Relaxation time shift of Cobalt related internal friction peak in WC-Co cemented carbide

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Introduction

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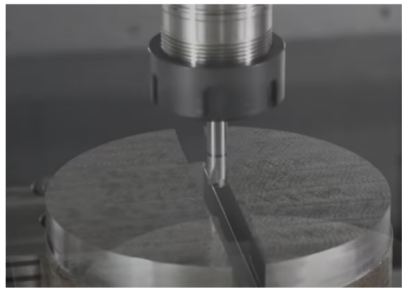
- Hardness
- Toughness
- Wear resistance



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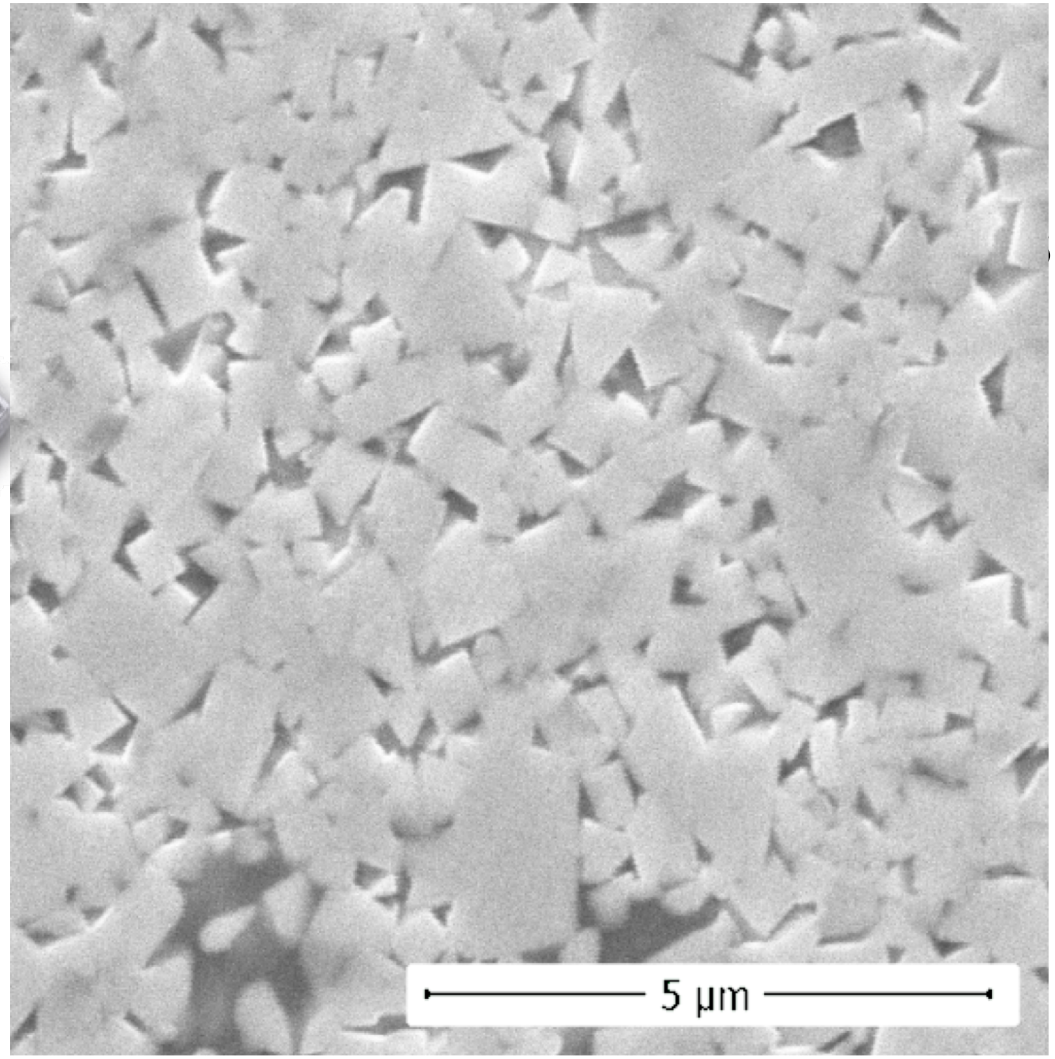

Introduction

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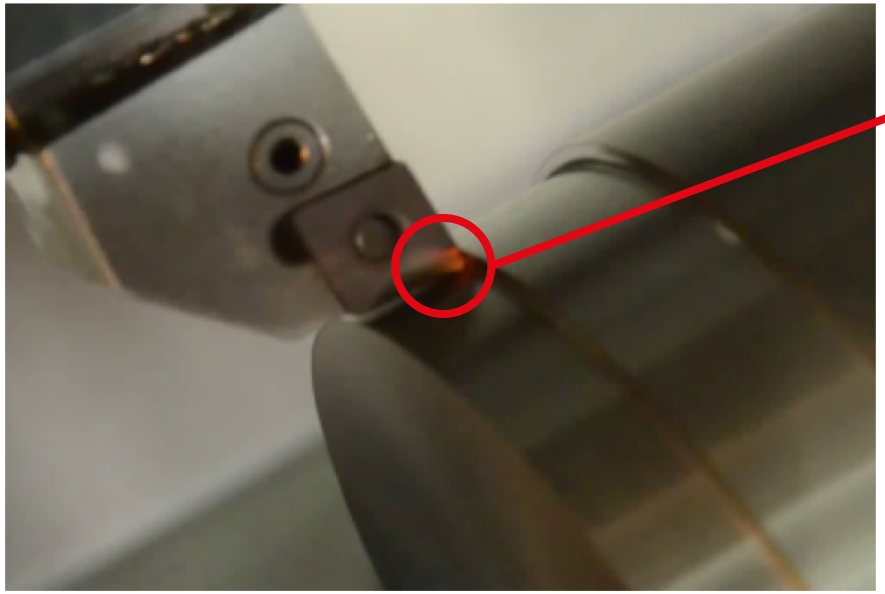
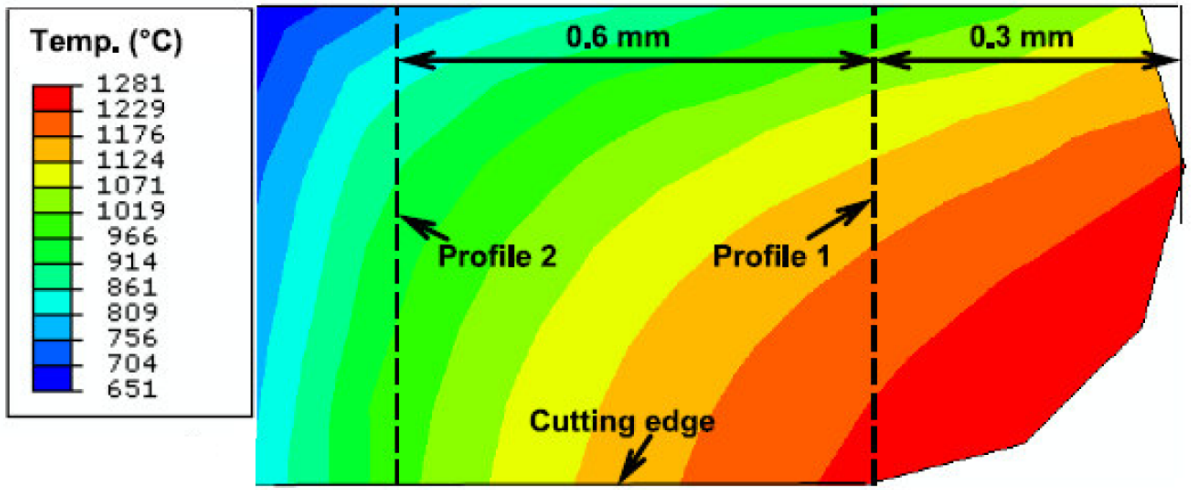




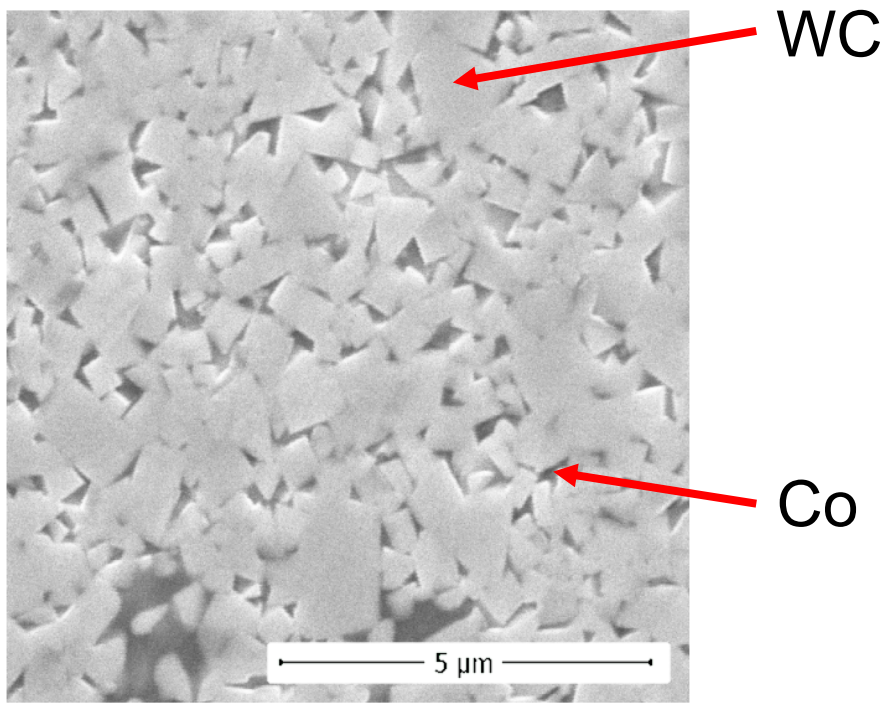
Kagnaya, Tchadja, et al. "Temperature evolution in a WC-6% Co cutting tool during turning machining: experiment and finite element simulations." *WSEAS Transactions on Heat and Mass Transfer* 6.3 (2011): 71-80

Agenda of this presentation

- Overview of the WC-Co structure
- WC-Co spectrum
- Focus of the second relaxation peak
- Comparing the frequency and temperature scans

WC-Co structure

The structure is composed of WC grains with a Co binder



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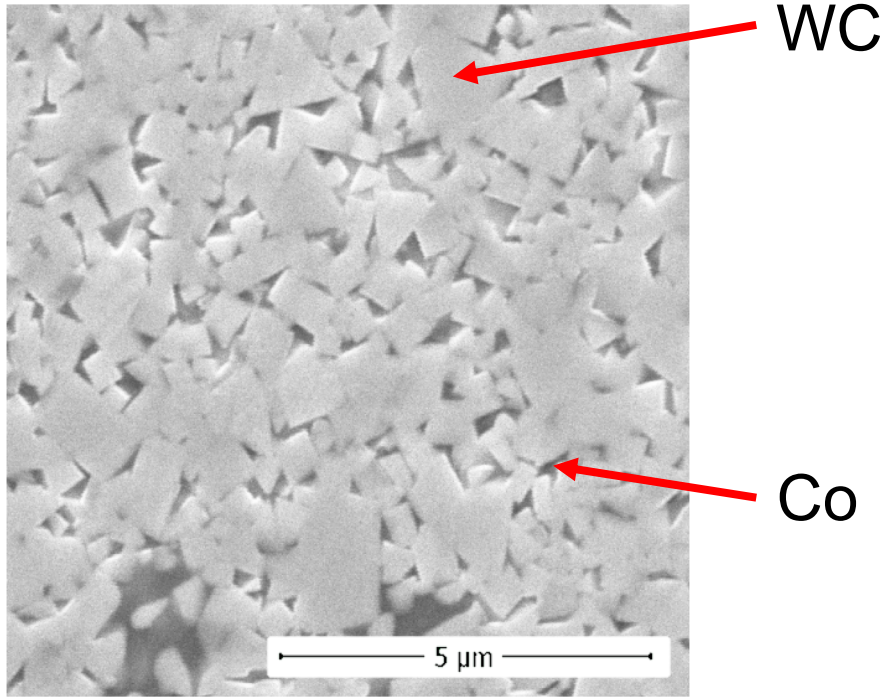
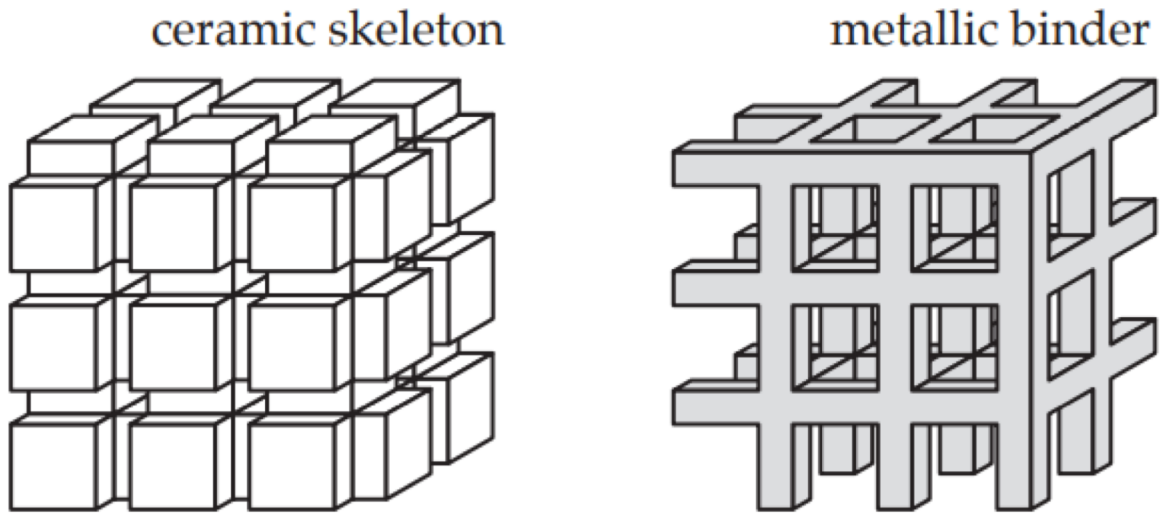
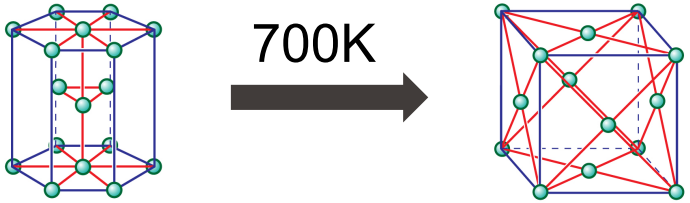


The two phases form continuous interpenetrated skeletons



WC-Co structure

Free Co undergoes a phase transition around 700 K.



