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Application of the arc melting method for the synthesis of new Zr-Nb-Mo alloys for medical applications

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Scientific background

The growing demand for innovative solutions for medicine significantly impacts biomaterials research advancement, particularly metals and their alloys, regarding their widely changeable properties. Nowadays, titanium alloys are the most recognized in the scientific community but are not the only way to achieve optimal results.

The zirconium-based alloys, well-known in the industry, exhibit excellent corrosion resistance and durability. Although research on zirconium-based biomaterials is rather limited, their promising characteristics hold potential value for medical applications, especially in terms of exceptional biocompatibility. Additionally, their relatively low density, around 6.51 g/cm³, contributes to lightweight yet strong medical devices. Moreover, zirconium is a very weak electrical conductor and is not affected by magnetic field, making it a material potentially safe for MRI imaging.

Conclusion

- The combination methods of powder metallurgy and arc melting make it possible to obtain Zr-Nb-Mo alloys with different elemental ratios.
- X-ray diffraction showed that the obtained samples were multiphase.
- The higher molybdenum content in the samples favoured the formation of a more refined and homogenous microstructure.
- Analysis of the chemical composition showed an uneven distribution of niobium and areas of uneven mutual distribution of zirconium and molybdenum.
- The increase in molybdenum content contributed to growth of the microhardness and the formation of new phases, including a ternary phase: MoNbZr (03-065-7204) Fd3̄m.

Elemental high-purity metal powders

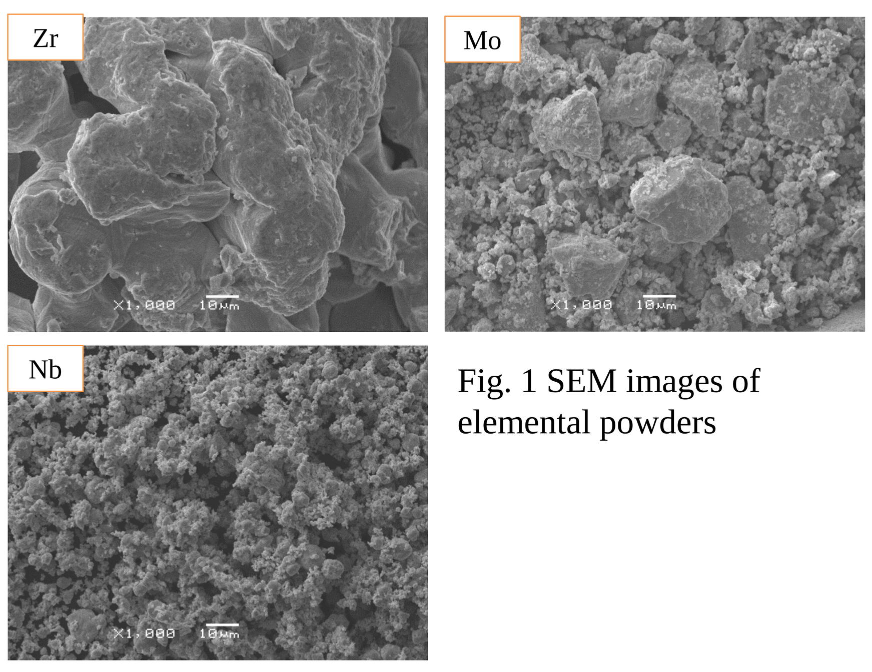

Fig. 1 SEM images of elemental powders

Initial chemical composition of alloys in wt. %

Sample number	Element content [wt. %]		
	Zr	Nb	Mo
J0	90	10	0
J2	88	10	2
J4	86	10	4
J6	84	10	6
J8	82	10	8
J10	80	10	10
J12	78	10	12
J14	76	10	14

Vacum arc melting

- **1.2 Bar**
- **Protective gas: argon**
- **Gas remains removal with high purity Ti-getter before smelting**

Microstructure analysis (OM & SEM)

