SUPERLASERS FOR THE REAL WORLD

Laser Shock Peening

EPIC Online Technology Meeting on Industrial Laser Manufacturing for Naval and Aeronautic Applications

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14.12.2020

EVROPSKÁ UNIE
Evropské strukturální a investiční fondy
Operační program Výzkum, vývoj a vzdělávání

MINISTERSTVO ŠKOLSTVÍ, MLÁDEŽE A TĚLOVÝCHOVY

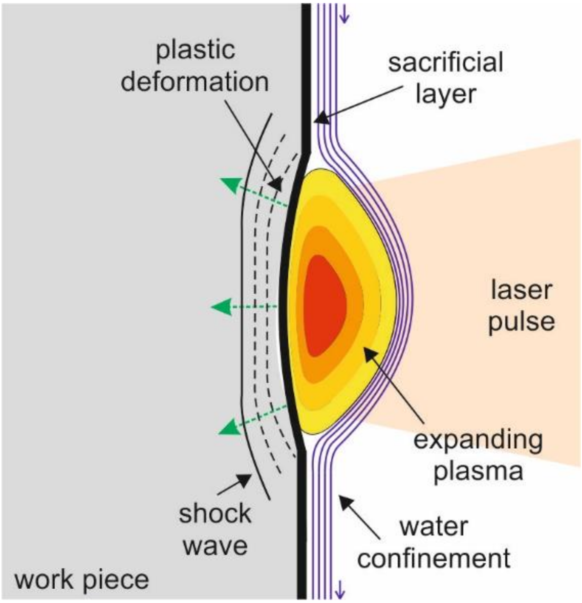
This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 739573 (HiLASE CoE)

hilase

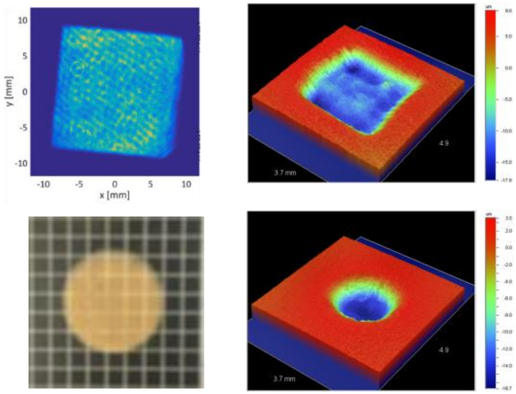
FZÚ

What is **Laser Shock Peening?**

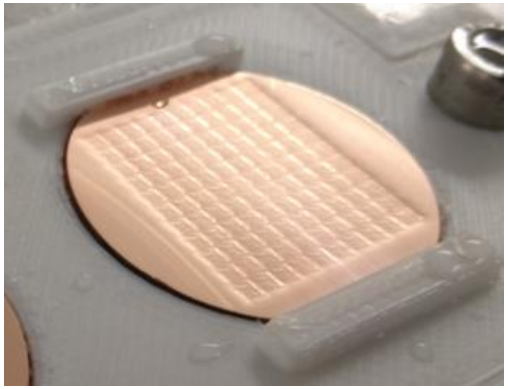
- cold working process
- uses high-energy nanosecond laser pulses to induce plastic strain in materials
- the result is a hardened surface layer with deep compressive residual stresses
- treatment of larger areas is achieved via laser patterning with overlap between pulses
- treatment effects:
    - prevention of crack initiation and propagation
    - fatigue lifetime extension
    - increased hardness
    - reduced material wear
    - prevents SCC
    - laser forming