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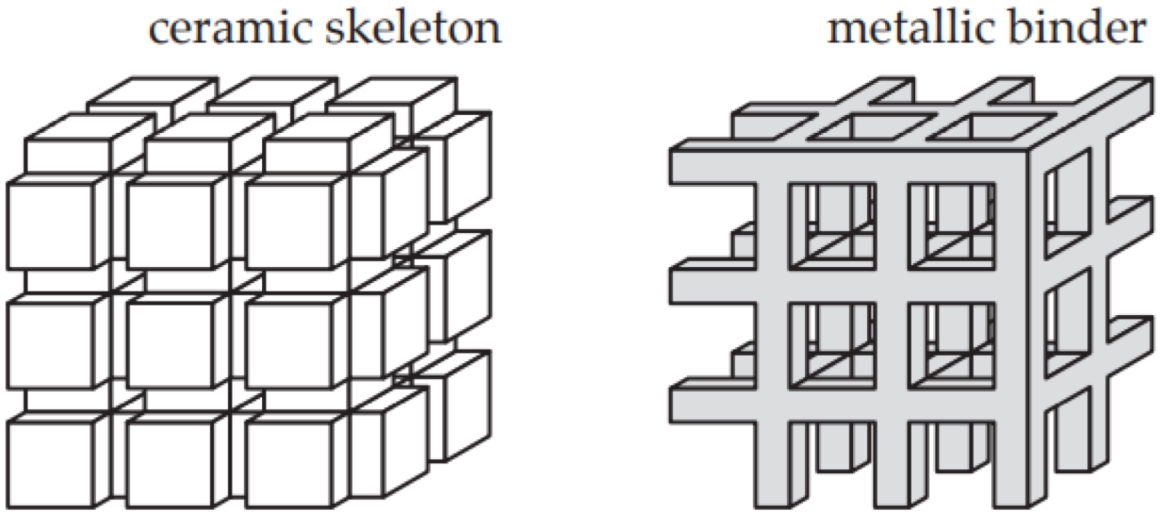

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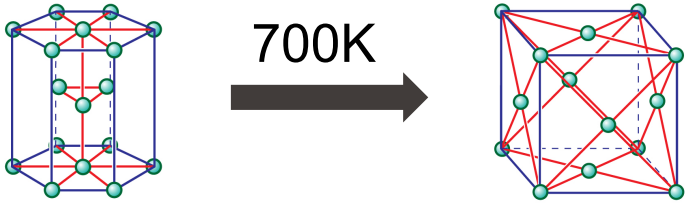
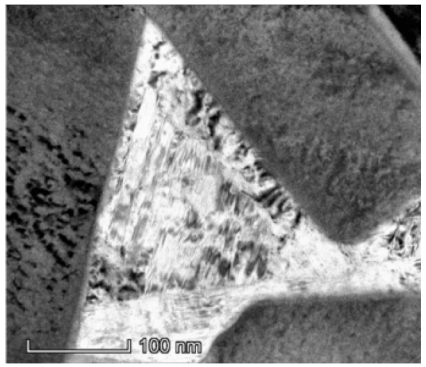


This transition does not appear in the WC-Co structure.



Adjam, S., D. Mari, and T. LaGrange. "Strain glass transition of cobalt phase in a cemented carbide." *International Journal of Refractory Metals and Hard Materials* 87 (2020): 105161

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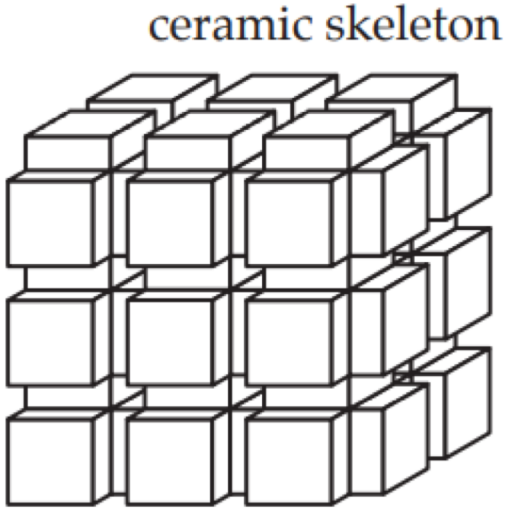

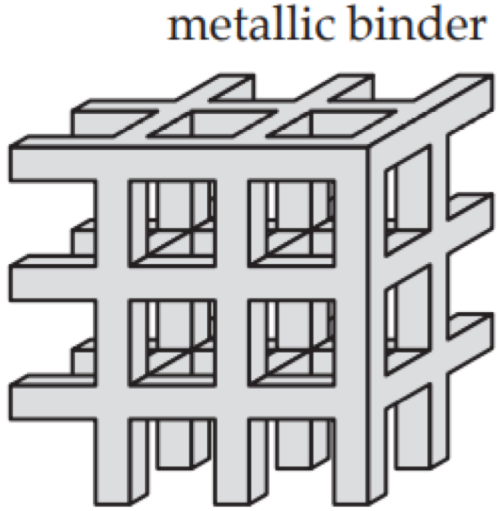

Material and experimental method

This study used WC-6wt.%Co and WC-10wt.%Co samples.

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The measurements were performed at subresonant frequency.

Between 700 K and 1350 K

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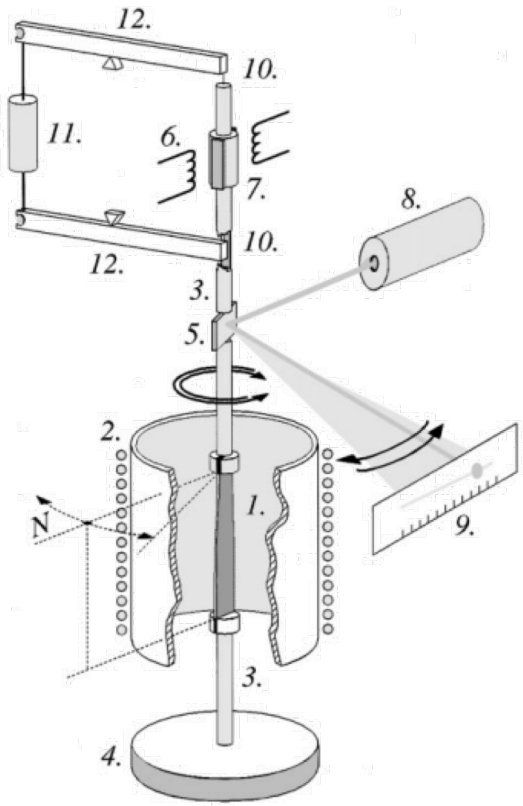

1 Sample
2. Oven
3. Mounting rod
4. Inertial weight
5. Mirror
6. Helmoltz coils
7. Magnet
8. Laser
9. Photocell
10. Tensioning wire
11. Balance weight
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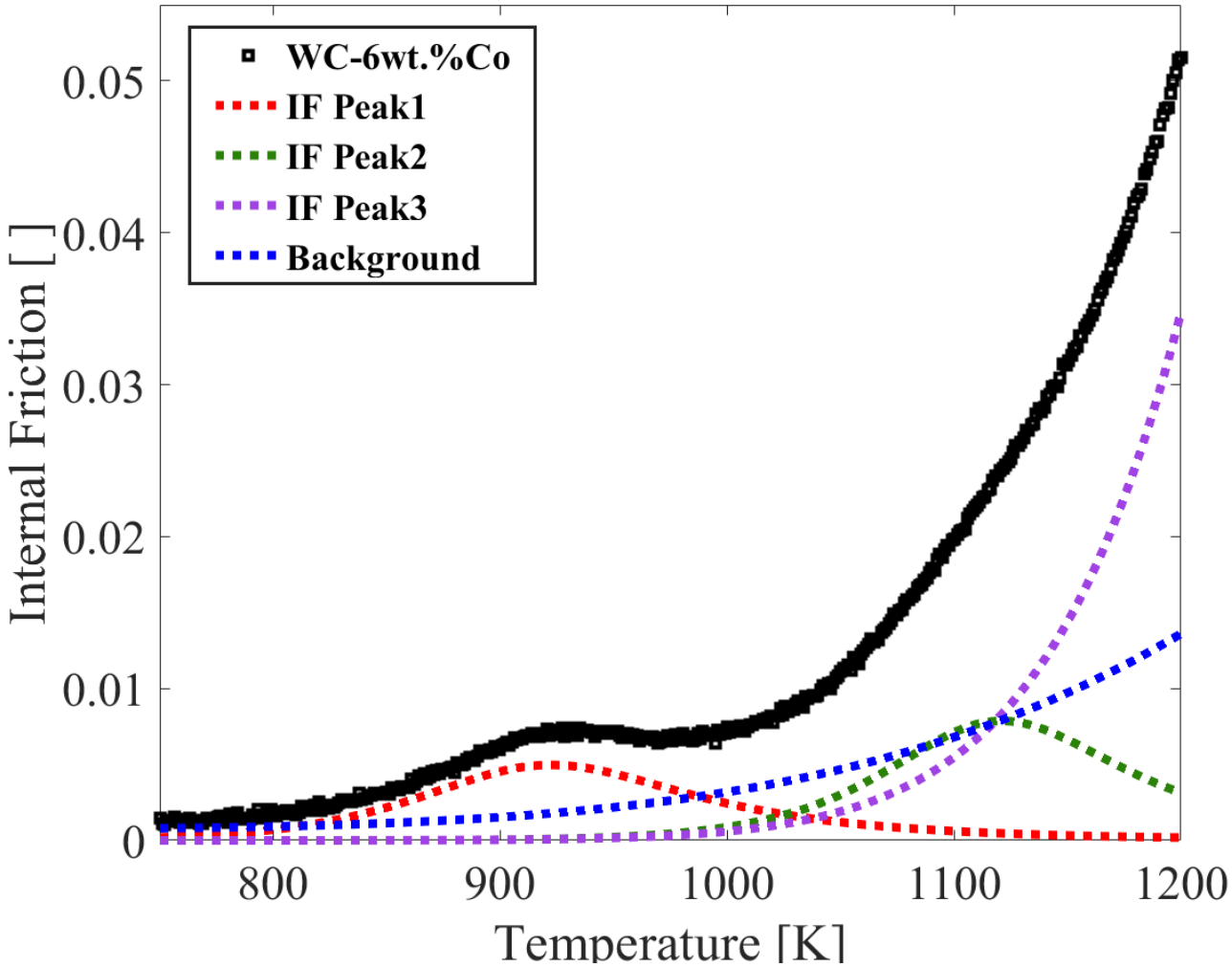
The Curie temperature was measured using a thermogravimeter as a high temperature magneto-meter.

WC-Co spectrum

A temperature scan between 700 K and 1200 K at 1 K/min and 1 Hz reveals 3 peaks.



