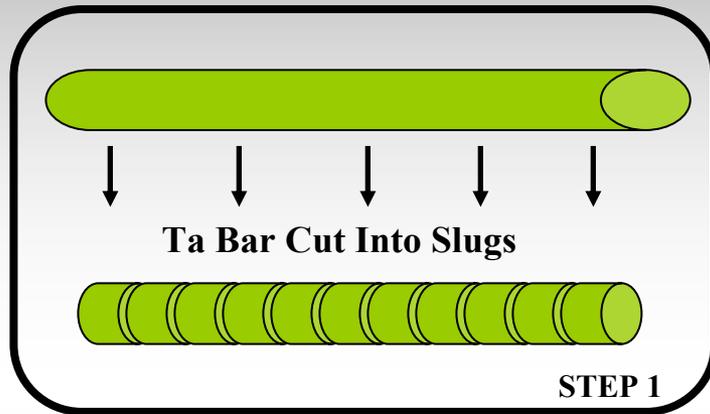
Multiple EFPs



Combined Effects EFP

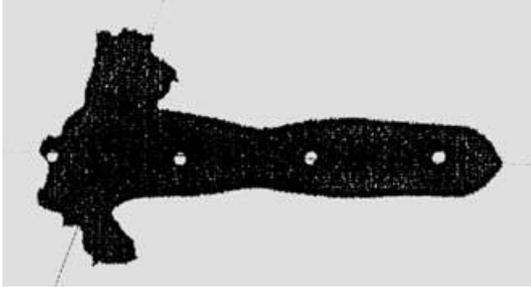


Conventional EFP Fabrication Process



EFP Formation Variation

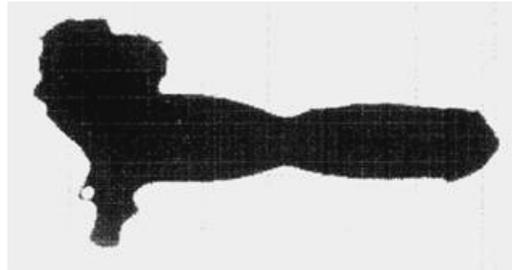
2nd Cut From Ta Bar



7th Cut From Ta Bar



9th Cut From Ta Bar





EFP Warhead Powder Tantalum Program



- Objectives: To develop
 - Powder process specification
 - Near net shape liner fabrication process
- Advantages of powder Tantalum approach
 - Availability
 - Consistency
 - Lower costs

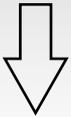


Powder Consolidation Processes

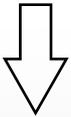
- Hot Isostatic Press
- Extrusion
- Resistance Sintered