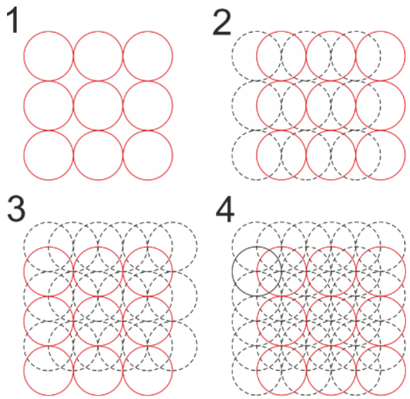
LSP mechanism



Single shot plastic deformation



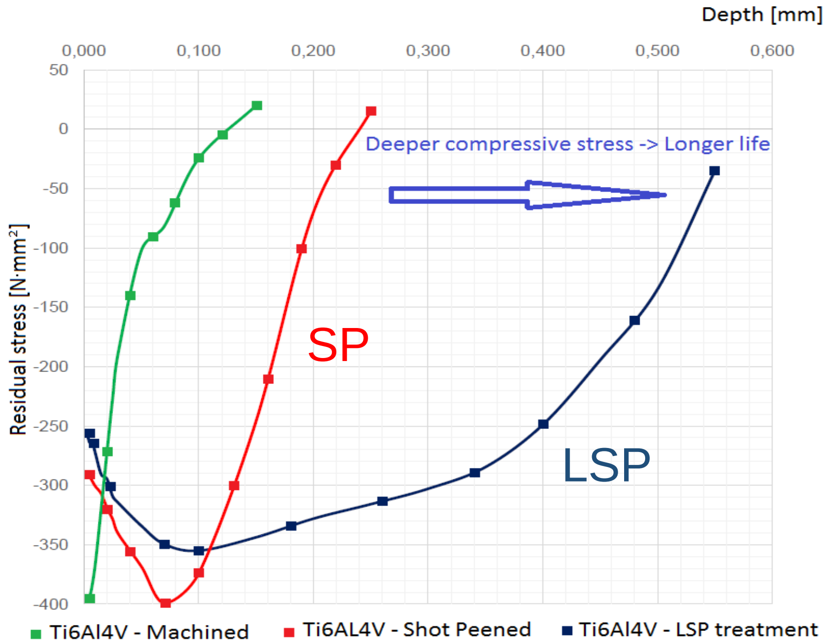
Single sequence



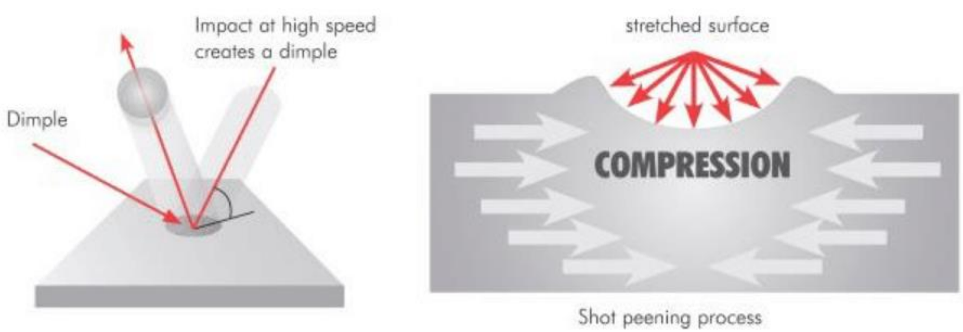
Sequencing for uniform coverage

LSP in comparison

Laser Peening	vs	Shot Peening
Deep compressive residual stresses up to 2 mm ●●●●●●●●●●●●●●●	Depth	Shallow compressive residual stresses up to 0.25 mm ●●●
Total control over laser impact location ●●●●●●●●●●●●●●	Precision	Semi-random shot distribution ●●●●
Roughness lowered through precise laser spot overlap ●●●●●●●●●	Roughness	Post-process polishing often necessary ●●
Up to 10x component life improvement in some cases ●●●●●●●●●●●●●●●	Fatigue life	Fatigue resistance limited by shallow compression depth ●●●●●●
Applicable to large parts in hard to reach places and environments ●●●●●●●●	Utility	Limited by access and component size ●●●
Creates less waste material and uses less consumables ●●●●●●●	Environment	Uses shots of various sizes and material with limited use ●●●●



In-depth residual stress measurement on Ti6Al4V



Shot peening mechanism, Credit: AmTech International 2020

Shot peened surface, Credit: ASCo American stripping co.

LSP in Aerospace industry

- Target applications
  - prevention of costly failures
  - decrease in downtime
  - fuel savings through light weight components
  - passenger safety
- Treatment areas
  - engine fan blades
  - critical airframe locations
  - welded components
  - wing attachments
  - landing gears
  - tailhooks
- Commonly used materials
  - Al, Ti, composites

B-B1 Lancer Bomber, Credit: Air Force Magazine 11 February 2018

Fractured blade of AirAsia engine failure. Credit: avherald.com 2020

Piper PA–28R-201 and broken off wing, Credit: Mike Fizer 2020

Damaged engine of Airbus A380, Credit: Jacob Soboroff (Twitter @jacobsoboroff) 2017

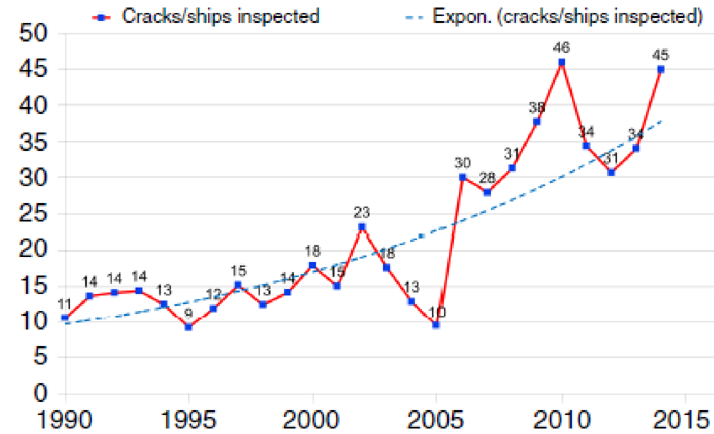
Civil aeronautic sector

what	when	challenges
LSP	MRO	time constraint portable LSP system, laser delivery strict safety standards
	manufacture	integration into the manufacturing process

