IOCFB 2024 Conference

The 1st International Online Conference on Functional Biomaterials

10–12 July 2024 | Online

Formation of calcium phosphate coatings on titanium and polymer substrates using gas-detonation deposition

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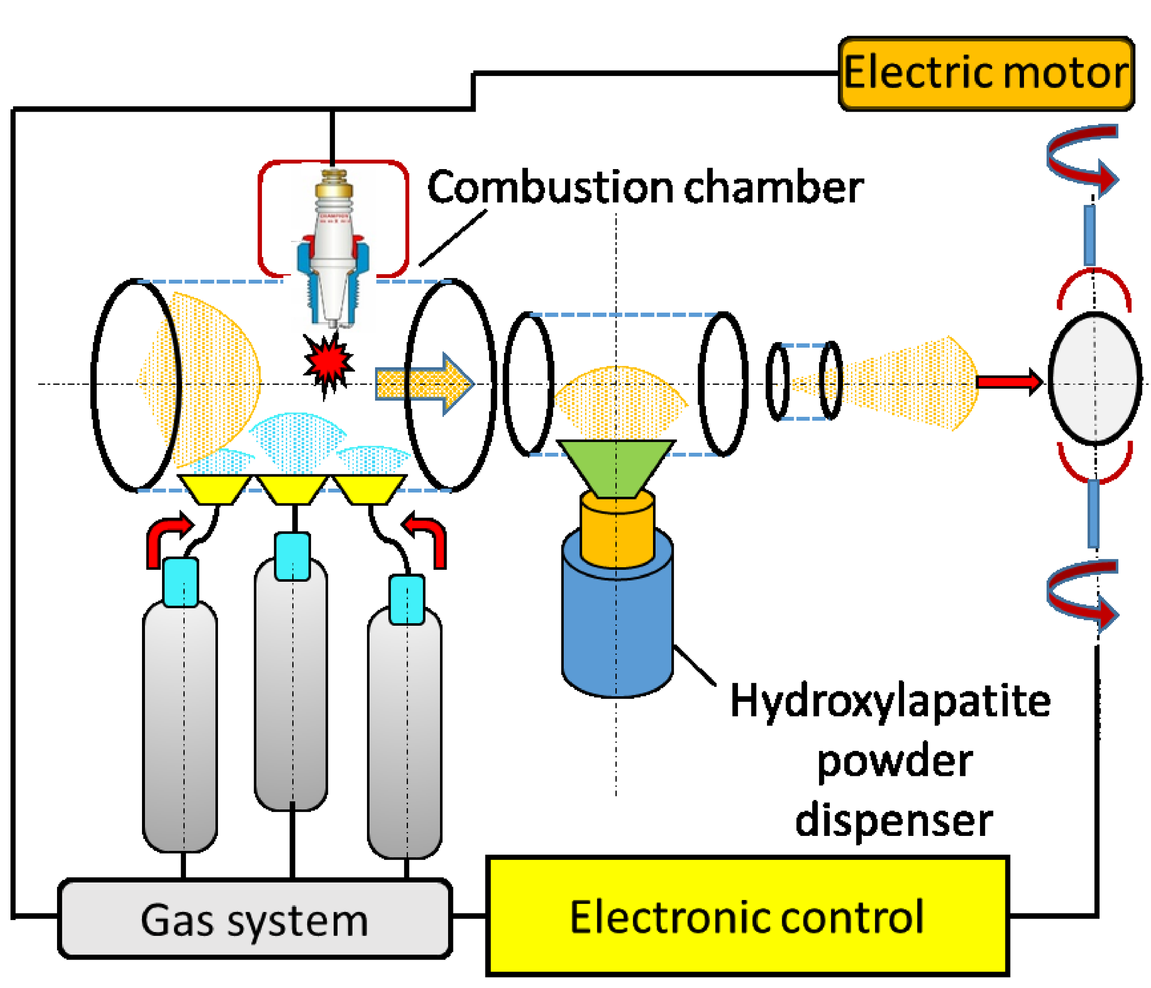
INTRODUCTION & AIM

Titanium-based implants are the most common now, but the polymer polyetheretherketone (PEEK) is studied as a substitute. Despite the biotolerance of titanium and PEEK, their implantation in the human body is often accompanied by some negative effects. This problem is solved by depositing biocompatible coatings on the implant surface, in particular, calcium phosphates (CP) or hydroxylapatite (HAP). CP and HAP coatings of implants are produced by different techniques, each of which has its own disadvantages related to both the quality of the formed coatings and their cost. One of the perspective methods for the coating deposition on the implants is the gas-detonation deposition (GDD) [1, 2].