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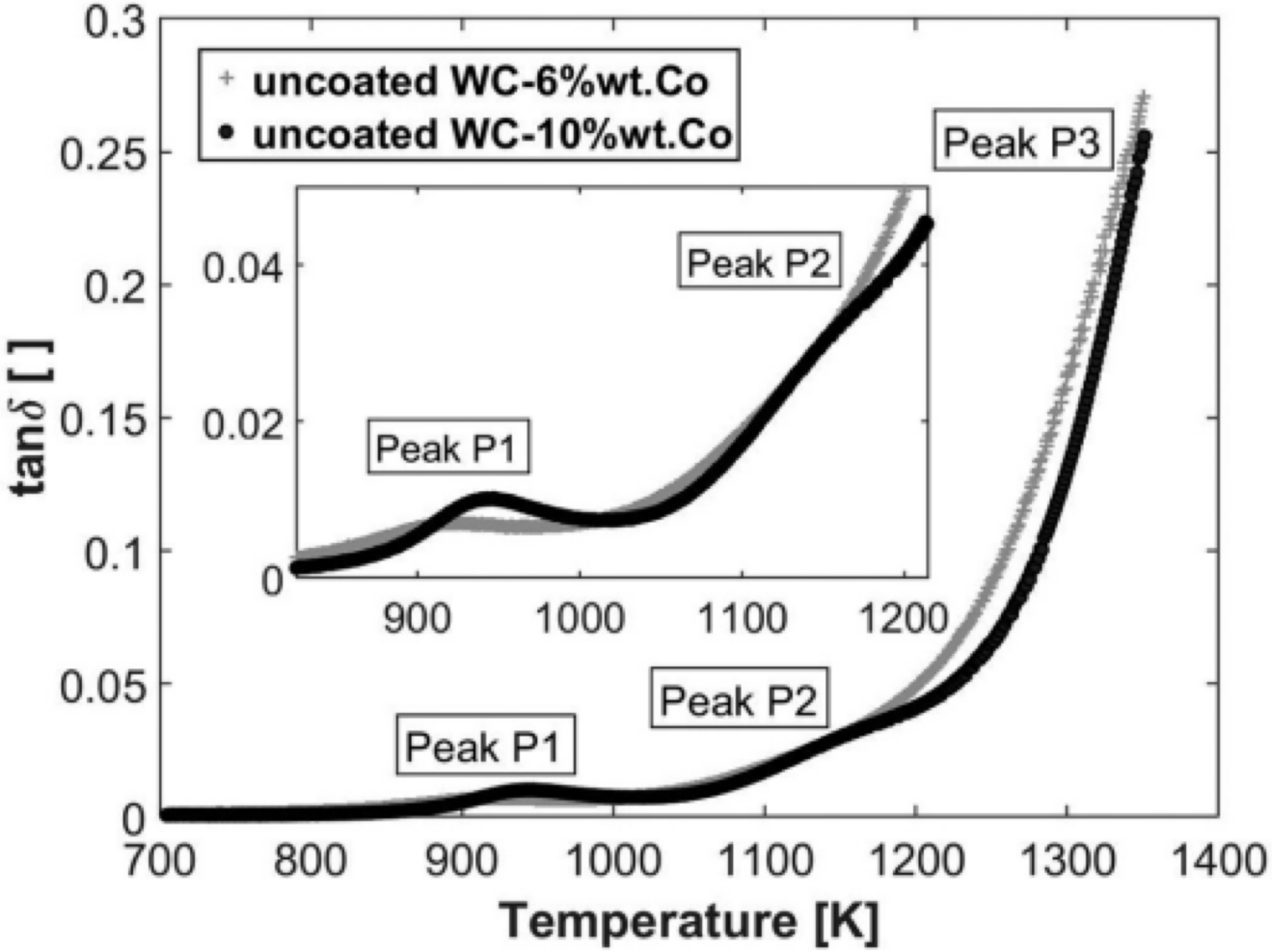

Adjam, S., and D. Mari. "A link between durability of WC-Co coated cutting tools and mechanical damping spectra." *International Journal Of Refractory Metals & Hard Materials* 85.ARTICLE (2019): 105068.

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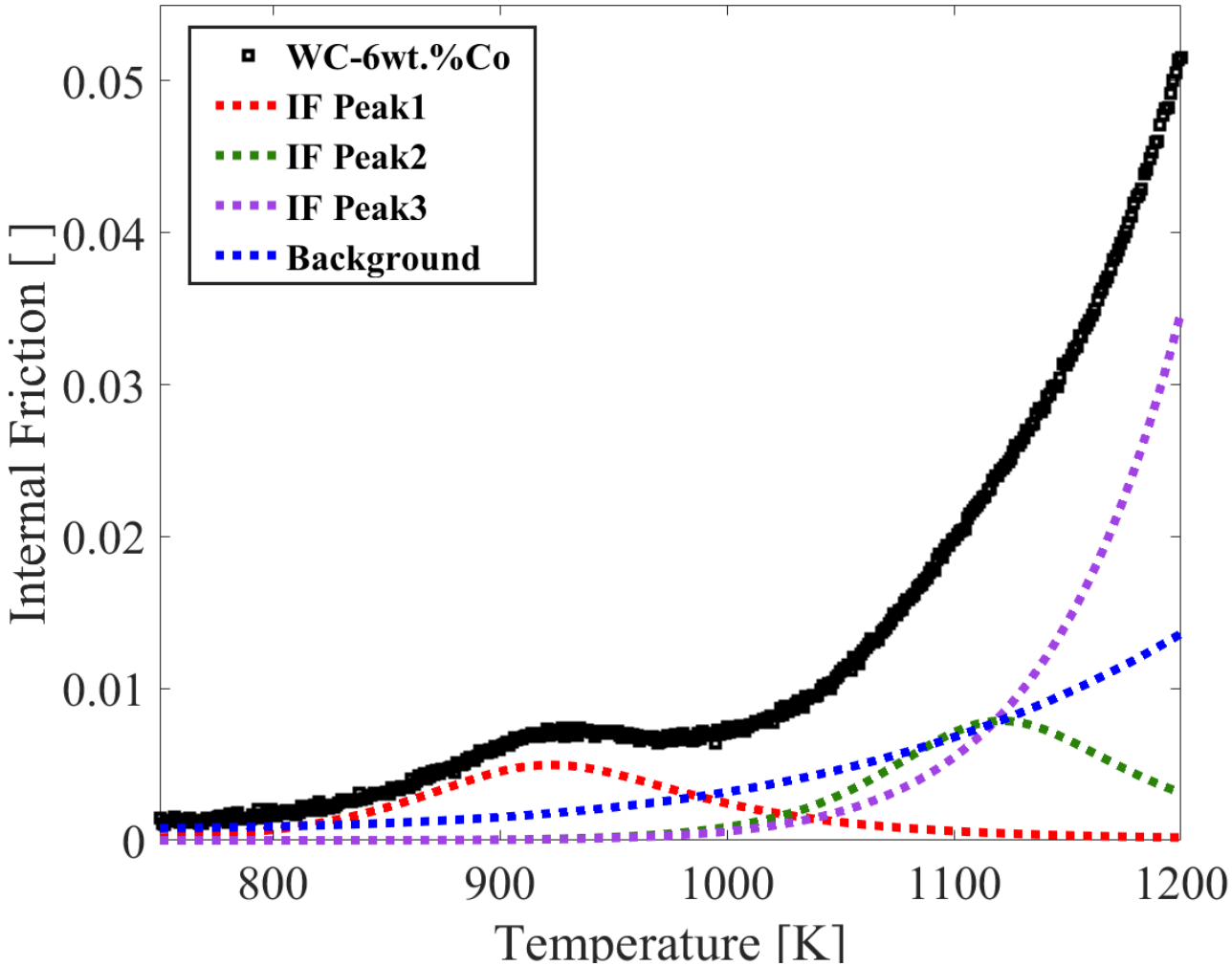

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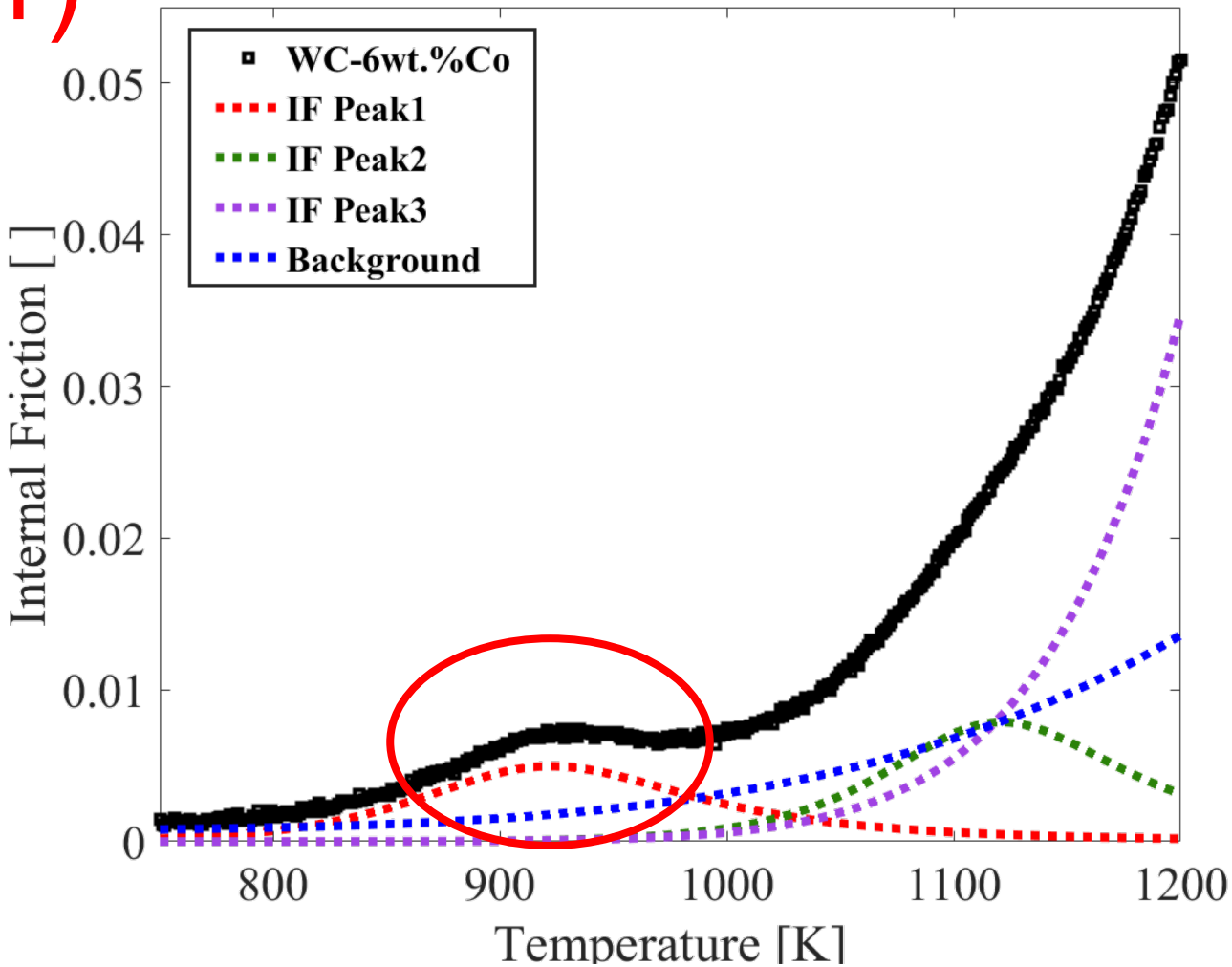
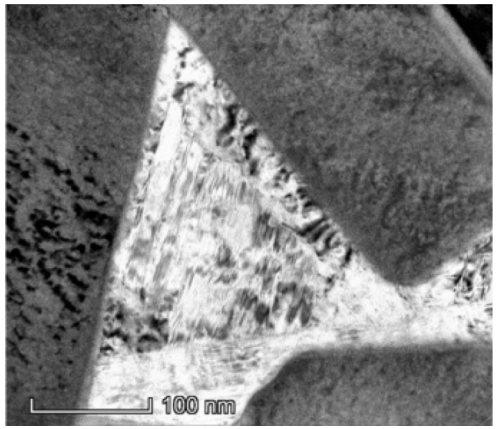
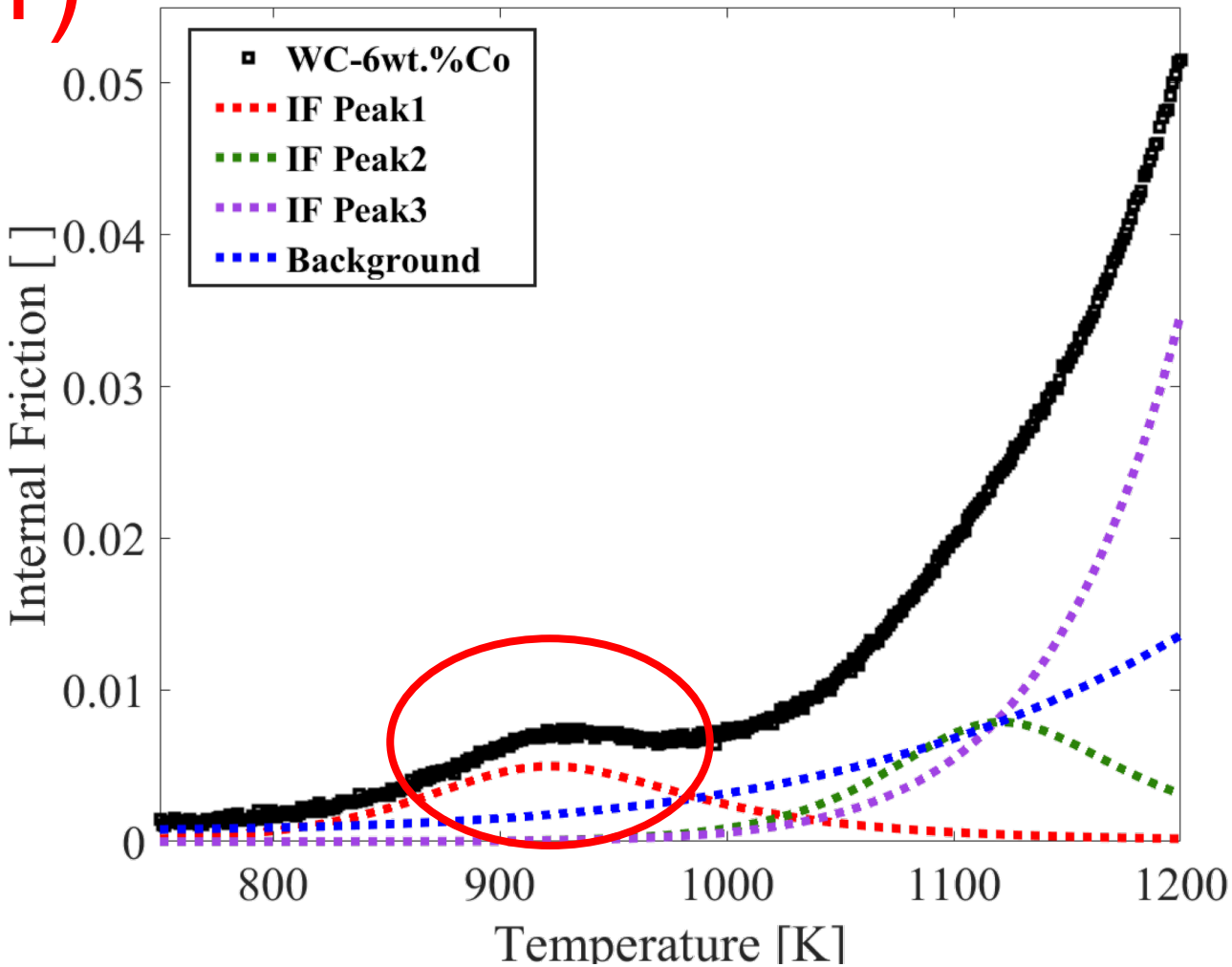


WC-Co spectrum (P1)

The first peak is related to the Co phase and is unstable.