HIP consolidation process

RAW POWDER



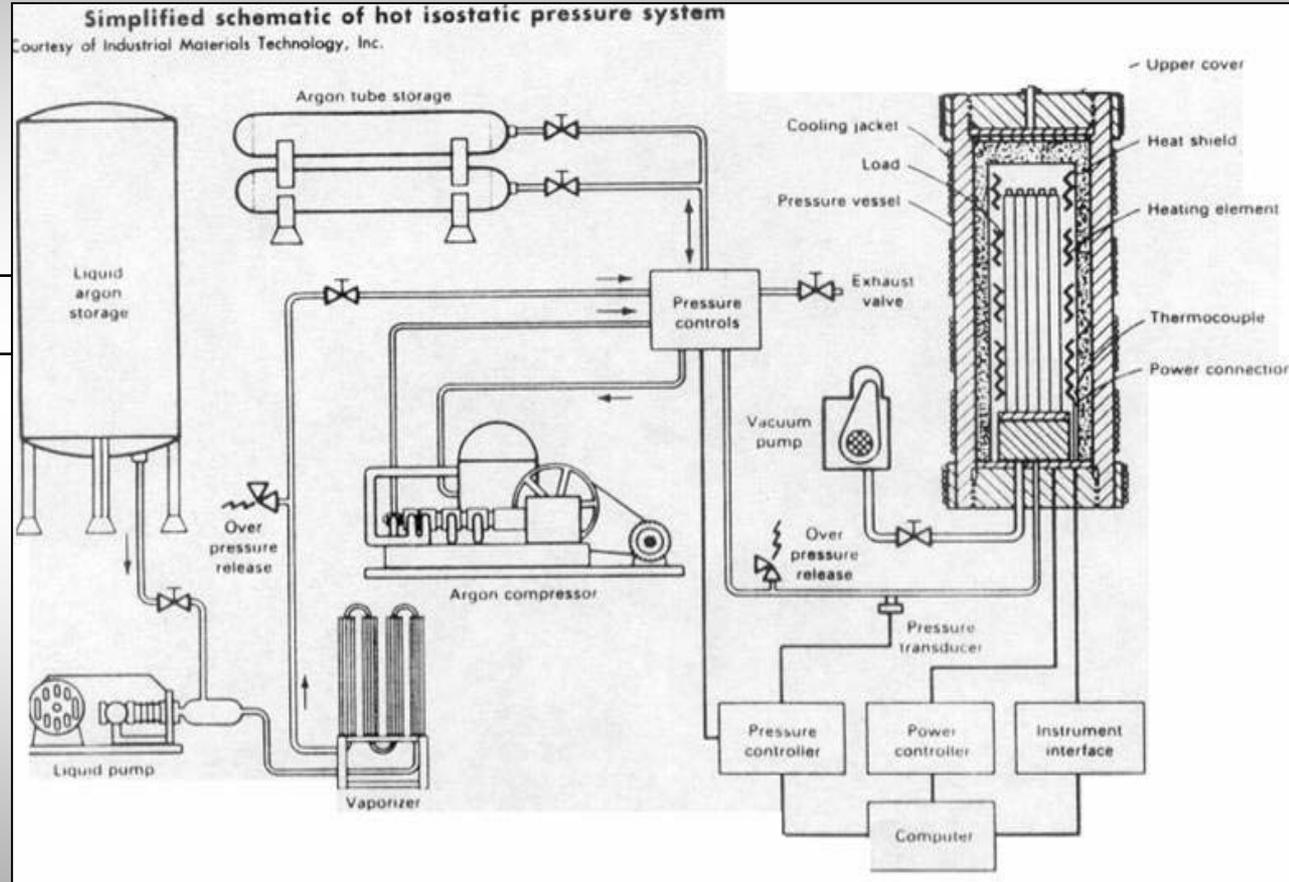
COLD ISOSTATIC PRESS



HOT ISOSTATIC PRESS



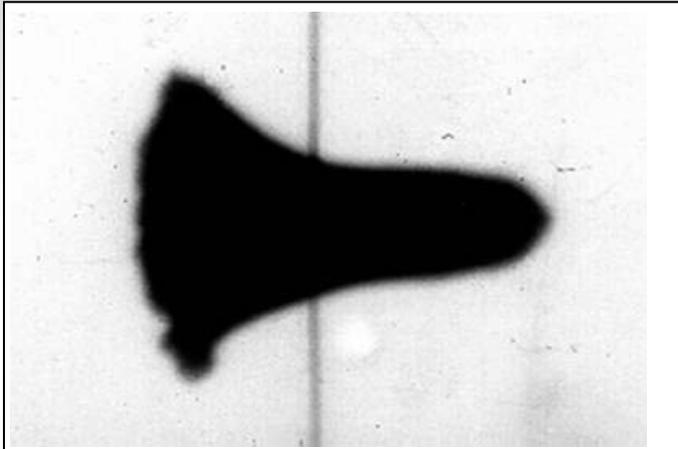
FINISHED BAR STOCK



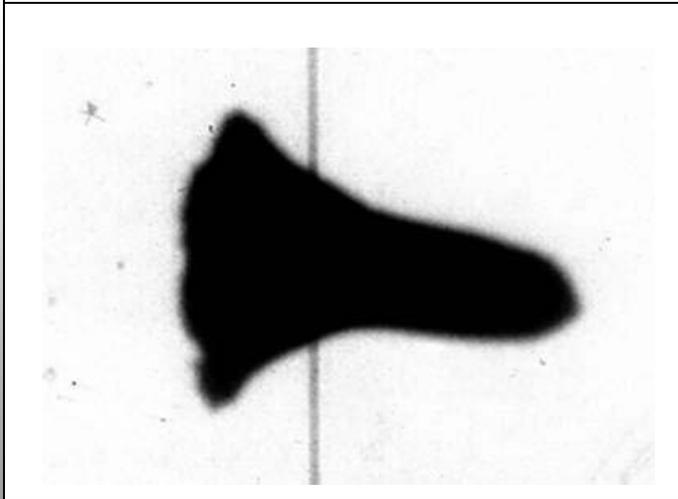
HIP Test Results

Orthogonal X-Ray Results

Horizontal



Vertical

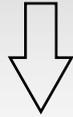