Therefore, the aim of the present work is the investigation of the structure, morphology, and phase composition of the HAP coating on PEEK and Ti substrates obtained by using the GDD technique in the same conditions from the HAP powder and their comparison.

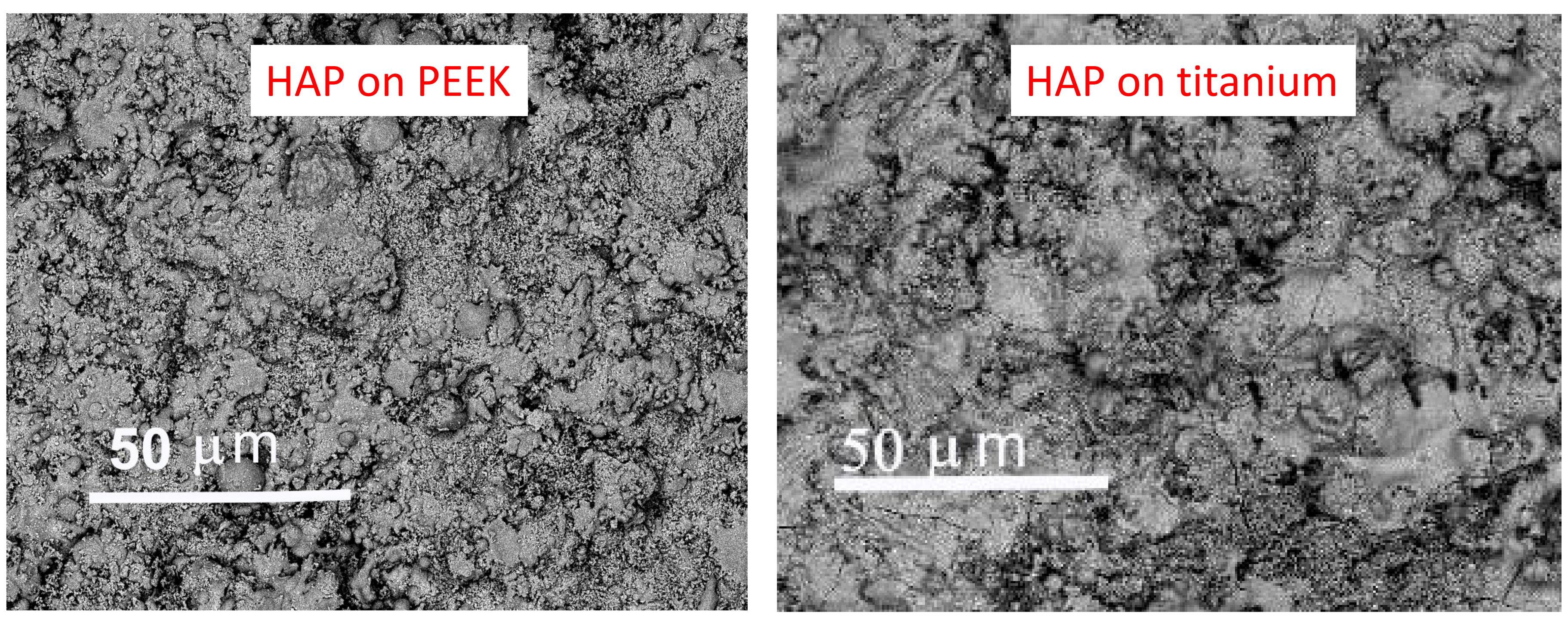
METHOD

For the formation of biocompatible coatings, the **GDD technique** was used, see the scheme below. The HAP powder with a fraction of 50 µm was inputted into the explosion flux at equal other parameters (propane/oxygen fraction, distance to the substrate, frequency of explosions) and accelerated in the direction of substrates.