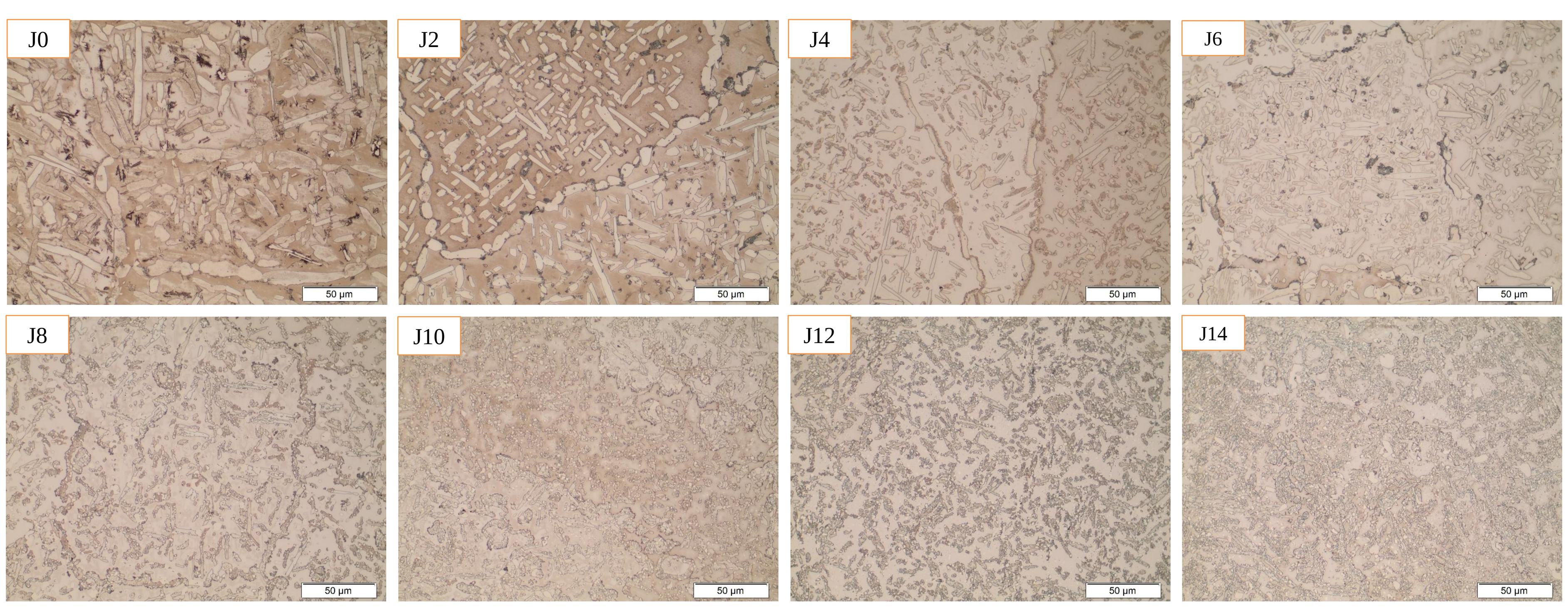

Fig. 2 OM images of samples microstructures (scale bar = 50μm)

