SURFACE MODIFICATION OF Ti- BASED MATERIALS FOR BIOMEDICAL APPLICATION

DI Jie Sun, BSc
Premature implant failure is categorized into:

- **Aseptic loosening**
- **Septic loosening**

Schematic aseptic loosening of a total hip replacement [1]

In case of septic loosening, a bacterial biofilm between bone and implant prevents osseointegration

---


Motivation - Orthopedic implant market development

- **Global market value:** $72.25 bn (2016) → $106.9 bn (2023)
- **Market value by region:** Europe 2nd highest with $19.95 bn in 2016, forecasted $26.44 bn in 2023 [3]

- **Fastest growing market by product:** orthopedic implants [4]
- **Fastest growing market by material:** metallic biomaterials [5]

- **Market share 2016** [6]
- **Minor orthopedic replacement** (Shoulder, wrist, ankle and foot joints) [7]:
  - Market growth: $1.5 bn (2017) → $2.2 bn (2021)
  - Annual growth of 7% expected
  - Driving force: higher rate of osteoarthritis, rheumatoid arthritis, fractures, failed previous joint replacement surgeries, infections by multi-drug resistant bacteria

Researchers agree that usage of antibiotic prophylaxis in implant surgeries (dip coated implants, antibiotic therapies) is required to achieve high long-term survival and success rates of implants.

**Multi-drug resistant bacteria (MDRB)**

- **Orthopedic implants** [8]:
  - 10% premature failures with up to 2,5% related to infections (rest related to aseptic loosening due to insufficient osseointegration)
  - 20% of revision surgeries are complicated by infections

- **Dental implants:**
  - 14,4% Periimplantitis within the 1st five years (increasing infections beyond five years) [9]
  - Postoperative infections [10] diagnosed within the 1st month:
    - removal/replacement surgeries: 77,3% due to antibiotic therapy failure
    - failure before prosthetic loading: 54.6%

→ Currently, no effective applied procedure exists to address postoperative infections, which lead to removal, replacement and in the worst case amputation.

---


Outline - Strategies

Defined nano-topography

greater bone-implant contact area, guidance of the implant vs. cell interaction

- Anodization
- Annealing

Formation of titania nanotubes
Transformation of TiO₂ to TiO₂-anatase phase

❖ Uniform circular shape with a diameter of 100 nm

antibacterial efficiency without use of pharmaceuticals promotes new bone formation and bone growth \[11, 12\]

Electrodeposition

Se
Ag₂Se
Cu₂Se

Electro-chemical deposition

Se-HAp


Research article

Surface modification of Ti6Al4V alloy for implants by anodization and electrodeposition

Jie Sun¹, Tzvetanka Boiadjieva-Scherzer¹,*, Hermann Kronberger², Kevin Staats³, Johannes Holinka³ and Reinhard Windhager³

¹ Centre of Electrochemical Surface Technology GmbH (CEST), Austria
² Technical University of Vienna, Institute of Chemical Technologies and Analytics, Austria
³ Medical University of Vienna, Department of Orthopedics and Trauma Surgery, Austria
The team

MSc. J. Sun
Dr. Tz. Boiajjeva-Scherzer
Prof. H. Kronberger
MDr. K. Staats
MDr. Prof. J. Holinka
MDr. Prof. R. Windhager

1 Centre of Electrochemical Surface Technology GmbH (CEST)
2 Technical University of Vienna, Institute of Chemical Technologies and Analytics
3 Medical University of Vienna, Department of Orthopaedic Surgery

Acknowledgement

These investigations were performed with the support of the Austrian Science Foundation FFG and the government of Lower Austria and Upper Austria in the frame of the COMET program.