It was associated to the nanotwinned structure of Co.





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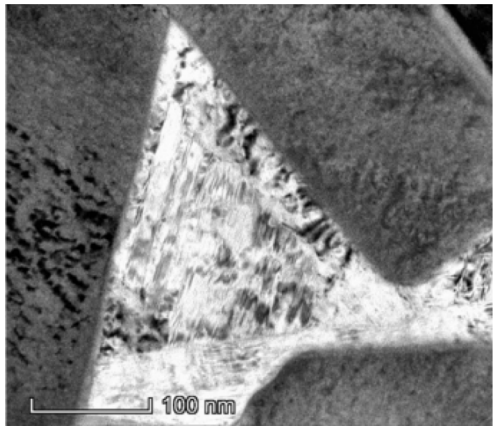

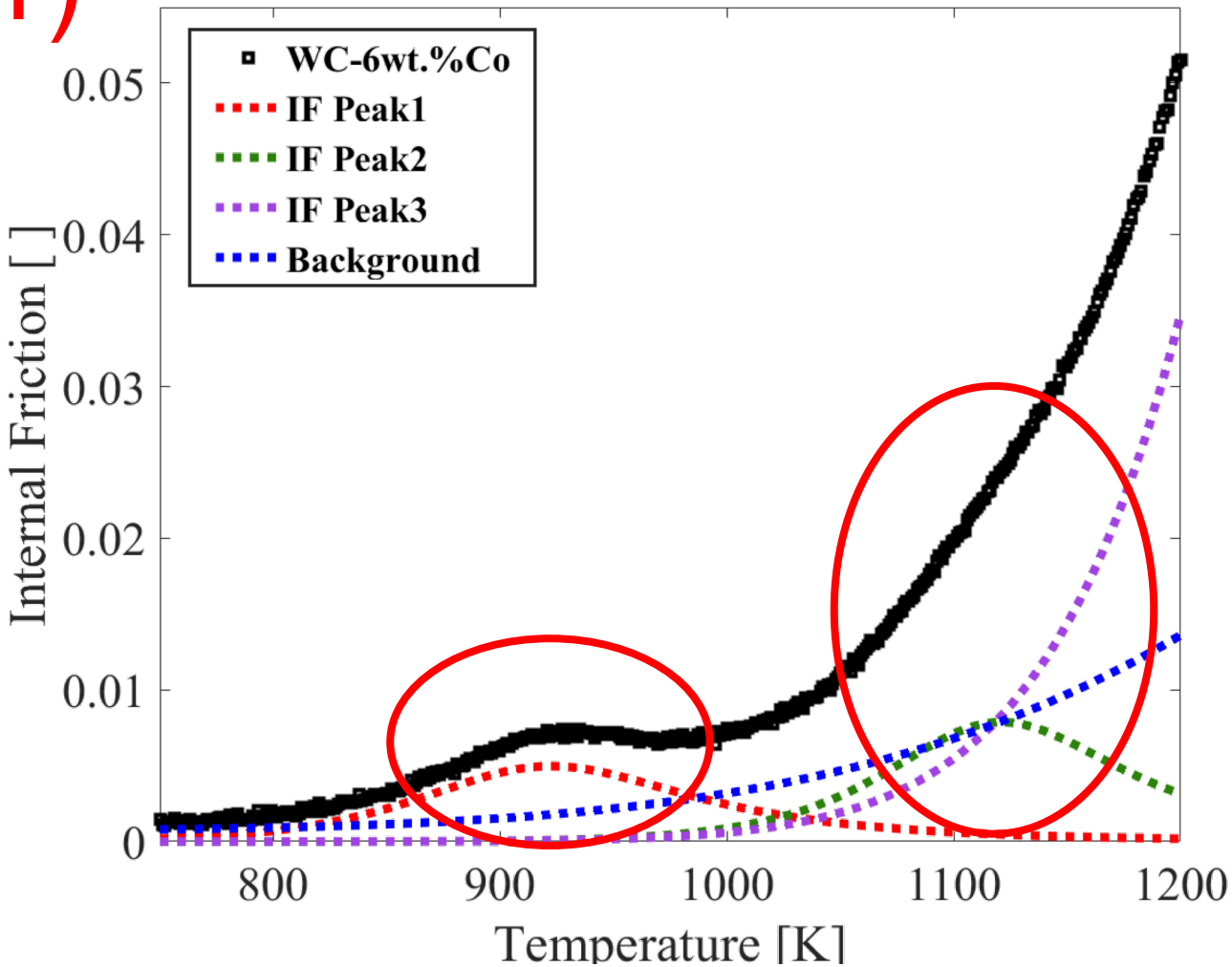

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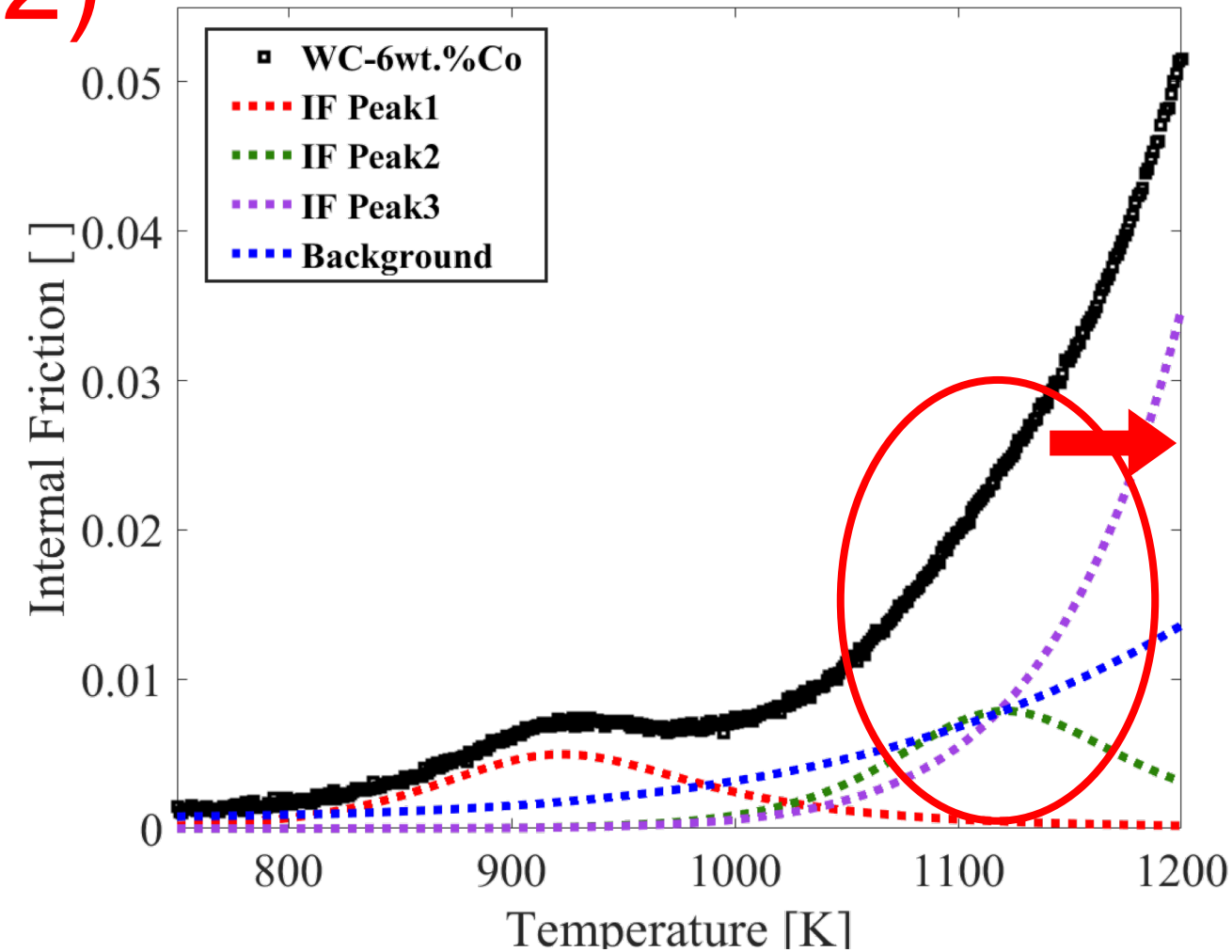
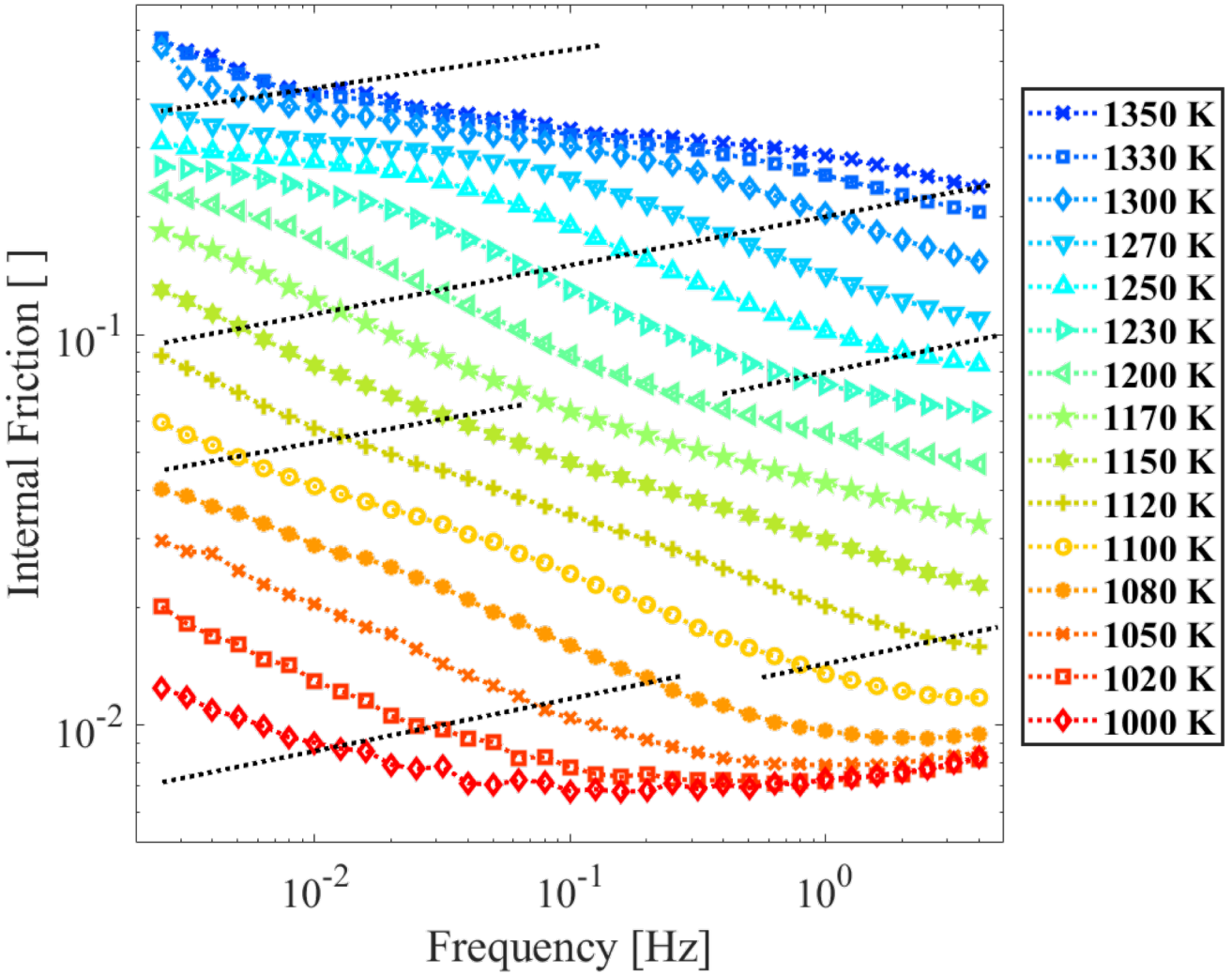
WC-Co spectrum (P2)

The second peak is related to the Co phase. It was stable during the temperature scans.