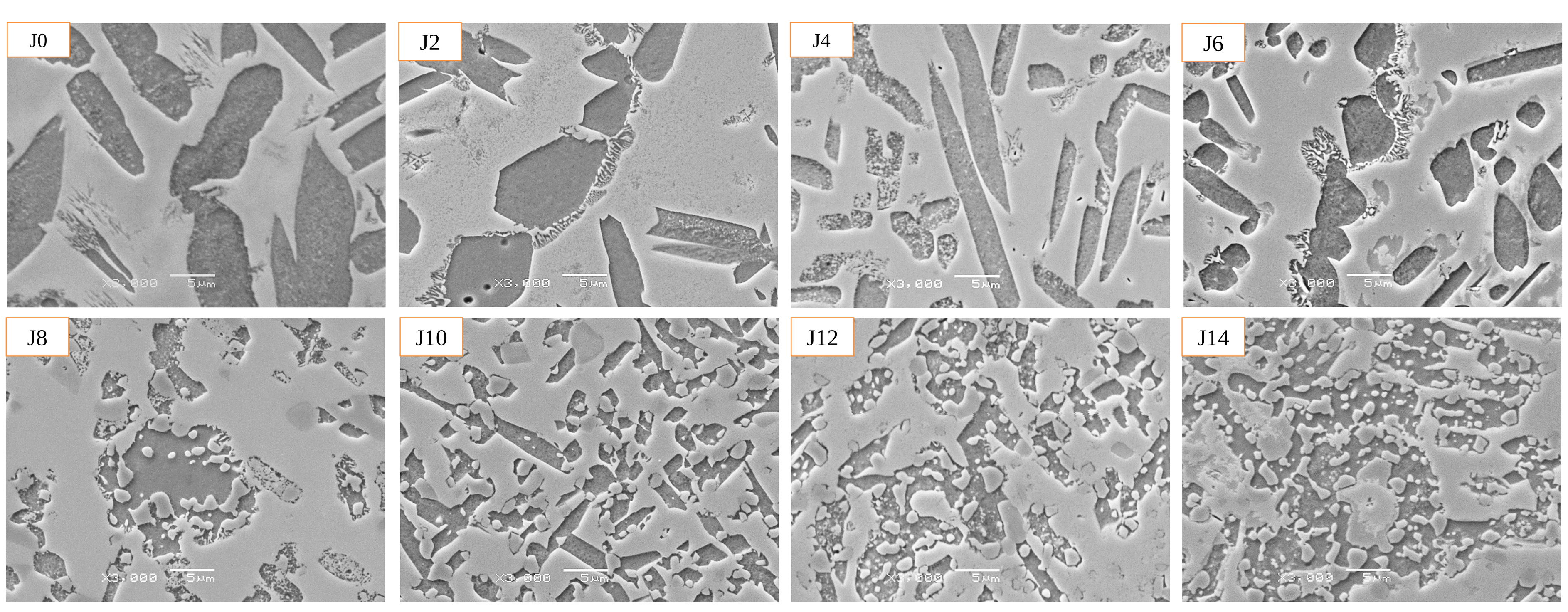

Fig. 3 SEM images of samples microstructures (scale bar = 5μm)

Phase analysis (XRD)

