

Solubility of Metals in Semiconductors: Insights from Iron Silicide System

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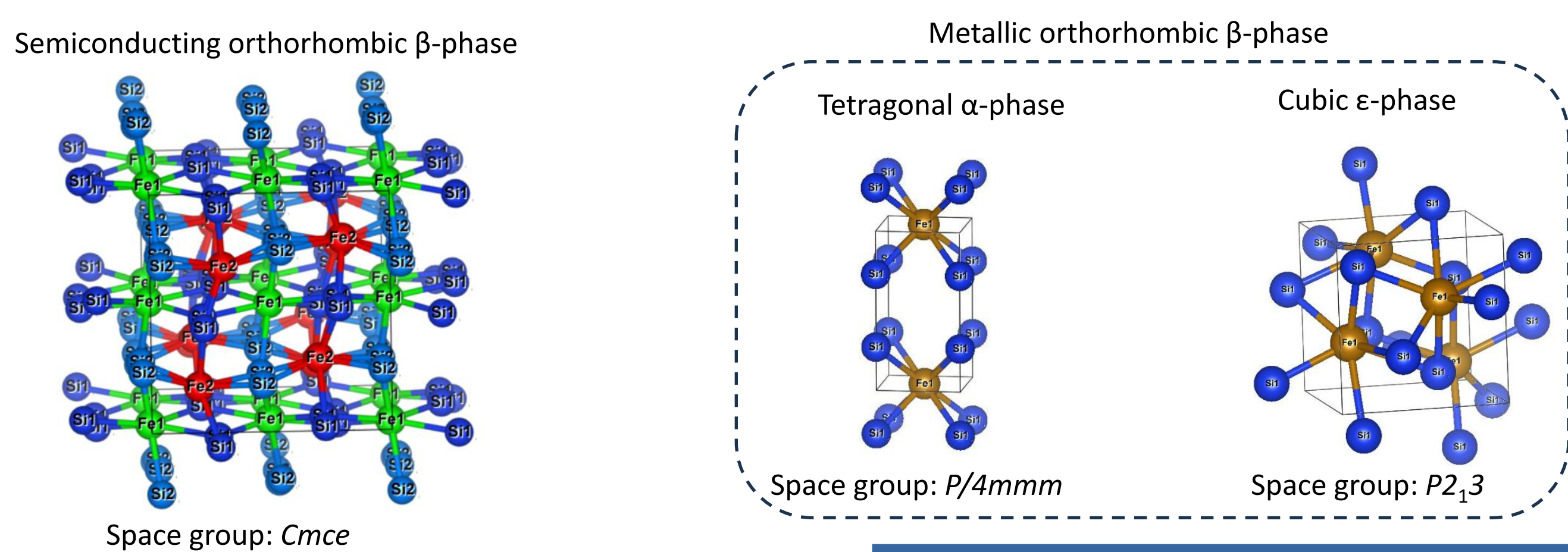
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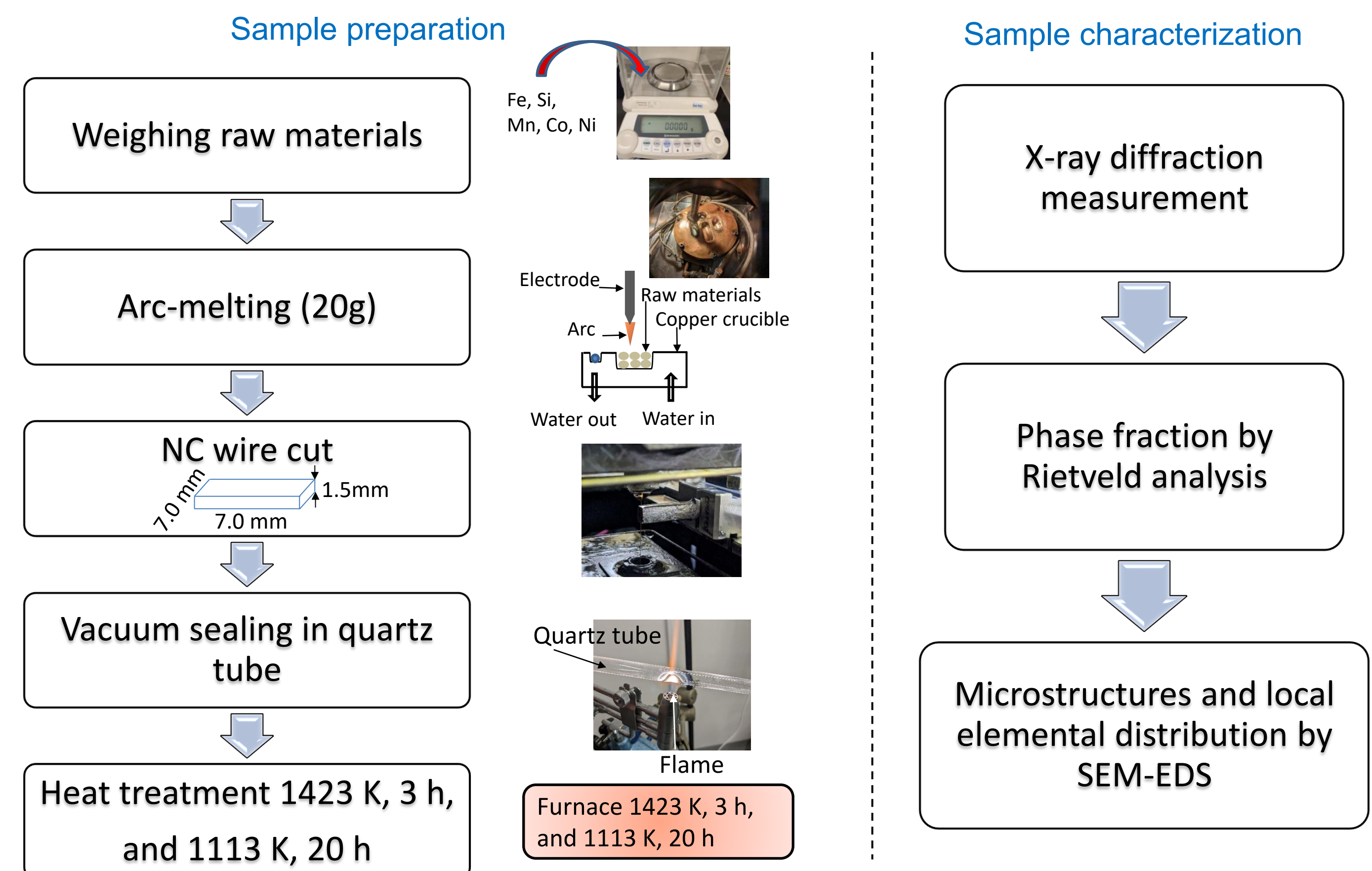
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INTRODUCTION & AIM