Frequency scans

Frequency spectra are measured between 1350 K and 1000 K, and between 4 Hz and 3 mHz.



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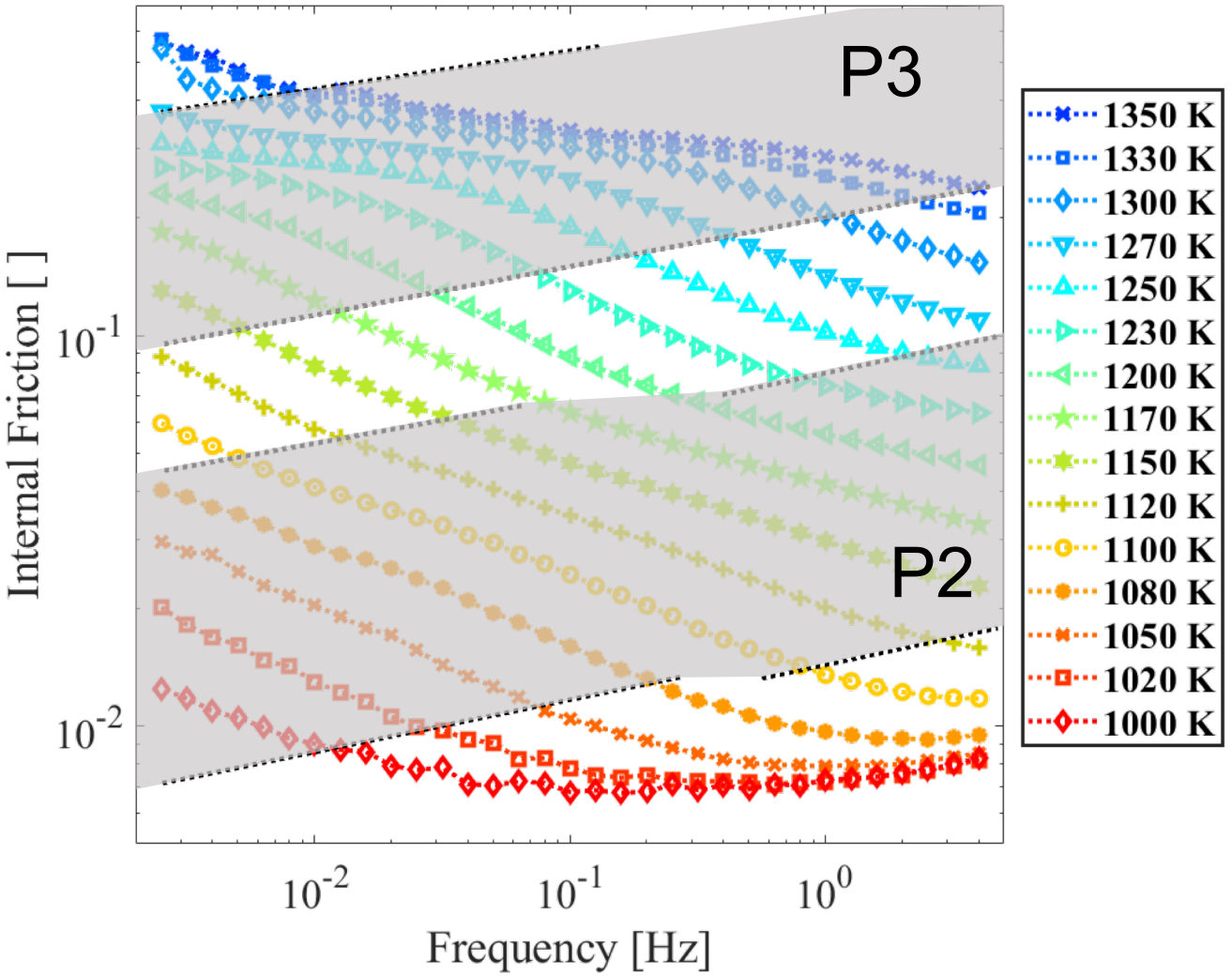
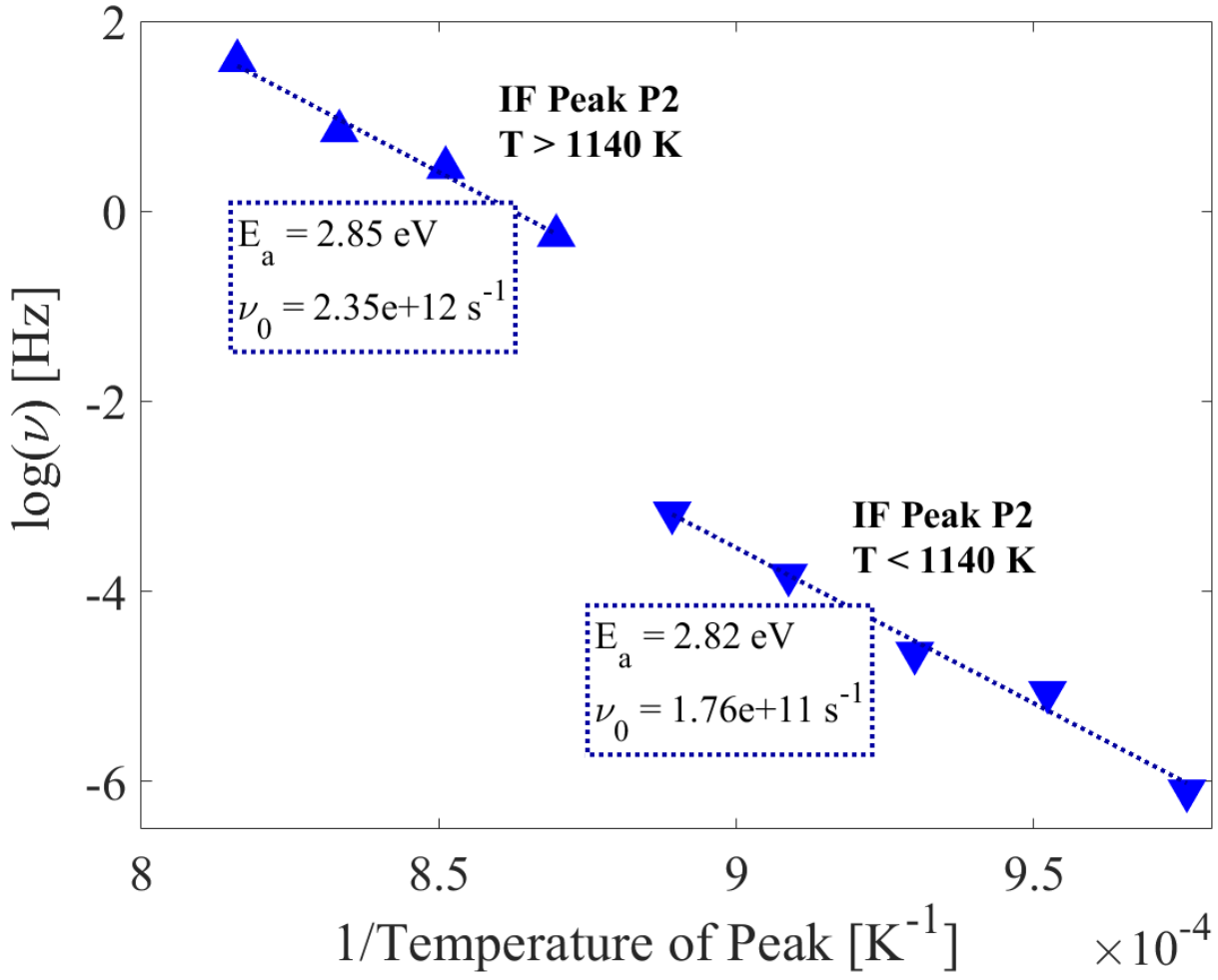


Arrhenius plot of P2

The couples of the temperature and the frequency of P2 are plotted in an Arrhenius plot.



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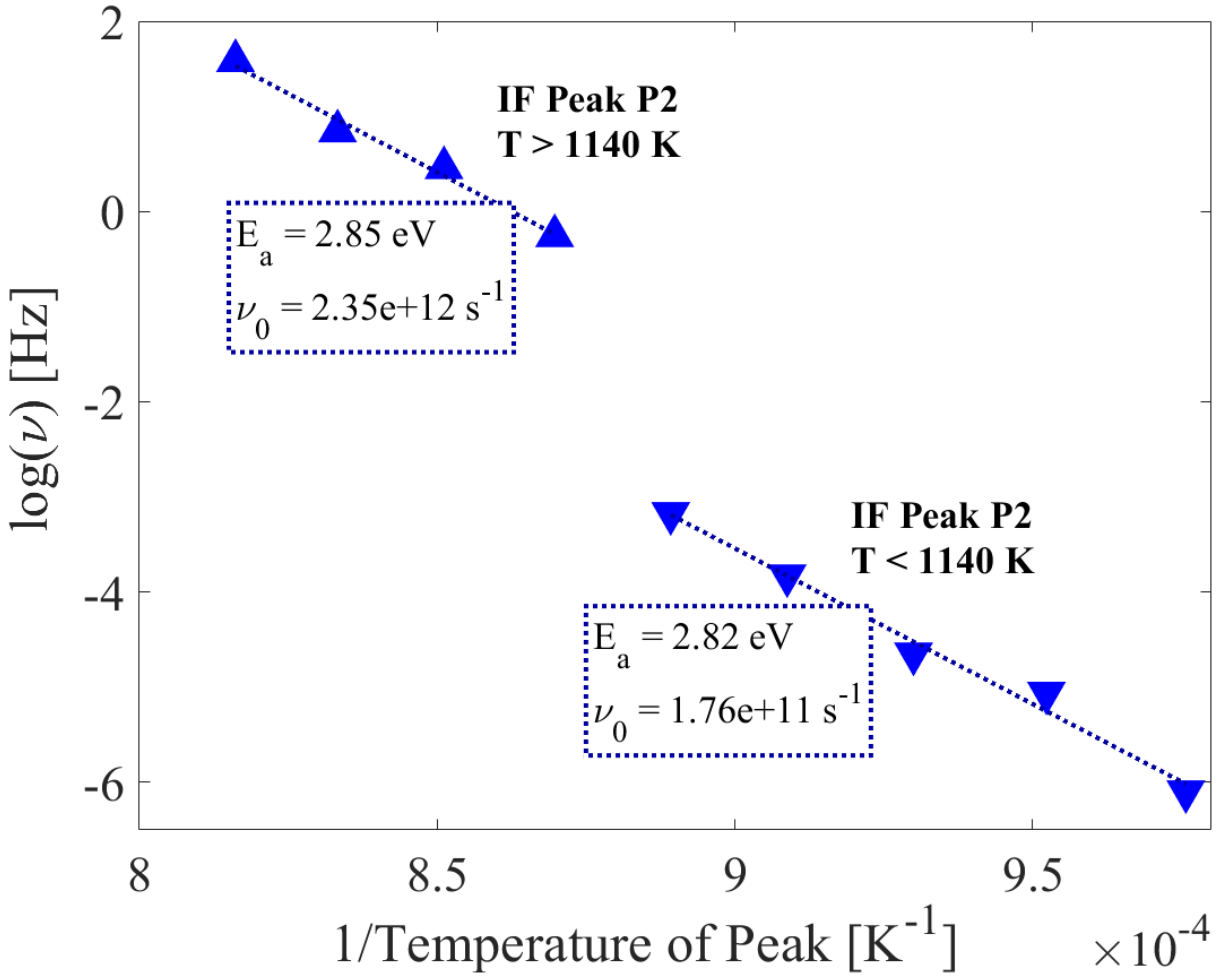
A shift at 1140 K is observable.