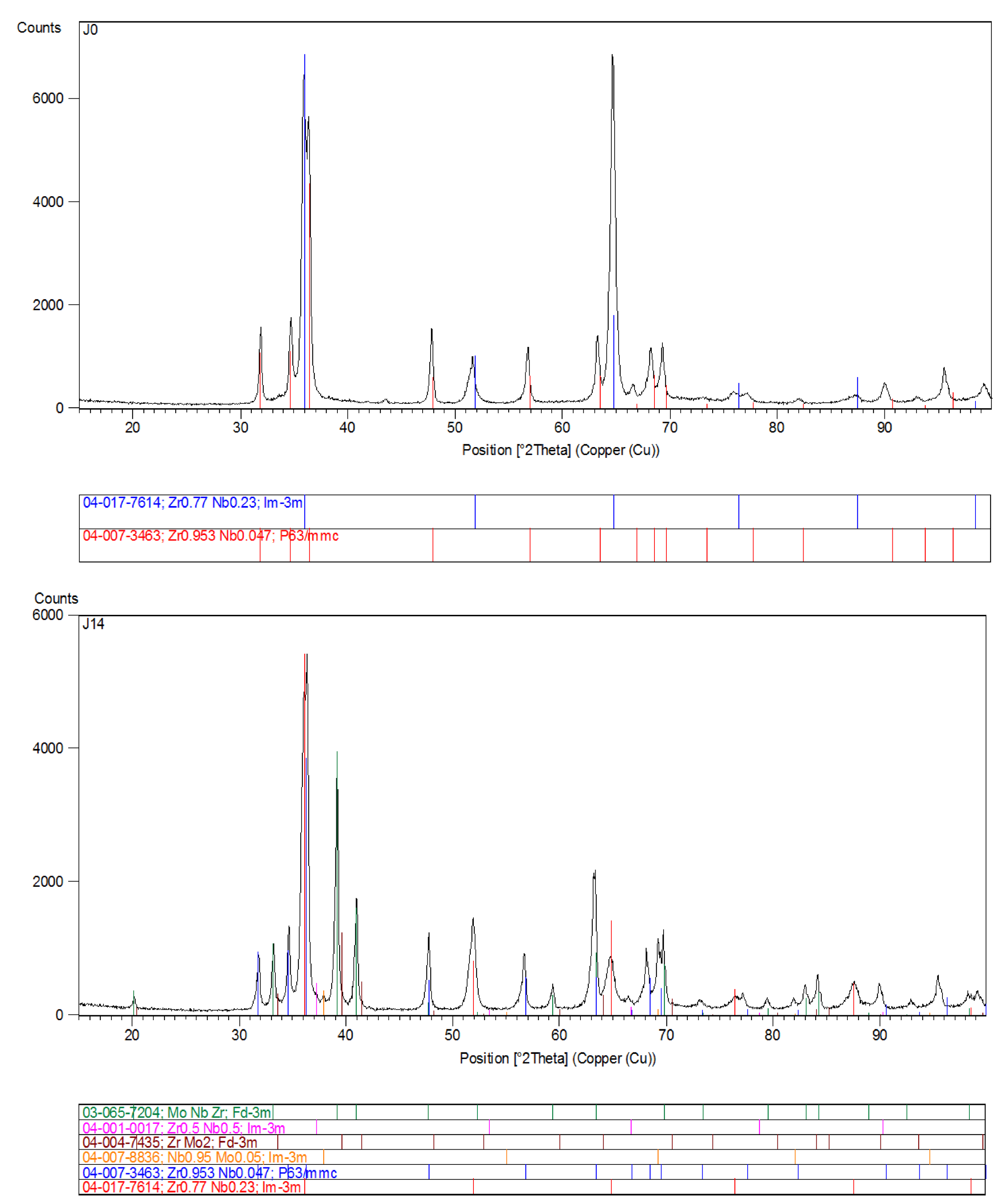

Fig. 4 Diffractograms for the two selected samples: J0 and J14

Elements distribution mapping (EDS)