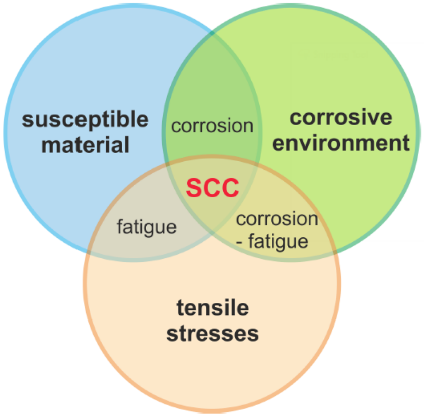
MRO, Credit: Media India Group

LSP in Naval industry

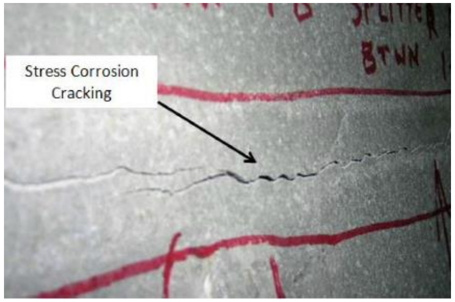
- Target applications
  - maintenance reduction
  - fuel savings through light weight components
  - cavitation
  - stress corrosion cracking (SCC)
  - sensitization resistance
  - corrosion resistance
  - laser forming
- Treatment areas
  - propellers
  - structural parts
- Commonly used materials
  - Al, steel



Average number of cracks per Ticonderouga class ship inspection, Credit: W.J. Golumbfskie et. al (2015), http://dx.doi.org/10.5006/1916.

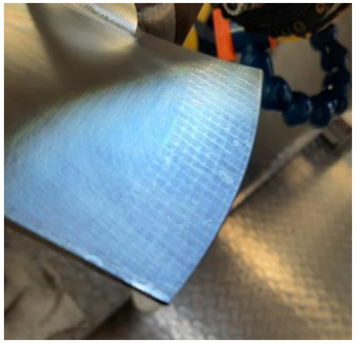


SCC factors

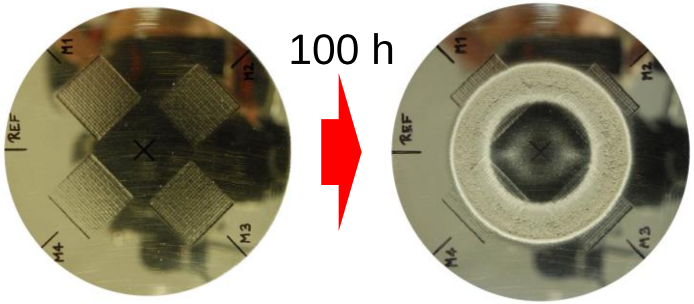


Stress corrosion crack in AA5456, Credit: W. Goins, NSWCCD

Cavitation on water pump propeller



LSPed water pump blade



Cavitation experiment on LSPed disc

HiLASE facility capabilities

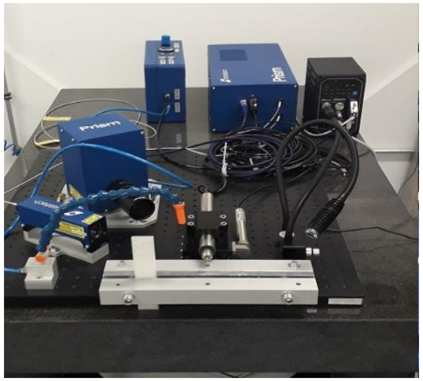
- High intensity laser system
  - 10 ns, 7 J, 10 Hz @ 1030 nm
  - 10 ns, 3.5 J, 10 Hz @ 515 nm
  - square, top-hat laser beam profile
  - real-time beam diagnostics
  - water tank for underwater peening

- Sample manipulation
  - 6-axis robotic arm
  - fully automated process
  - processing of complex geometries
  - 20 kg load capacity and 80 μm precision

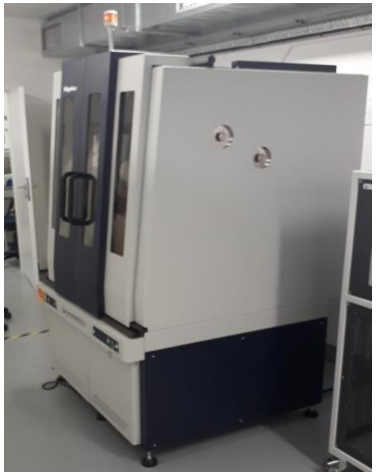
- Sample characterization
  - metallography equipment
  - in-depth residual stress analysis (XRD, hole drilling)
  - confocal microscope
  - electrochemistry

HiLASE LSP station

Metallographic cell



Hole drilling



XRD machine

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Thank you for your attention.