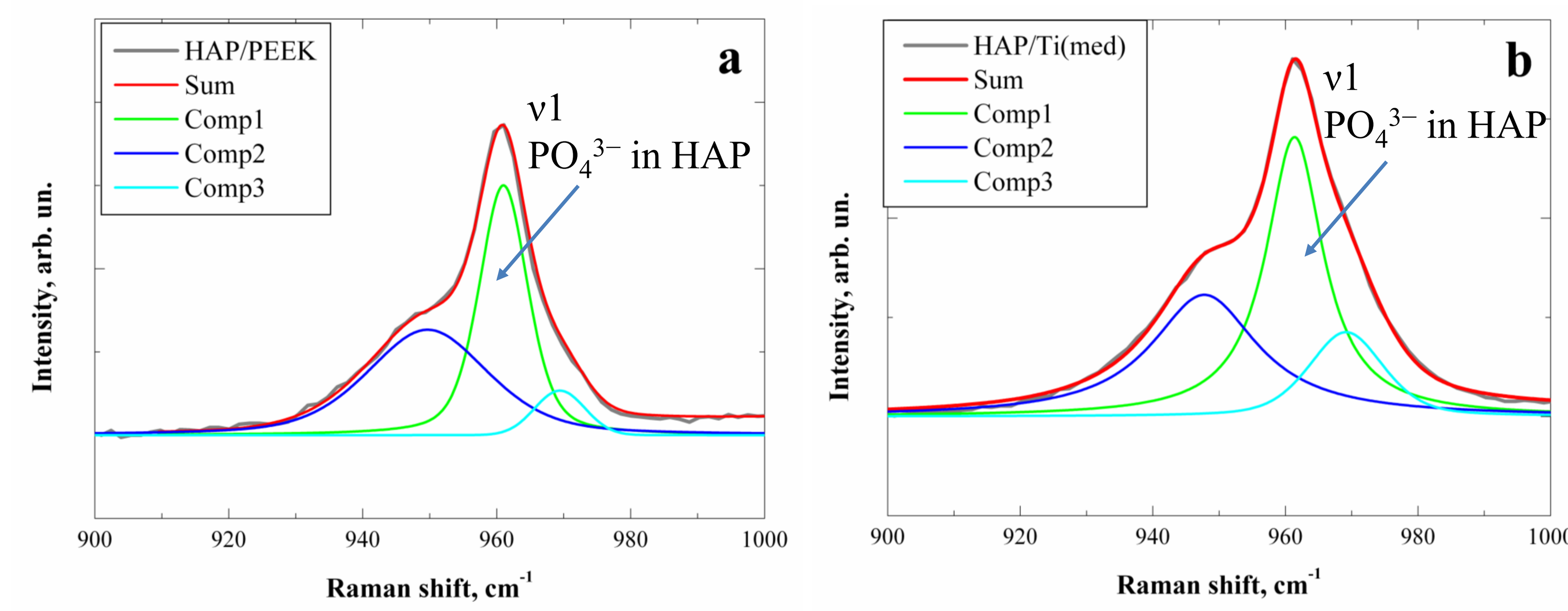


The obtained HAP coatings were investigated using **Raman spectroscopy**, **X-ray diffractometry** (XRD), **scanning electron microscopy** (SEM) as well as **energy-dispersive analysis** (EDS).