Cordin Photo Results

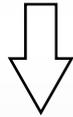


Extrusion consolidation process

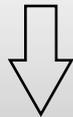
RAW POWDER



COLD ISOSTATIC PRESS



EXTRUSION



FINISHED BAR STOCK



Extrusion Test Results

Orthogonal X-Ray Results

Horizontal

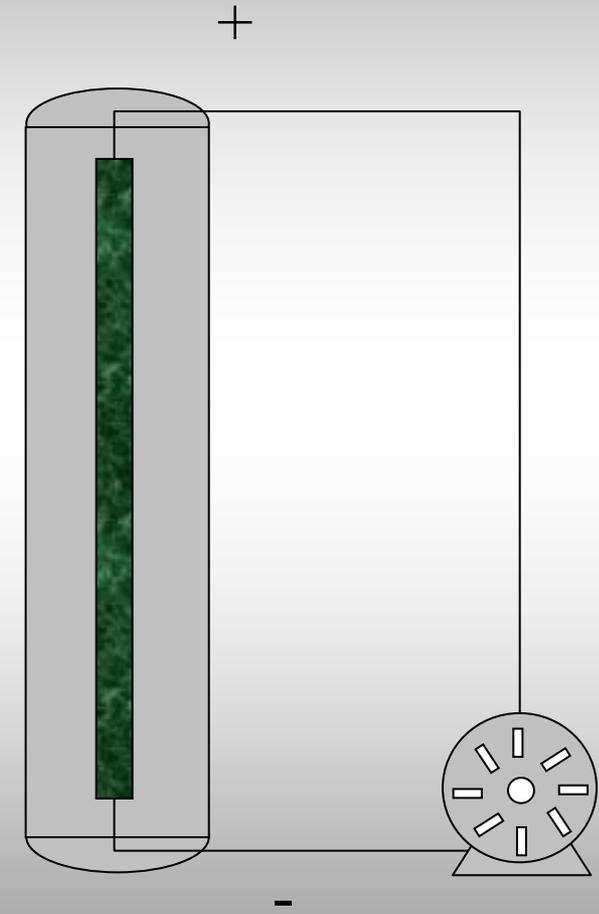
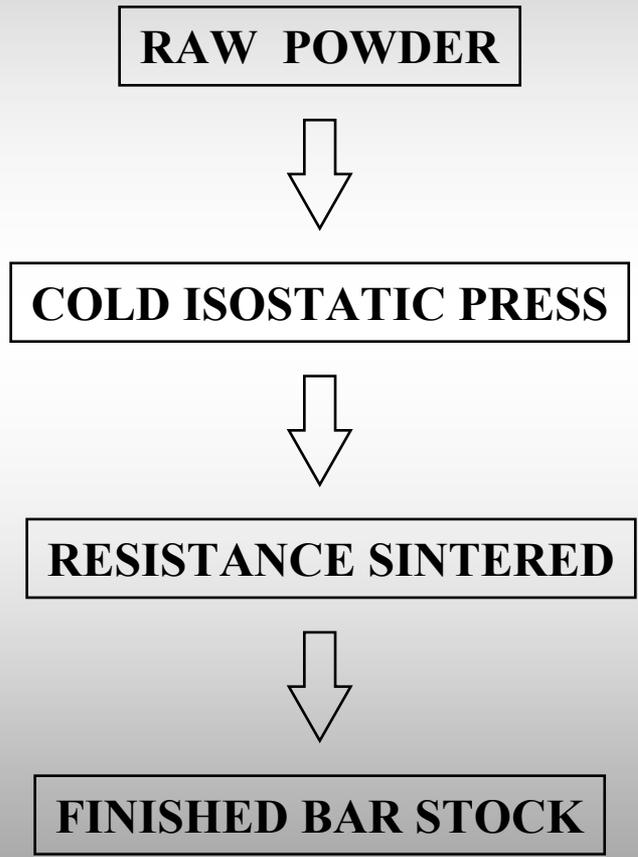


