Novel Laser Technology to Enhance the Wear Resistance of Shape Memory NiTi Alloy for Total Joint Replacement Applications

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**Introduction**

**Reasons Why Implants are Replaced**
- Within 1st year, the most common reasons: dislocation, fracture or infection
- After 5th year, the most common reason: aseptic loosening, pain or wear

**Implant Failure Rate for Revision**
- 1. Aseptic Loosening (50.0%)
- 2. Pain (23.1%)
- 3. Wear (13.6%)
- 4. Dislocation (12.9%)
- 5. Facture (11.9%)
- 6. Infection (9.0%)

Wear contributed “13.6%” for implant failure (2003-2014) [1]

**Laser Gas Nitriding**
1. Selective Area Processing
2. Fast and Clean
3. Non-Contact Method

**Research Objective**
To improve the wear resistance of shape memory NiTi alloy and to reduce the processing time by “Selective Laser Gas Nitriding” (To change the coverage ratio of TiN on laser nitrided surface)

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**Experiments**

**Laser Machine**
SPI CW 100W Fibre Laser (Wavelength: 1091 nm)

**Laser Gas Nitriding**
Laser nitriding process was carried out using the CW fibre laser. The sample was purged with a continuous supply of high purity nitrogen at a flow rate of 30 L/min.

**Microstructural Characterization**
1. Optical Microscopy (OM): Preliminary observation of the surface appearance
2. Scanning Electron Microscopy (SEM): Examination of the cross-sectional surface
3. X-ray Diffraction (XRD): Identification of the phases present in the surface

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**Results and Discussions**

**Surface Appearance**

- **Sample 1**: Laser Nitrided Surface with “52%” of TiN coverage
- **Sample 2**: Laser Nitrided Surface with “76%” of TiN coverage

**Wear Resistance**

- **Sample 1**: TiN Coverage 52%  
- **Sample 2**: TiN Coverage 76%  
- **Sample 3**: TiN Coverage 100%

**Wear Factor**
(Lower the better)
- Sample 1: TiN Coverage 52%  
- Sample 2: TiN Coverage 76%  
- Sample 3: TiN Coverage 100%

**Processing Time**
(Shorter the better)
- Save “59%” treatment time compare to fully covered surface

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**Conclusions**
After laser gas nitriding, a very hard and wear-resistant surface layer (TiN) is fabricated in the NiTi sample. Our findings indicate that the laser-nitrided surface covered with 76% of TiN has similar wear resistance to that of the fully covered sample.

Reference:

Acknowledgment: Laser surface treatment and wear experimentations were done at the QUB, UK and the HKPolyU, HK, China. Surface characterization were done at the University of Chester, UK.

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