RESULTS & DISCUSSION

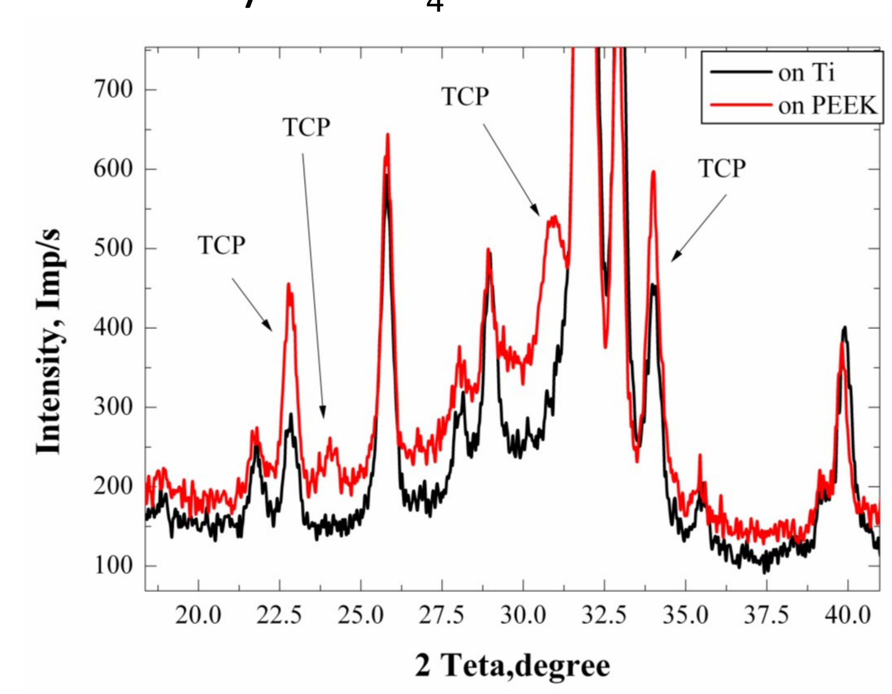


The SEM images of the surface of HAP coatings obtained using the GDD technique



Raman spectra of HAP/PEEK (a) and HAP/Ti (b) coatings within the spectral range 900 – 1000 cm^{-1} with its decomposition on elementary contours

The presence of ν1 band indicates clearly, that the formed by using the GDD technique coatings on titanium as well as PEEK consist of hydroxylapatite. The presence of the addition bands within the mentioned frequency range is also induced by the PO_4^{3-} vibrational modes.



The diffractograms of HAP/PEEK and HAP/Ti coatings within the range of 20 – 40 degrees.

The X-ray diffractograms show that all the peaks of HAP/Ti coating black line) are the reflexes of the hexagonal phase of HAP with the following parameters:*a* = 9.4181Å, *c* = 6.8887Å, (No 010-89-6337). The coating HAP/PEEK has the additional monoclinic α-$Ca_3(PO_4)_2$ phase (No 010-70-0364) with the parameters *a* = 12.887Å; *b* = 27.28 Å; *c* = 15.219 Å. It follows from the individual additional reflexes with the positions 2Teта = 24.08 ° and 2Teта = 30.92 ° (red line). Also, the strengthening of the HAP reflexes in the position 2Teта = 22.83 ° and 34.05 ° by the other reflexes of tricalcium phosphate **(TCP)** occurs.

CONCLUSIONS

- The obtained coating **HAP/PEEK** consists of **hydroxylapatite** with an unsubstantial fraction of **TCP** and defective **HAP**/oxyapatite phases.
- The intermediate layer with the higher content of additional phases forms between the coating and substrate.
- On the metal substrates the formation of the secondary phase also occurs, however, but others – amorphous and defective HAP.
- The difference in the secondary phase formation is probably caused by the substantial difference in the thermal conductivity of the substrates.

Acknowledgments

The work was carried out within the "Development of the technology of **National Research Foundation of Ukraine Project No. 200/0103** biocompatible antibacterial coatings for orthopedic implants by the gas-detonation deposition method for the needs of military and civilian medicine".

REFERENCES

1. V.P. Temchenko, et al., Structural and morphological properties of hydroxylapatite coatings obtained by gas-detonation deposition on polymer and titanium substrates, SPQEO. 26(4) (2023) 368–375. https://doi.org/10.15407/spqeo26.04.368.
2. N.I. Klyui, et al., Properties of gas detonation ceramic coatings and their effect on the osseointegration of titanium implants for bone defect replacement, Ceram. Int. 47(18) (2021) 25425–25439. https://doi.org/10.1016/j.ceramint.2021.05.265.