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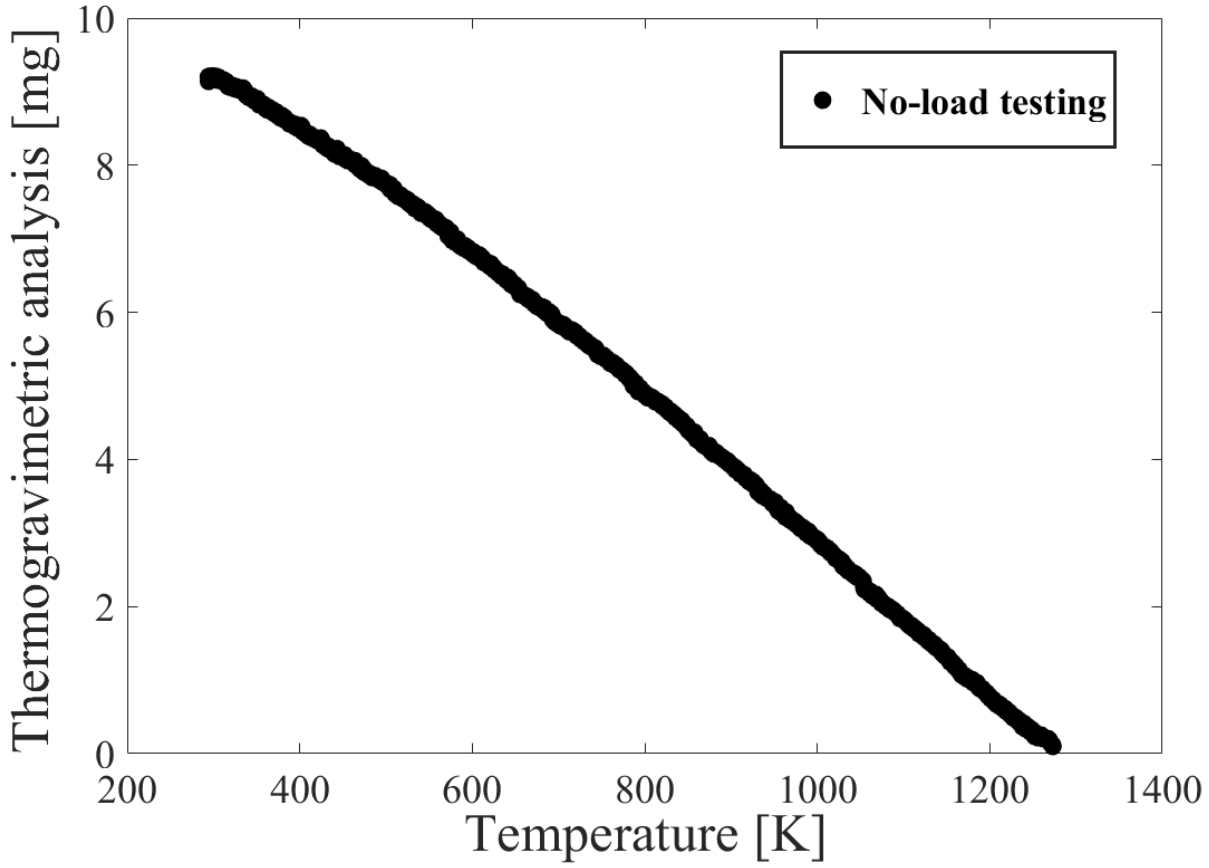

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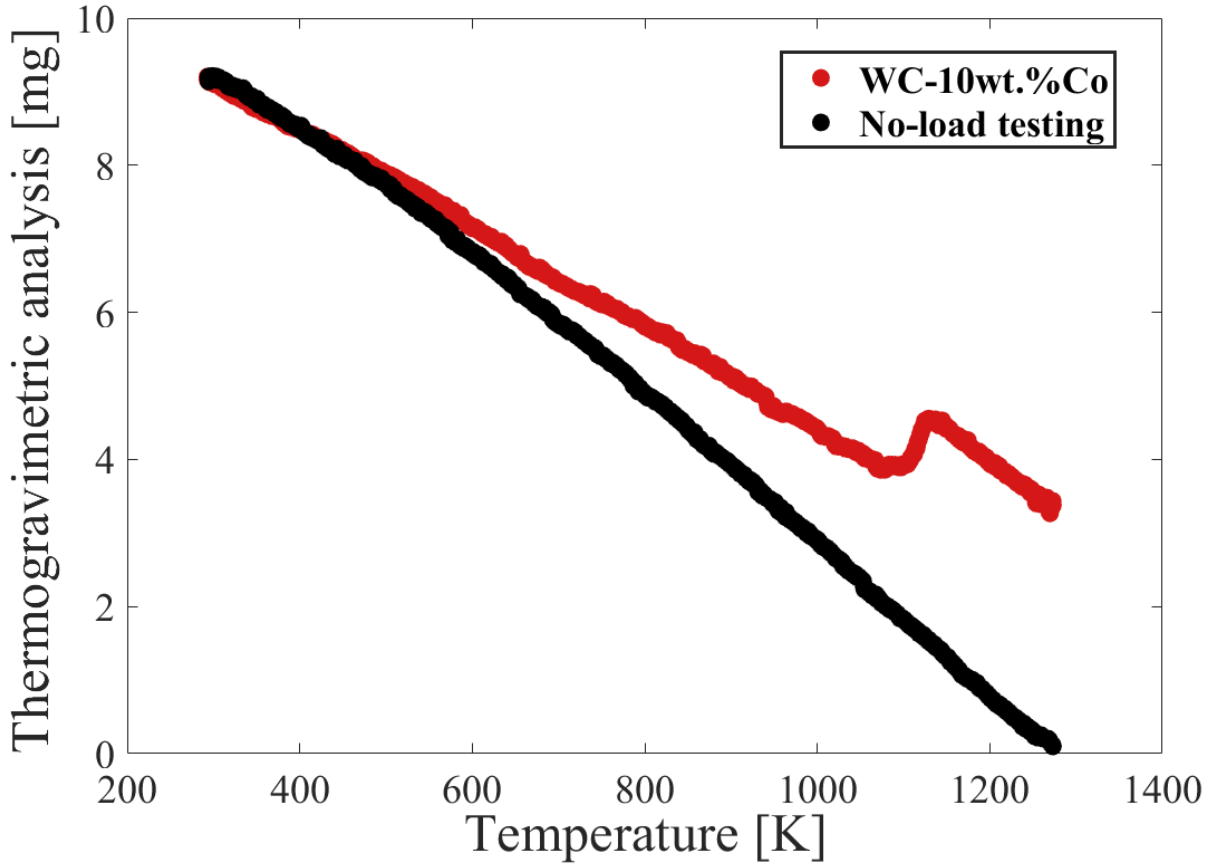
The addition of the magnetic field induces a variation in the measurement.



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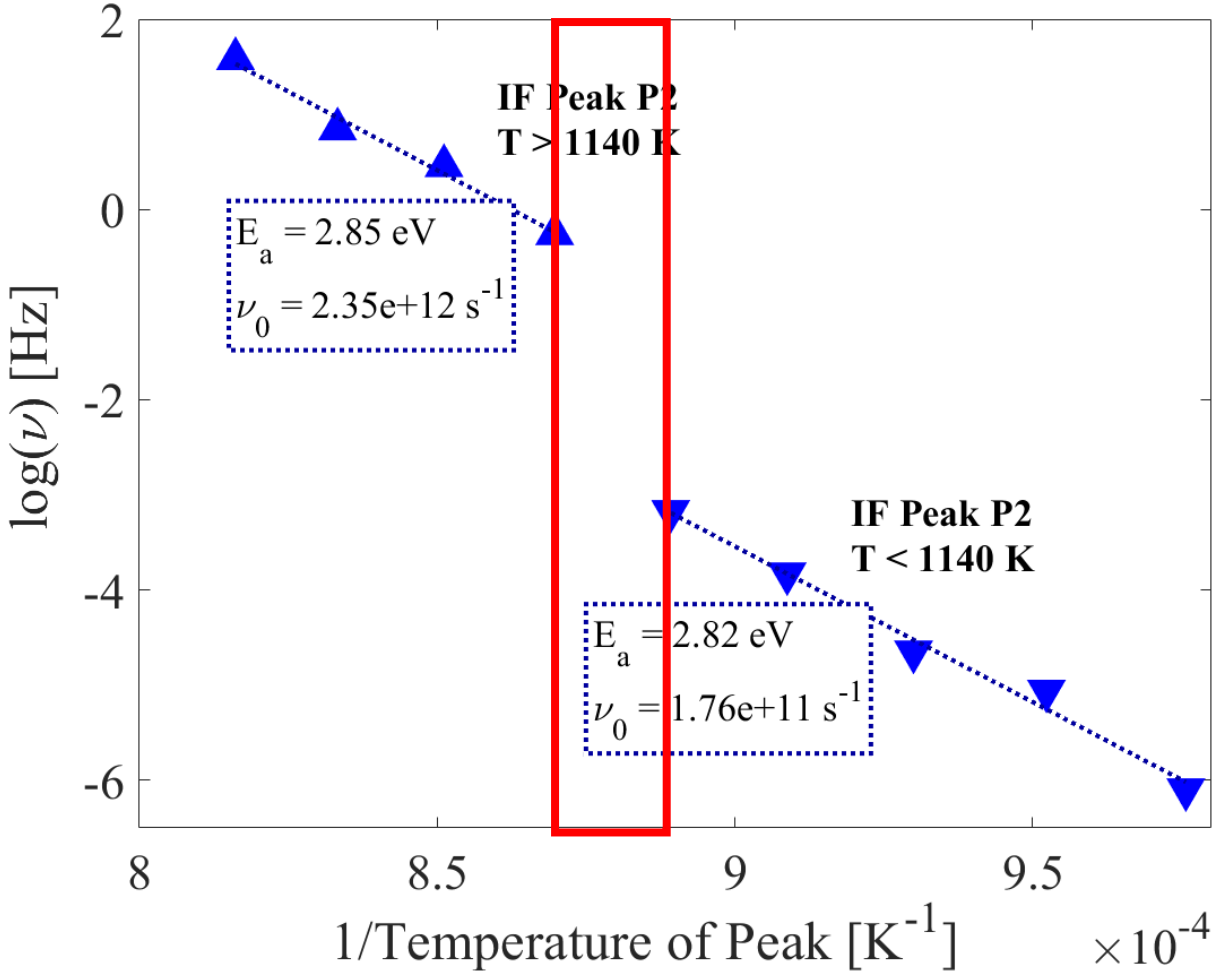
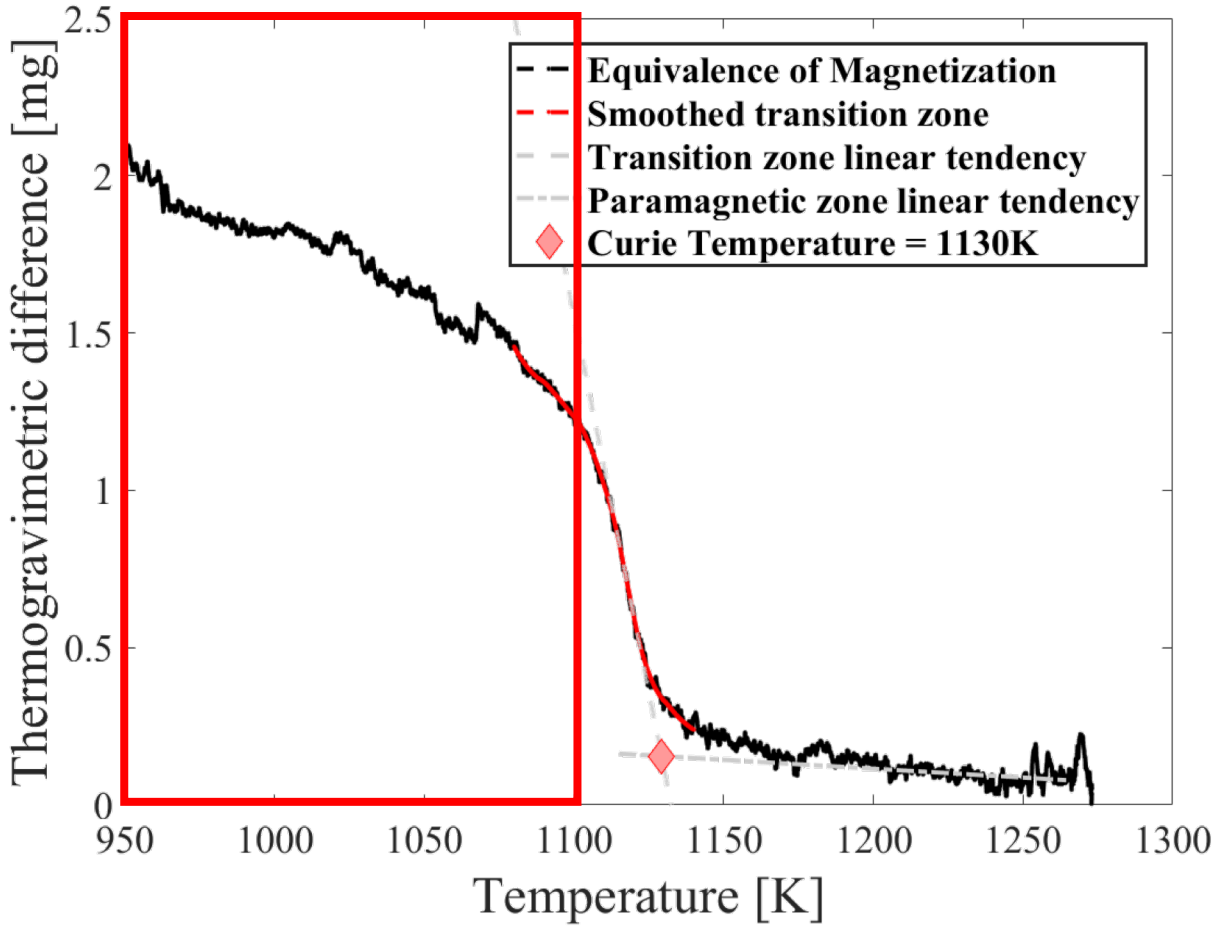
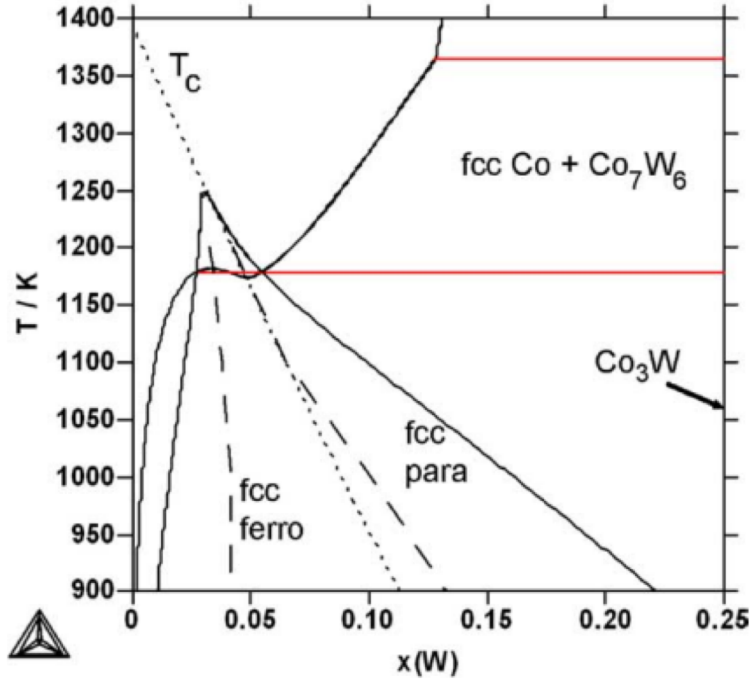




Interpretations of P2

The classical interpretation of P2 relates the shift to a change in the free length of the dislocations.