Vertical

Cordin Photo Results



Resistance Sintered consolidation process



Resistance Sintered Results

Horizontal



Vertical

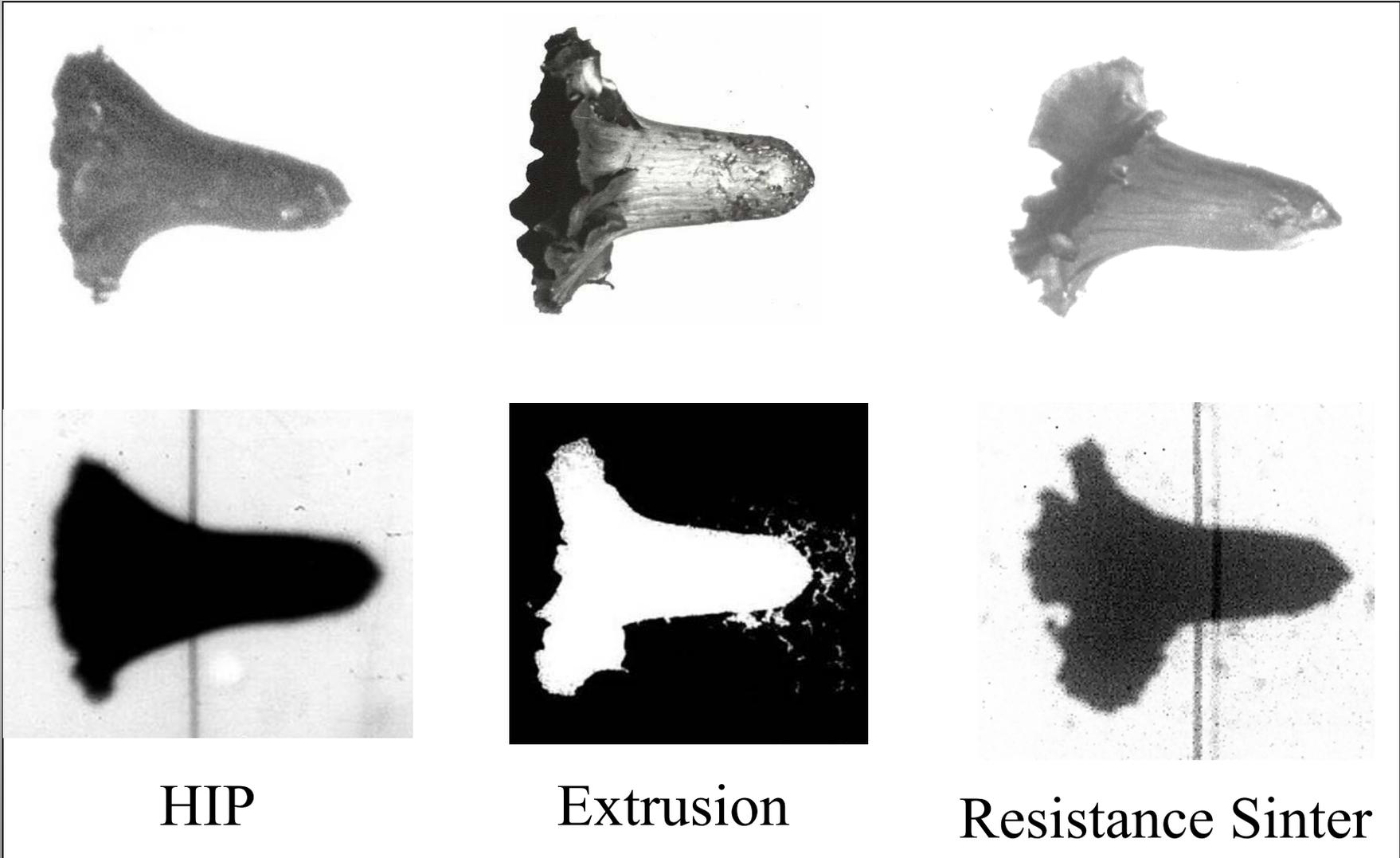


