Laser Texturing for High Friction Applications

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1. Introduction

Surface modification can be used to change and improve various surface properties of a material, including:

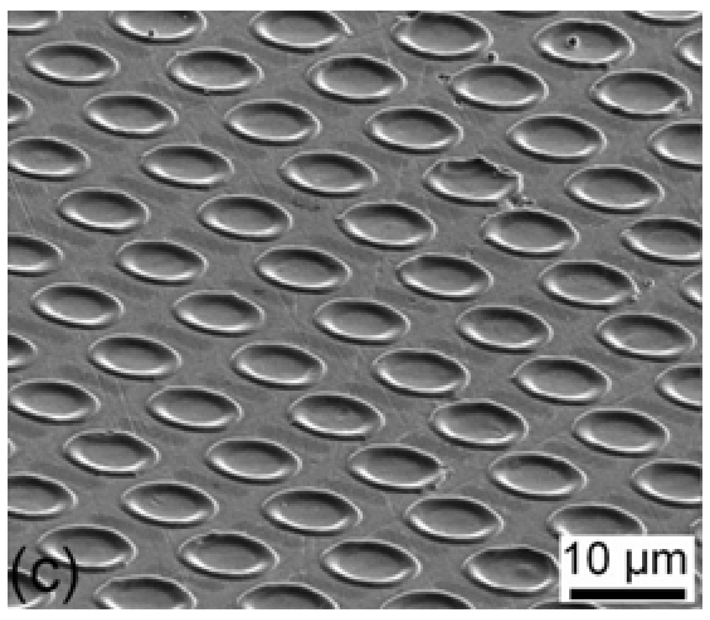
- Friction
- Wettability
- Optical Properties
- Hardness

Whilst there are many techniques which can be used to alter surface properties, each has its own advantages and disadvantages. Laser texturing is such a technique, with several distinct advantages over many traditional methods:

- Flexibility
- Speed
- Accuracy
- Negligible effect on bulk properties

2. Motivation

- Laser Surface Texturing (LST) has been shown to be industrially relevant and is being actively researched for friction reduction, where dimples are often used (right)
- High friction surfaces can also be desirable

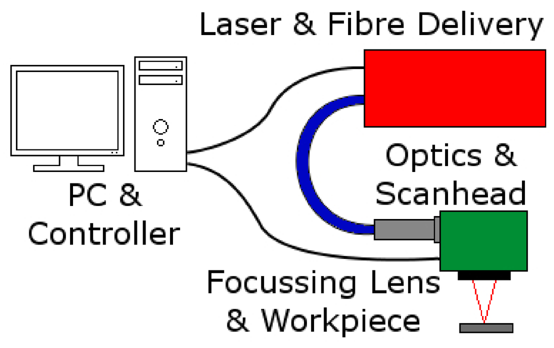


M. Duarte et al., *Increasing Lubricant Film Lifetime by Grooving Periodical Patterns Using Laser Interference Metallurgy*

- MAN Diesel & Turbo (MDT), for example, are looking for a reliable method of generating surfaces with a high static friction coefficient (μ_s>0.6 for normal loads 50-150MPa)

3. Set-Up & Testing

- Laser texturing performed with an SPI fibre laser (λ=1064nm)
- The beam was then deflected to the work piece by a galvo scan head



Schematic of laser processing set-up

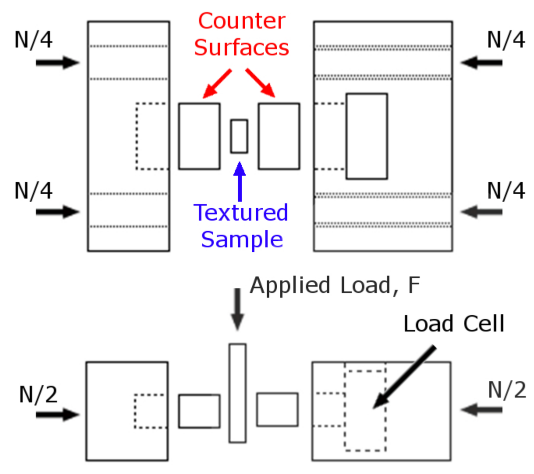
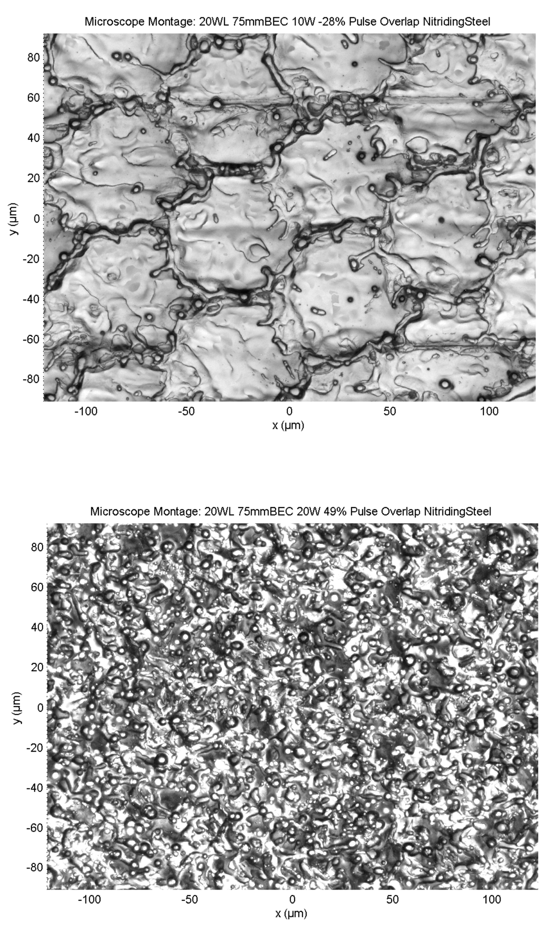


