Roughness and mechanical properties of silicon nitride coatings – an alternative for joint replacements

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INTRODUCTION

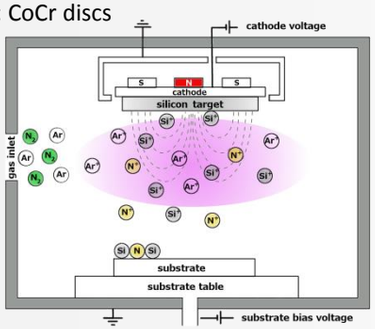
Joint replacements are a common and often successful procedure, however as the population become more active and older the demands on these implant become higher. An alternative bearing material for joint replacements could be silicon nitride coatings on cobalt chromium (CoCr). Potential advantages include:

- A more wear resistant surface
- Resorbable wear particles
- Reduced release of metal ions

MATERIALS AND METHODS

Deposition:

- High power impulse magnetron sputtering
- Substrate temperature: 200˚C, 350˚C and 430˚C
- Varying nitrogen-to-argon flow ratio, $f_{(N2/Ar)}$: 0.06, 0.17 and 0.30
- Substrates: CoCr discs



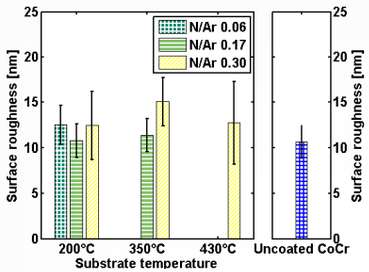
A schematic image of a sputtering process.

Evaluation of the coating properties:

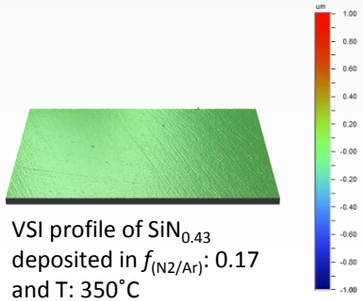
- Vertical scanning interferometry (VSI): surface roughness
- X-ray photoelectron spectroscopy (XPS): composition
- Nanoindentation: Young's modulus and hardness

RESULTS

SURFACE ROUGHNESS

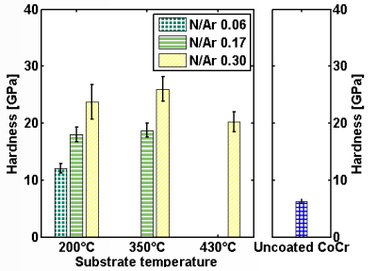


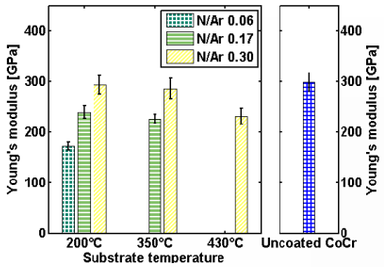
- Similar R_a for all coatings
- Similar or slightly higher surface roughness compared to substrate



VSI profile of $SiN_{0.43}$ deposited in $f_{(N2/Ar)}$: 0.17 and T: 350˚C

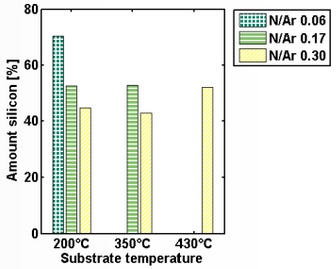
HARDNESS & YOUNG'S MODULUS

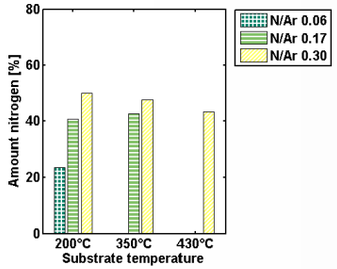




- Hardness and Young's modulus increased with increased $f_{(N2/Ar)}$
- Young's modulus decreased with increased substrate temperature

COMPOSITION





- Silicon content decreased while nitrogen content increased with increasing $f_{(N2/Ar)}$
- Nitrogen content decreased slightly with increasing substrate temperature

DISCUSSION

- All coatings show low surface roughness
- High nitrogen flow results in high nitrogen content, as consequence of increased nitrogen availability during deposition
- Hardness and Young's modulus increase as nitrogen content increase
- Increased substrate temperatures yield slightly decreased nitrogen contents, volatile N-containing species are readily formed as a result of increased mobility

CONCLUSIONS

Silicon nitride coatings provide hard and smooth surfaces and could potentially be a candidate for joint implant surfaces.

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