Orthogonal X-Ray Results

Cordin Photo Results



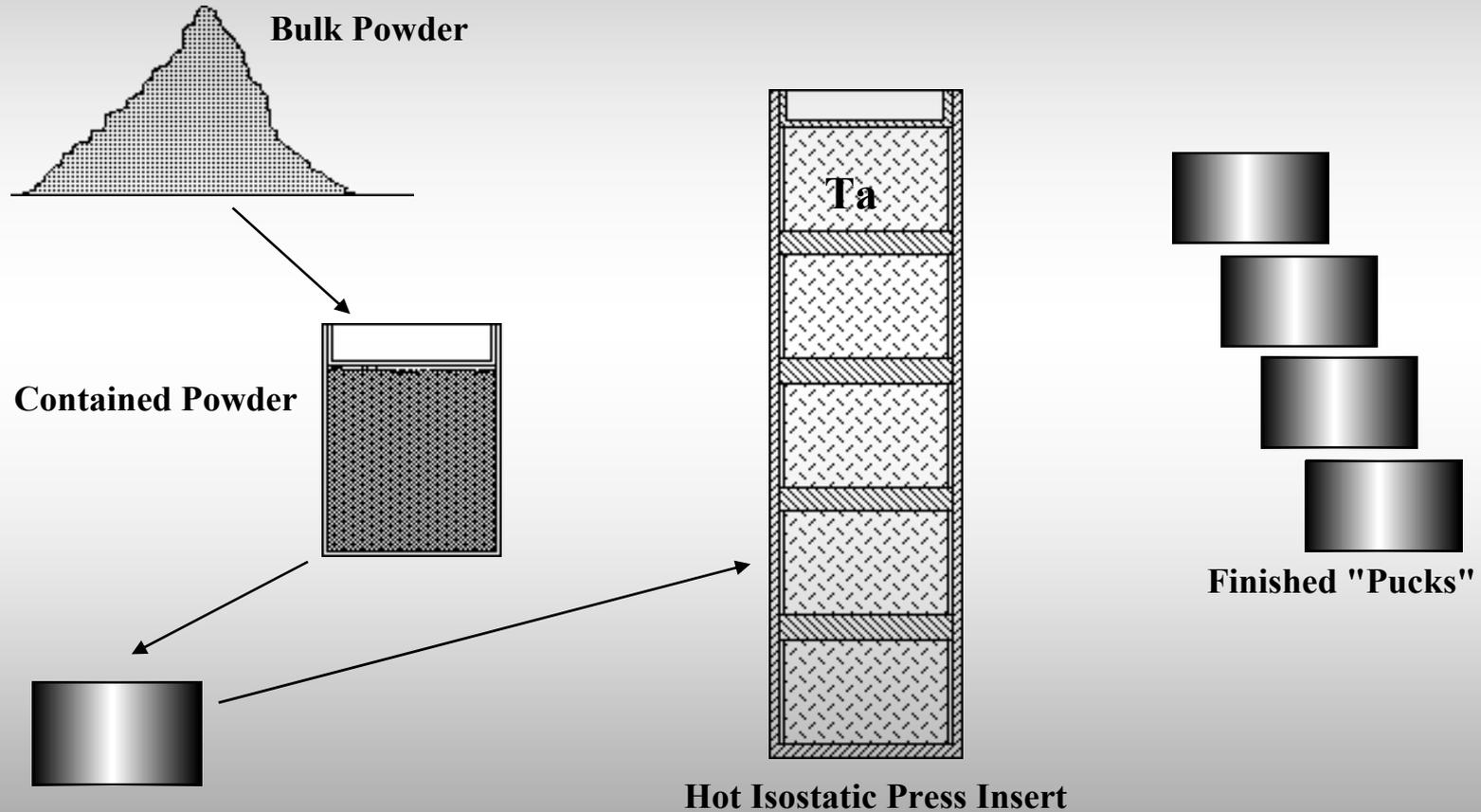
Comparison of Consolidation Processes





Near Net Process

Near-Net Process – Powder To “Pucks”