Diagram of friction testing rig

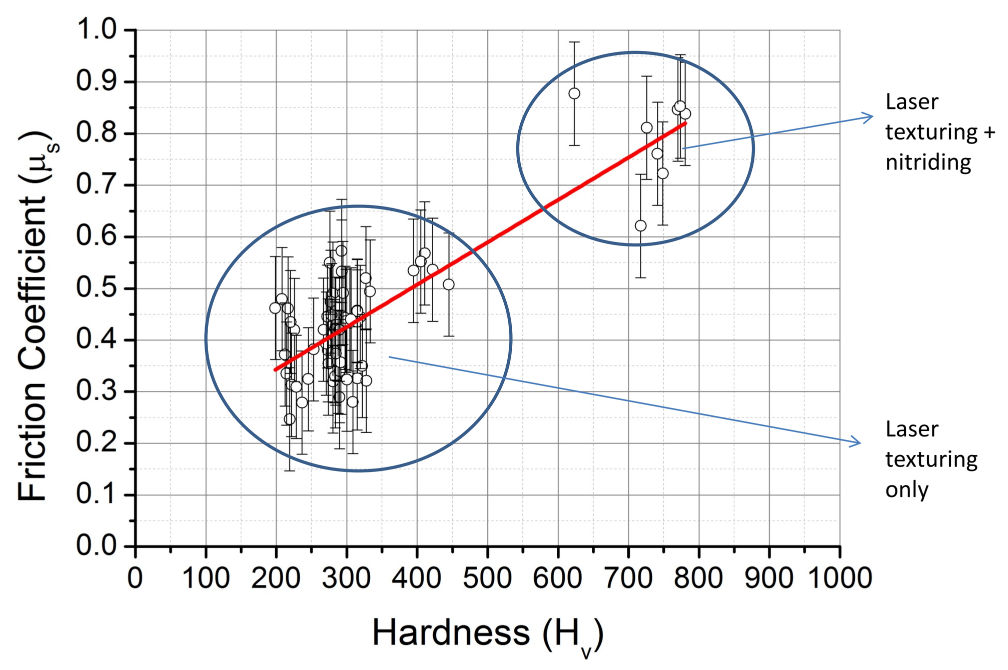
- Friction testing of the laser textured samples (steel) was performed on a custom designed testing rig
- The load force, F, was supplied by a hydraulic press and the normal force, N, by two high strength bolts