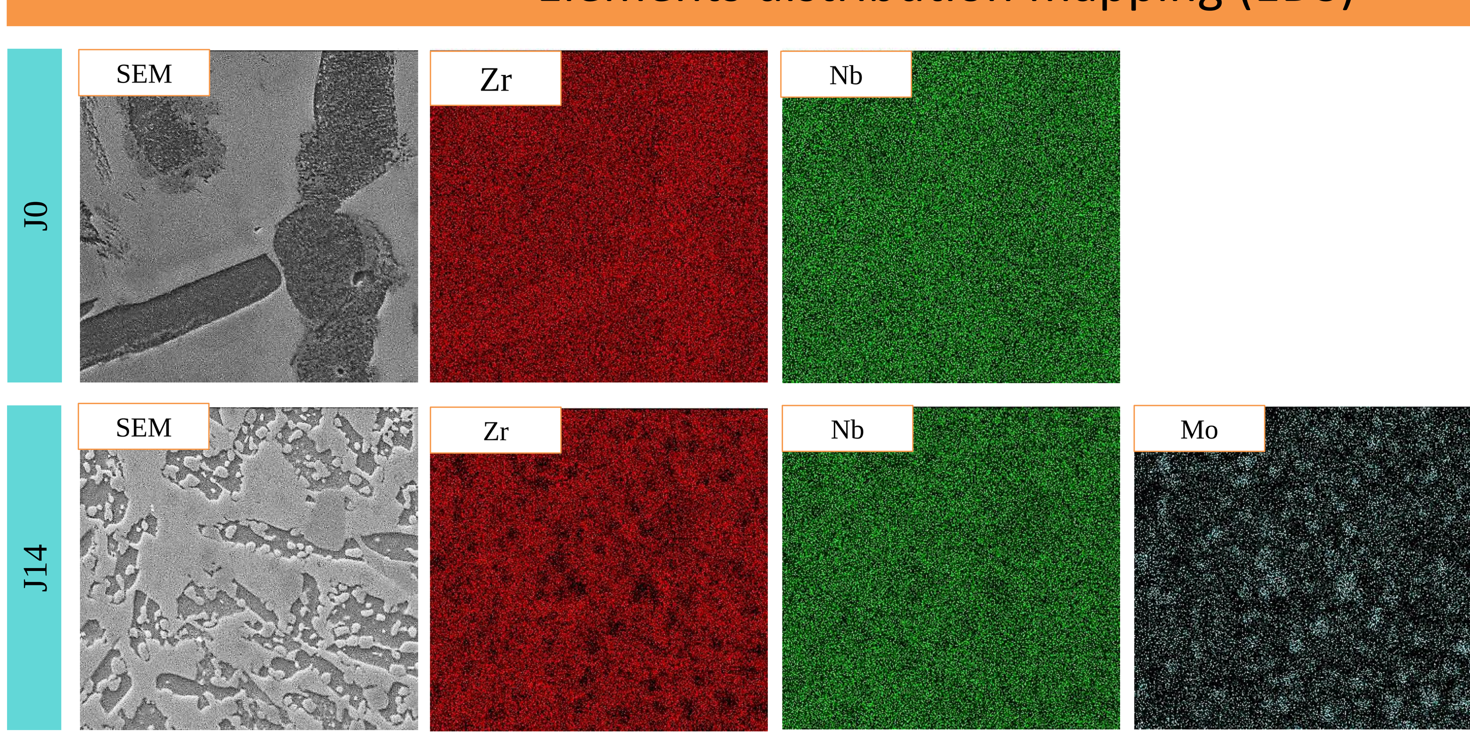

Fig. 5 Distribution of elements: Zr, Nb and Mo in samples J0 and J14

Microhardness $HV_{0.5}$

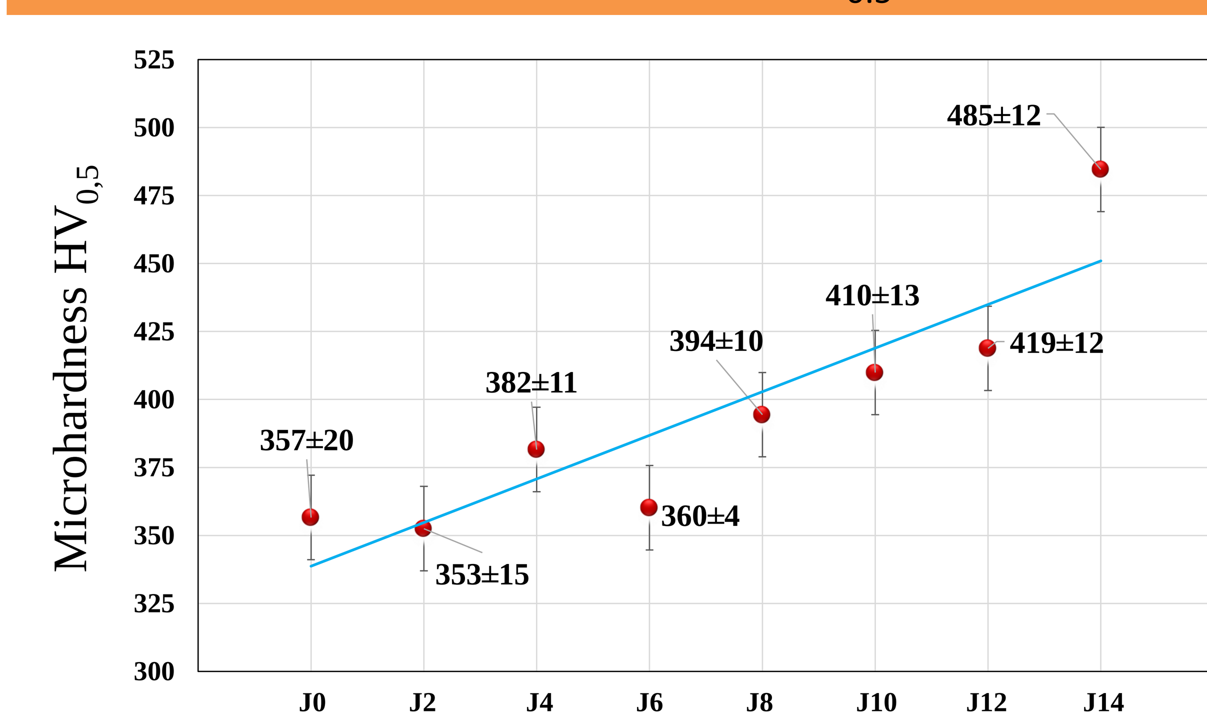

Fig. 6 Vickers microhardness as a function of the samples number