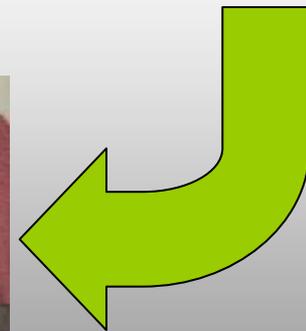
HIP To Puck Process

Pucks in Container

Consolidated Pucks



Pucks (Post-HIP) Containers removed



HIP

Test Data (HIP)

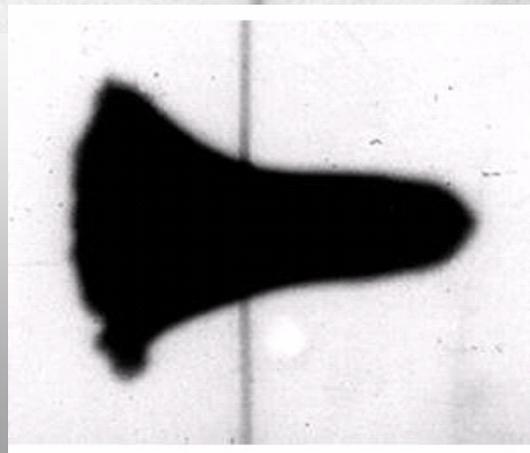
X-Ray Results

Cordin Photo Results

HIP to PUCK



HIP to Bar

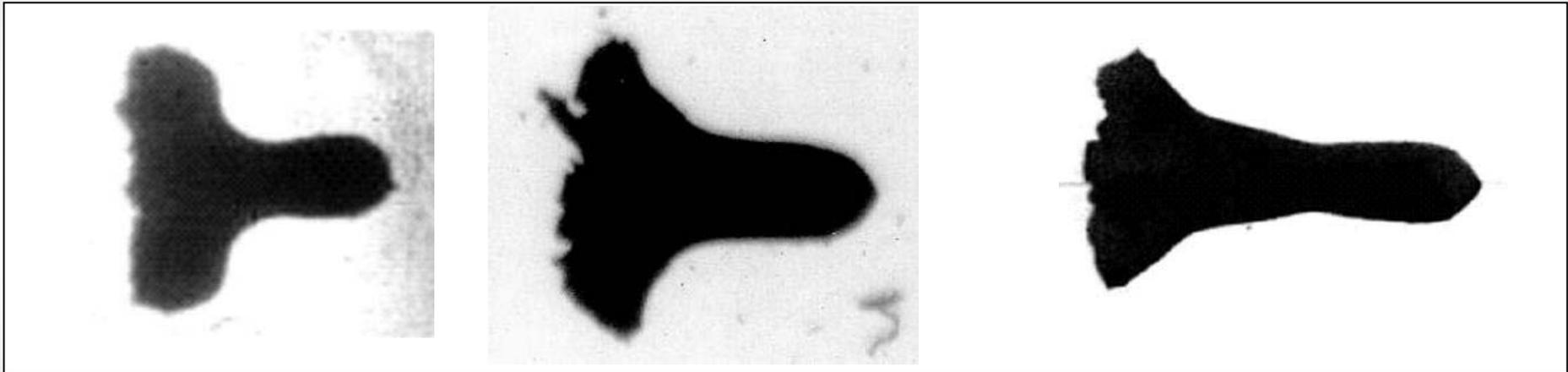




EFP Design and Material Evaluation



EFP Design Progression



Design #1

Design #2

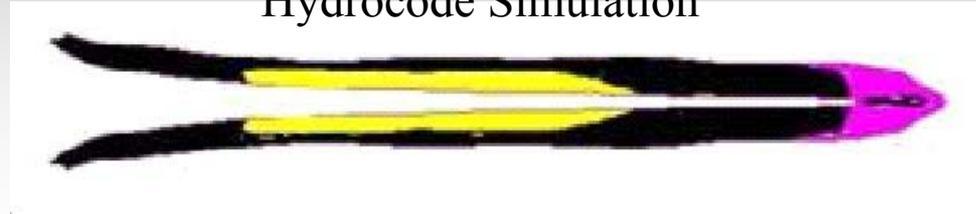
Design #3

Material Evaluation

To assess Powdered Ta ductility for advance EFP designs

Advance EPF Design

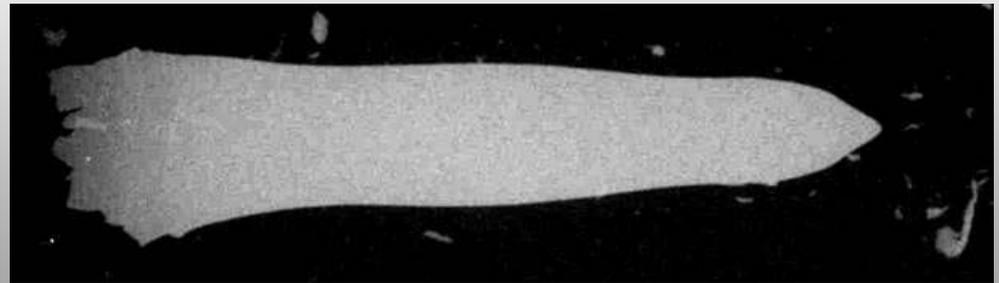