4. Texturing Single Surface



-50 – 75% overlap, 25kHz, 0.4-0.8mJ pulse energy

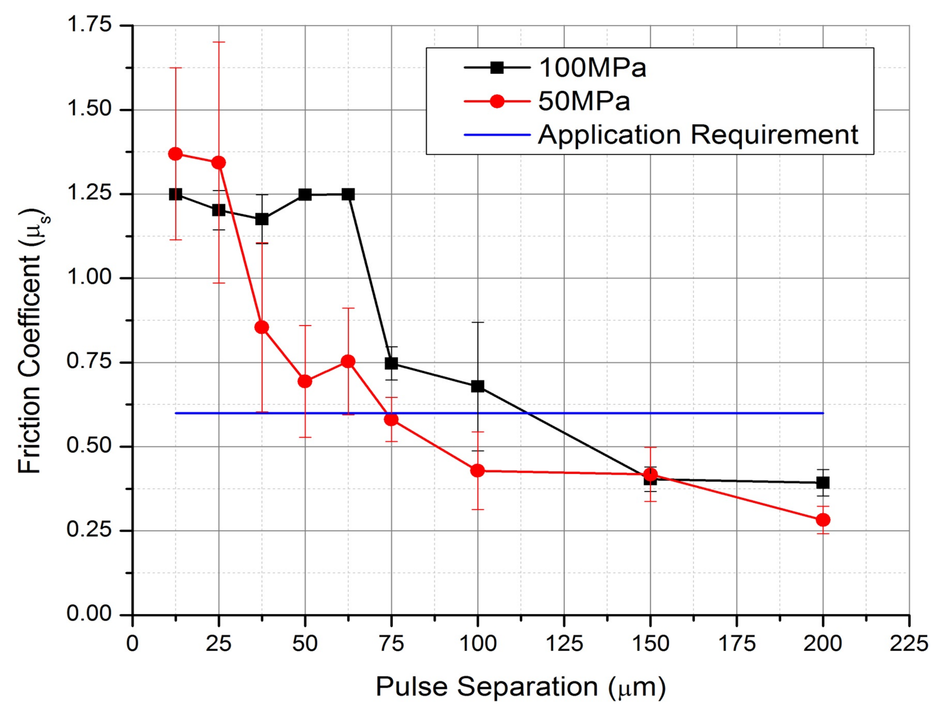
- For the initial MDT application, only one surface of the contact was to be textured
- Texturing using a 'hexagonal' pulse layout resulted in high friction coefficients, μ_s>0.8, at high normal force (60kN, 150MPa)
- At lower normal force (40kN, 100MPa), friction coefficients rarely exceeded 0.6 with laser texturing, although harder samples were observed to perform best
- Plasma nitriding (a surface hardening process) was then used in conjunction with laser texturing

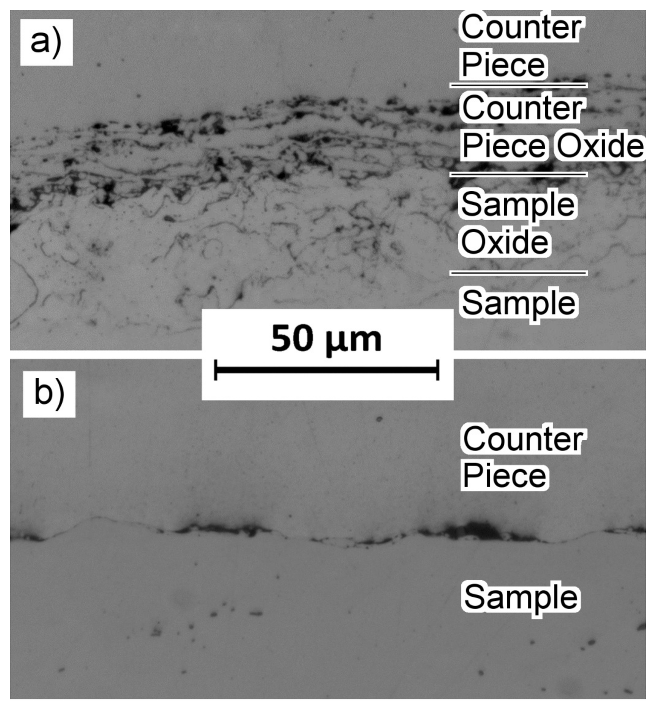


- Resulting friction coefficients observed to be consistently >0.8 at 40kN normal force

5. Texturing Both Surfaces

- The effect of texturing both of the contacting surfaces was also studied
- In this case, method of fabricating and testing the textures stayed the same, but with 40/20kN normal force used for testing





Dependence of friction coefficient on pulse separation for when both contacting surfaces are textured (left) and cross-section of interlocking textures after application of normal force (right)

- Consistently high friction coefficients, μ_s>1, are obtained by texturing both surfaces, with normal forces as low as 20kN
- Increased contact area and interlocking facilitated by deformations due to the high normal force
- Processing speeds of industrial relevance have already been shown (μ_s>0.9 at >3.4cm^2/s; >1.2m^2/hr) for 20kN normal force, with further optimisation possible

6. Conclusion

- Laser texturing can increase friction; increasing pulse overlap increases friction and hardness
- External hardening processes greatly increased the achieved friction coefficient, μ_s>0.8
- Texturing of both surfaces greatly increases the friction coefficient, without hardening
- Processing is comparatively slow, but industrially relevant with further optimisations possible

Acknowledgements

MAN Diesel & Turbo

SPI Lasers

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