

# IN-SITU FORMATION OF LASER FUSED NANOCRYSTALLINE COMPOSITE COATINGS FROM FE-BASED AMORPHOUS ALLOYS TO IMPROVE WEAR RESISTANCE IN TBM DISC CUTTERS

**Researchers:** C. A. Blue, W. H. Peter, N. B. Dahotre, T. J. Edgemon, J. O. Kiggans, and P. G. Engleman  
**Collaborators:** Lawrence Livermore National Laboratory, Colorado School of Mines, and Herrenknecht AG  
**Funding Support:** Department of Energy – Yucca Mountain Project

## Introduction

Tunnel boring machines use periodically spaced 'disc cutters' to crush and break rock in the construction of tunnels. The disc cutters undergo cycling of compressive and tensile strains as they rotate against rock surfaces with loads greater than 50 kips (230 kN). Materials are needed that exhibit high wear resistance as well as impact toughness. Current disc cutter technologies/materials are limited, and previous coatings have been unsuccessful.

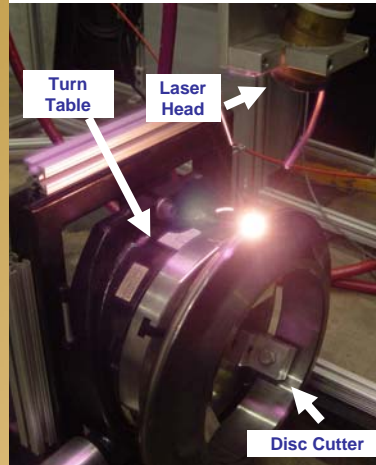
## Objective

Develop materials and processing techniques to produce economical solution for disc cutters with high hardness, high wear resistance, and sufficient toughness; this will increase the drift distance a tunnel boring machine can travel before maintenance is required. Successful design would lower cost, increase energy efficiency, and provide a safer working environment.

## Approach

- Laser fuse Fe-based amorphous powders on existing steel disc cutters
  - High hardness and good wear properties of coating
  - Superior impact resistance and toughness of steel disc
- Amorphous/Nanocrystalline Coatings
  - Supersede the Hall-Petch Relationship, providing limited to no dislocation movement
  - Increase control of microstructure and mechanical properties
- 4 kW Continuous Nd: YAG Laser
  - Programmable Turntable Compatible with TBM Disc Cutter and Laser Movement in 3-Axis
  - Intricate coating designs improve tolerance of complex strain conditions
  - Increased control of process parameters, structurally engineered coatings

Laser fusing amorphous powder to steel disc cutter.



Laboratory evaluation of laser-fused disc cutter on Granite at the Colorado School of Mines.



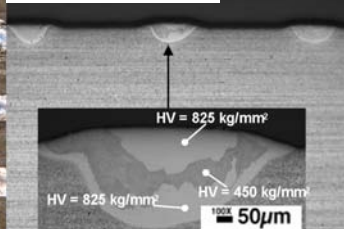
## Conclusion

- 1) Successful synthesis of glass-nanocrystalline composites yielding desirable properties.
- 2) Engineered layered-structure with hardness values up to 1800 kg/mm<sup>2</sup> (VHN).
- 3) Excellent bonding characteristics between coating and substrate.
- 4) First composite/coated surface to successfully be tested at the Colorado School of Mines where disc was subjected to point loads of 300,000 lb (1.3 MN) and average loads of 75,000 lb (340 KN)

Coating designed to accommodate strain in 2-D.

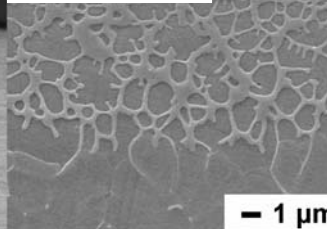


Cross sectional microstructure of coating freckle.



300µm

Metallurgical bonding between coating and substrate.



Disc Cutter team visiting Yucca Mountain site. 18' - Tunnel boring machine with disc cutters used to bore main shaft.