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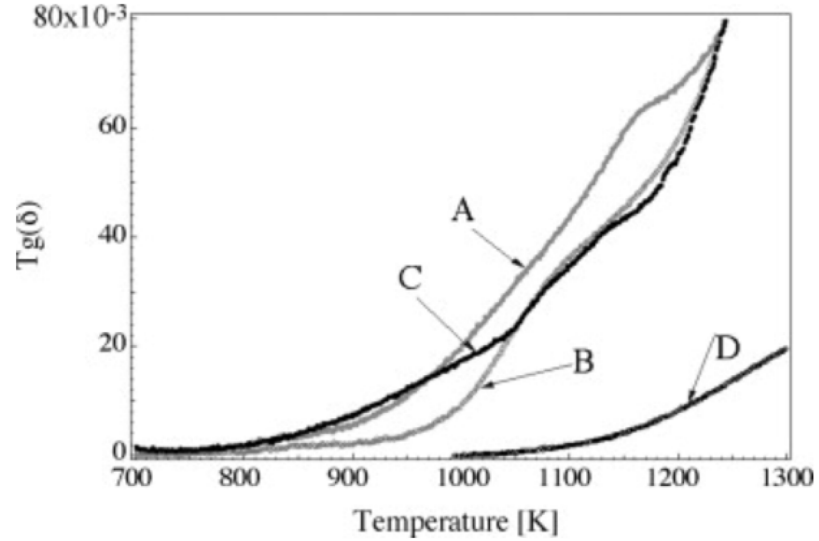

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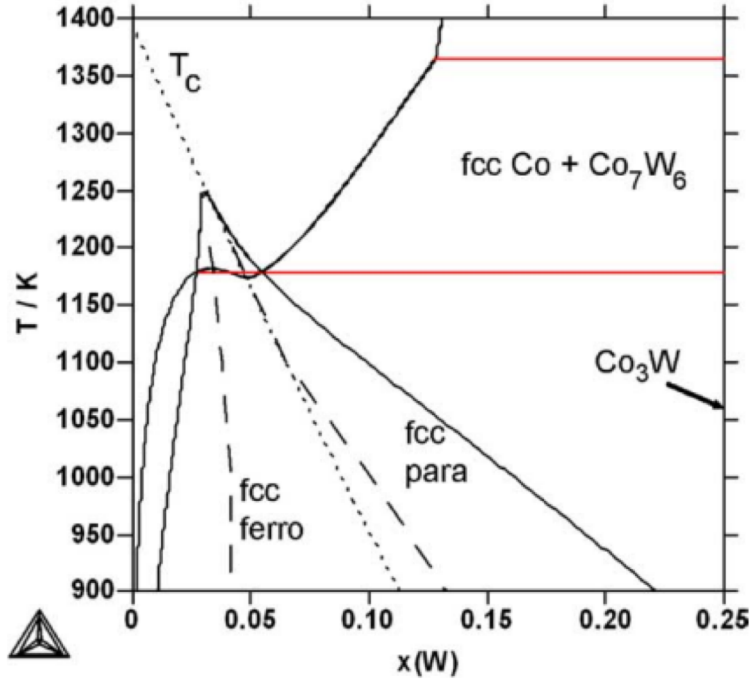

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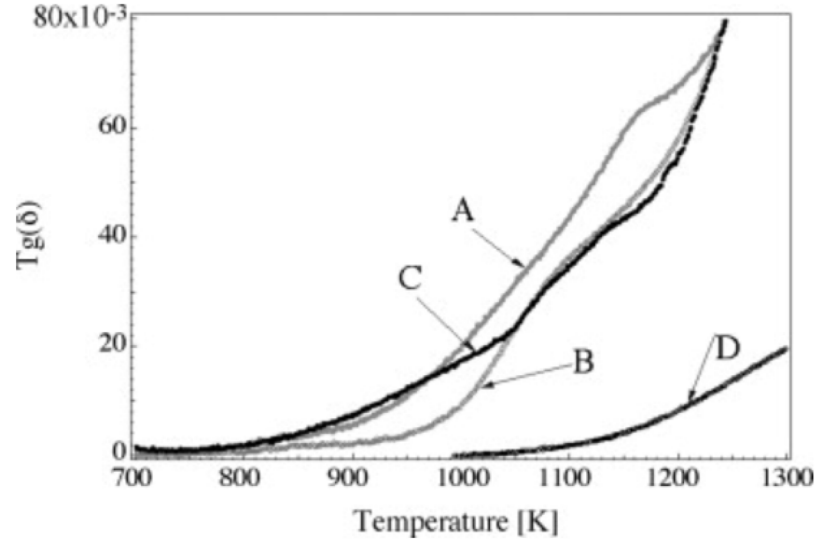

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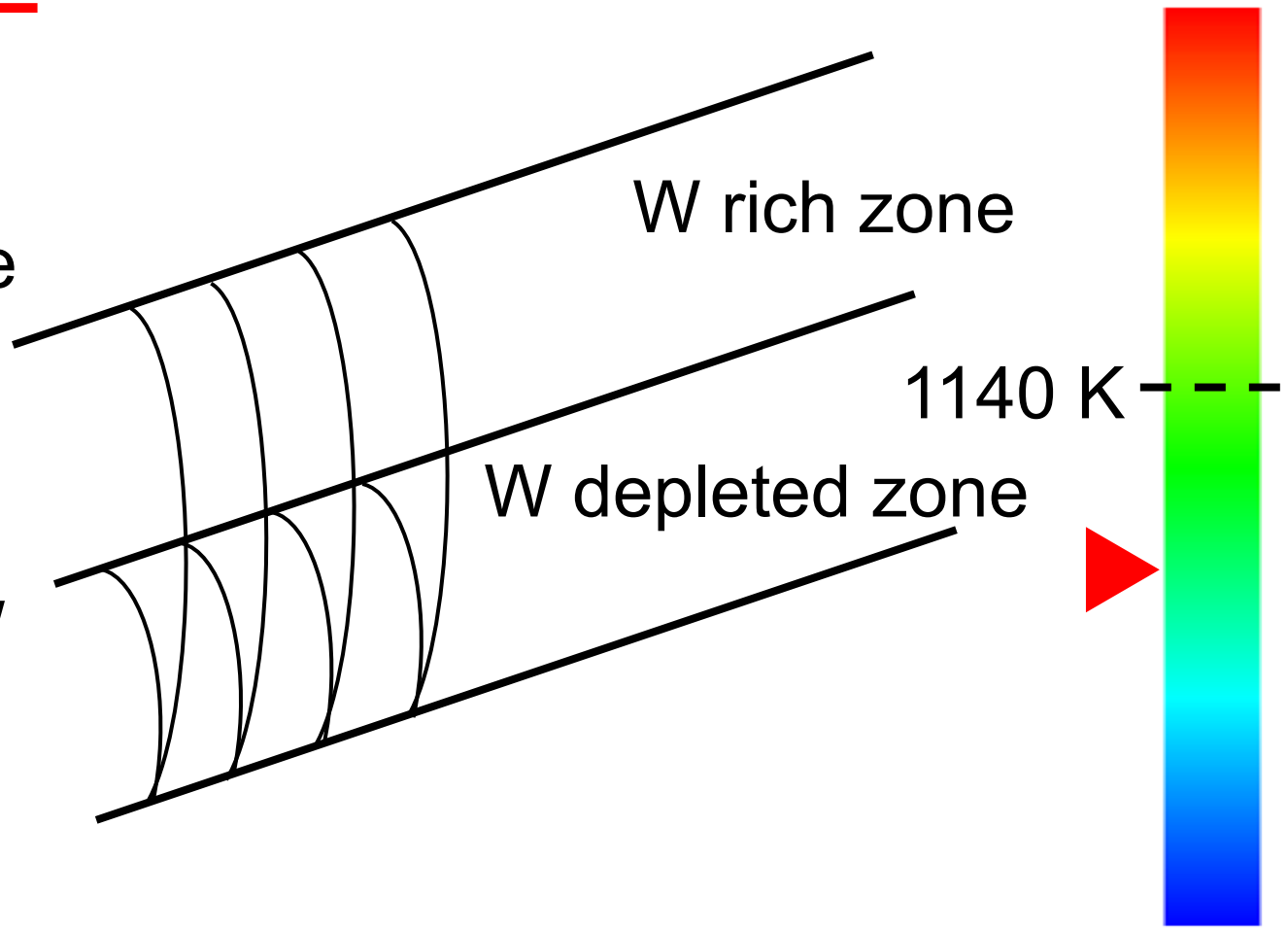

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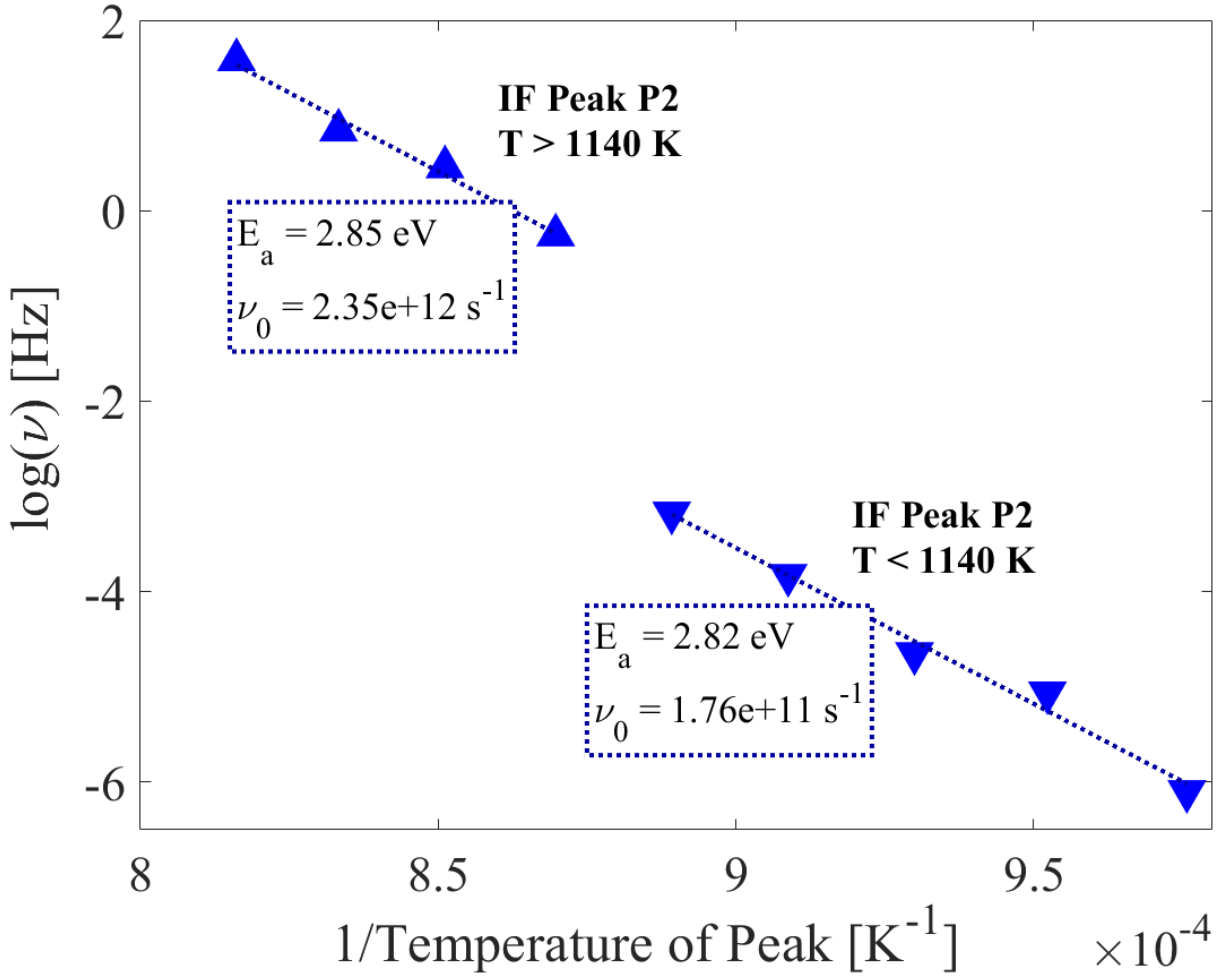
The fits in the Arrhenius plot give some hints.