Hydrocode Simulation



EFP with pure Ta

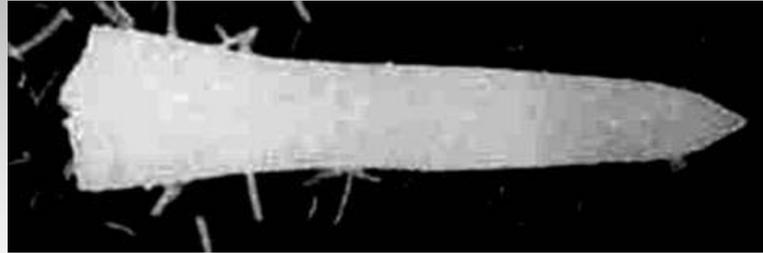


EFP with TaW alloy



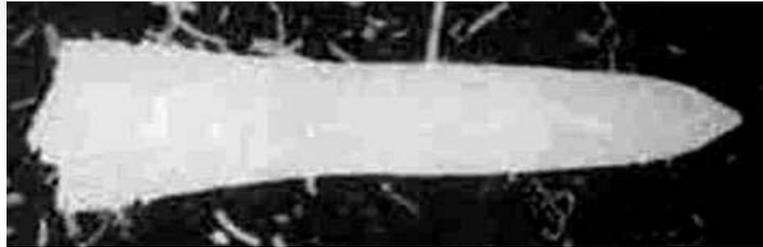
Material Evaluation – Con't

Powder Ta liner shot #1



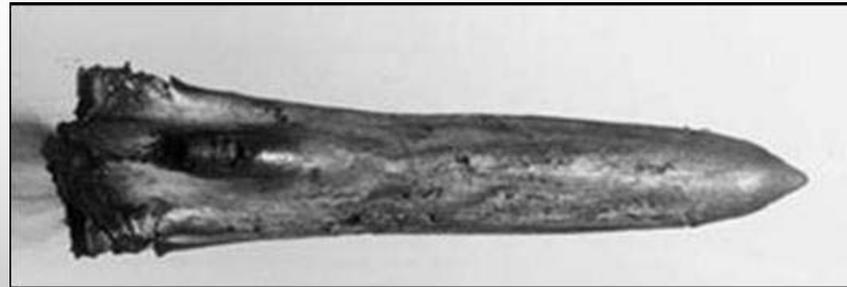
X-Ray

Powder Ta liner shot #2



X-Ray

Powder Ta liner shot #2



Cordin Photo

Pure Ta Bar



X-Ray



Summary



- Demonstrated lower cost repeatable EFP Liner fabrication process using Powder Tantalum.
- Eliminated lot-to-lot variations in material property
- Generated a powder tantalum material process and liner fabrication specification