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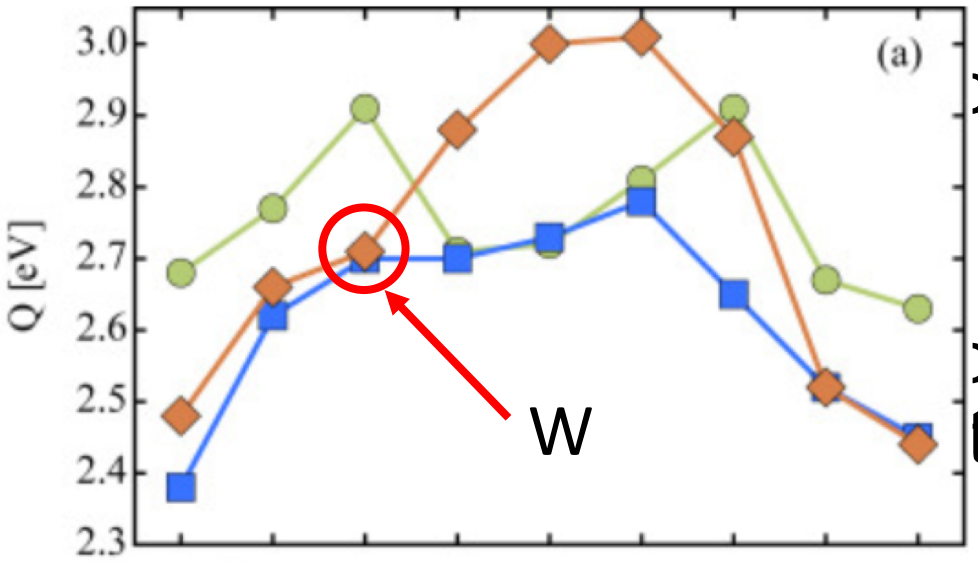
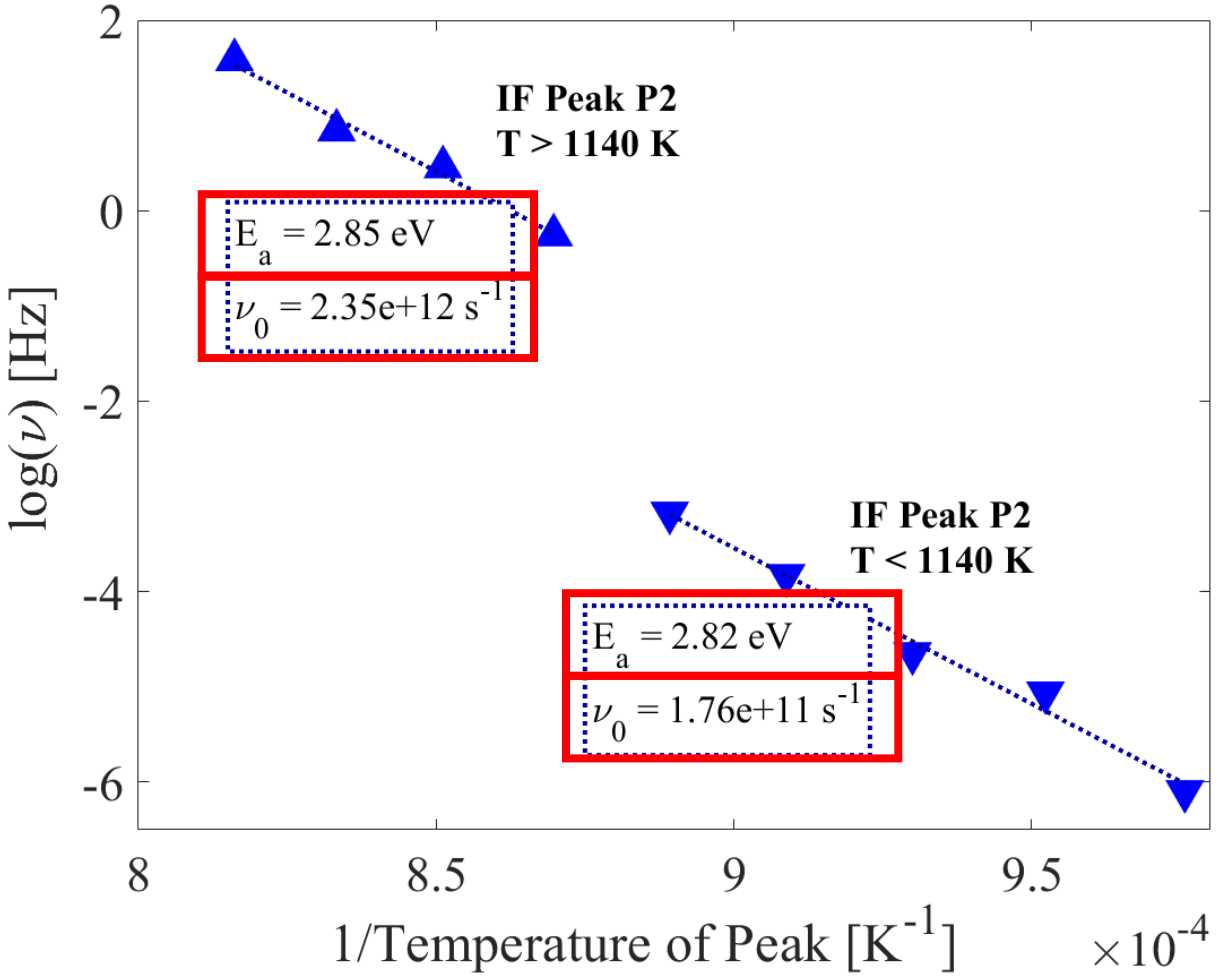


Naghavi, S. Shahab, Vinay I. Hegde, and C. Wolverton. "Diffusion coefficients of transition metals in fcc cobalt." *Acta Materialia* 132 (2017): 467-478.

The activation energy remains constant, and is equal to the one of the diffusion of W in Co.



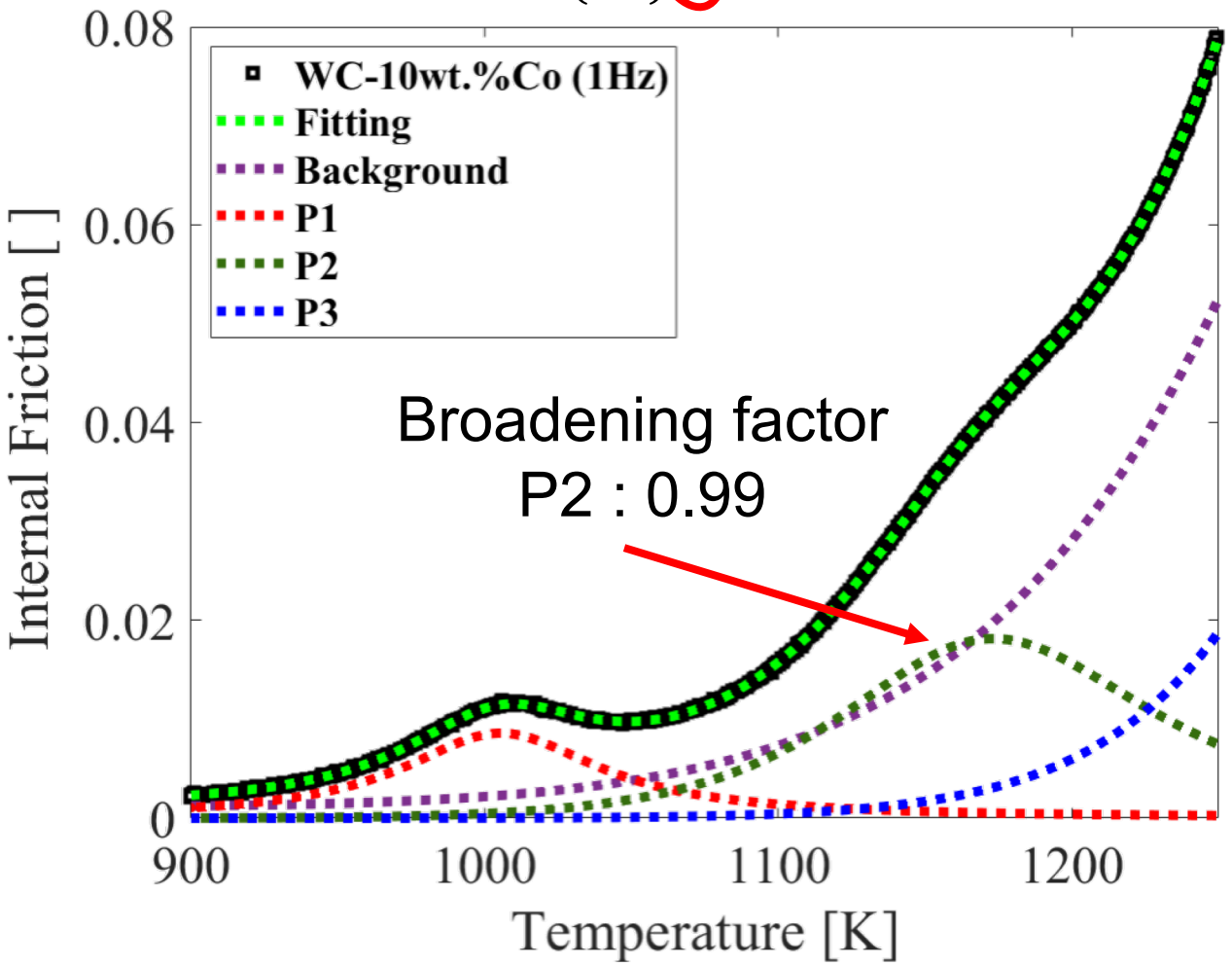
A new interpretation

$$IF = \Delta \frac{(\omega\tau)^{\alpha}}{1+(\omega\tau)^{2\alpha}}, \quad 0 < \alpha \leq 1$$

The temperature scans also give some hints.

Point defect peaks do not show broadening.

The fits do not show broadening for P2.



Temperature scans

Temperature spectra are measured between 5 mHz and 7 Hz, and between 1250 K and 900 K.

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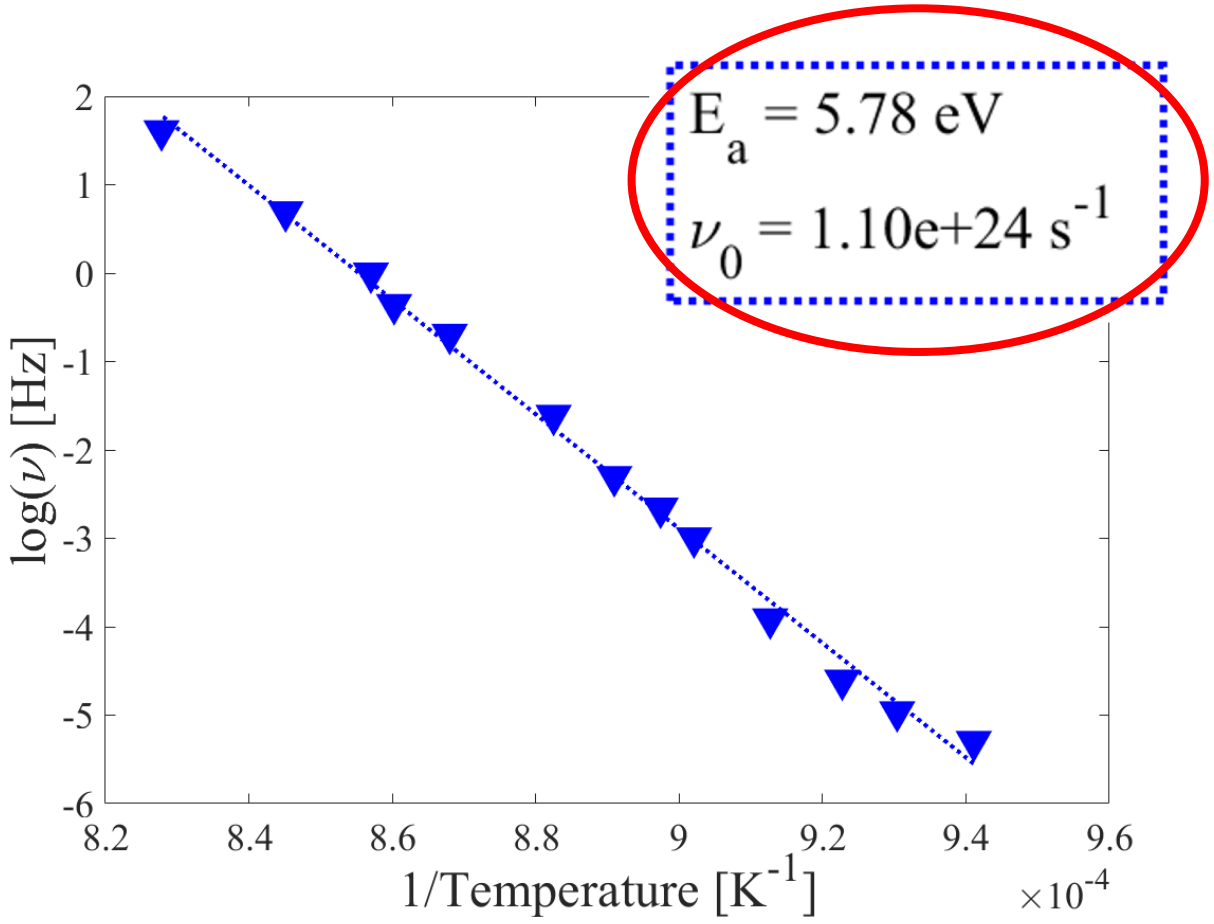
The Arrhenius plot does not reveal the shift.



Summary

- Three peaks are revealed by temperature dependent spectrum, and only two by frequency dependent spectrum.

- The Arrhenius plot of P2 with frequency scans shows a shift at 1140 K. This shift occurs in correspondence with the ferro-para magnetic transition of Co.

- Two possible interpretations of P2 are deduced.

Thank you for you attention