- The transport properties of the semiconductor, iron silicide (β -FeSi₂), can be improved by metal doping [1].
- Excessive doping leads to the formation of secondary metallic phases and deteriorates transport properties [2].
- Understanding dopant solubility in β -FeSi₂ semiconductor is important.
- This study aims to investigate the solubility of some metal dopants, including Co, Ni, and Mn, in the β -FeSi₂ semiconductor.

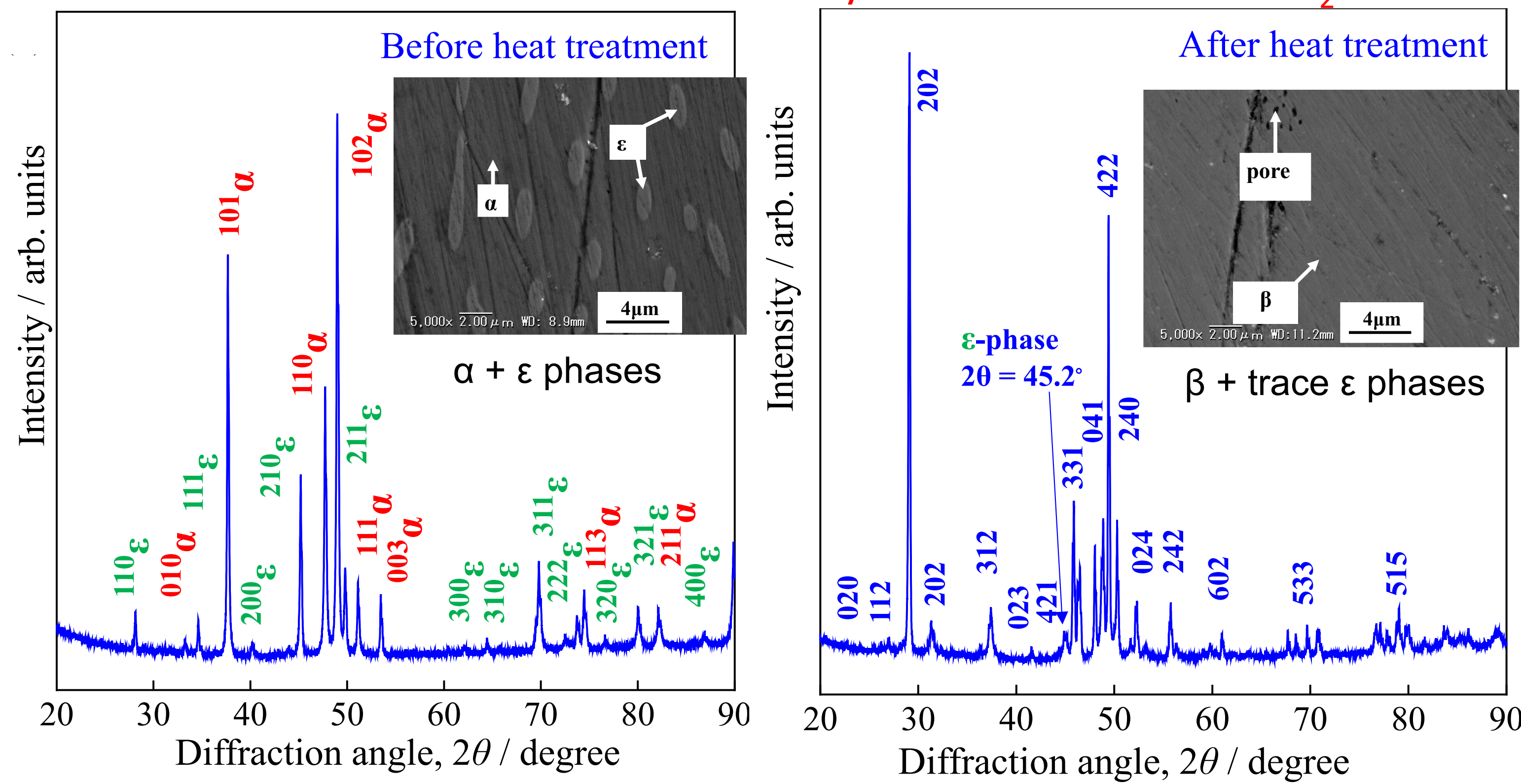


METHOD

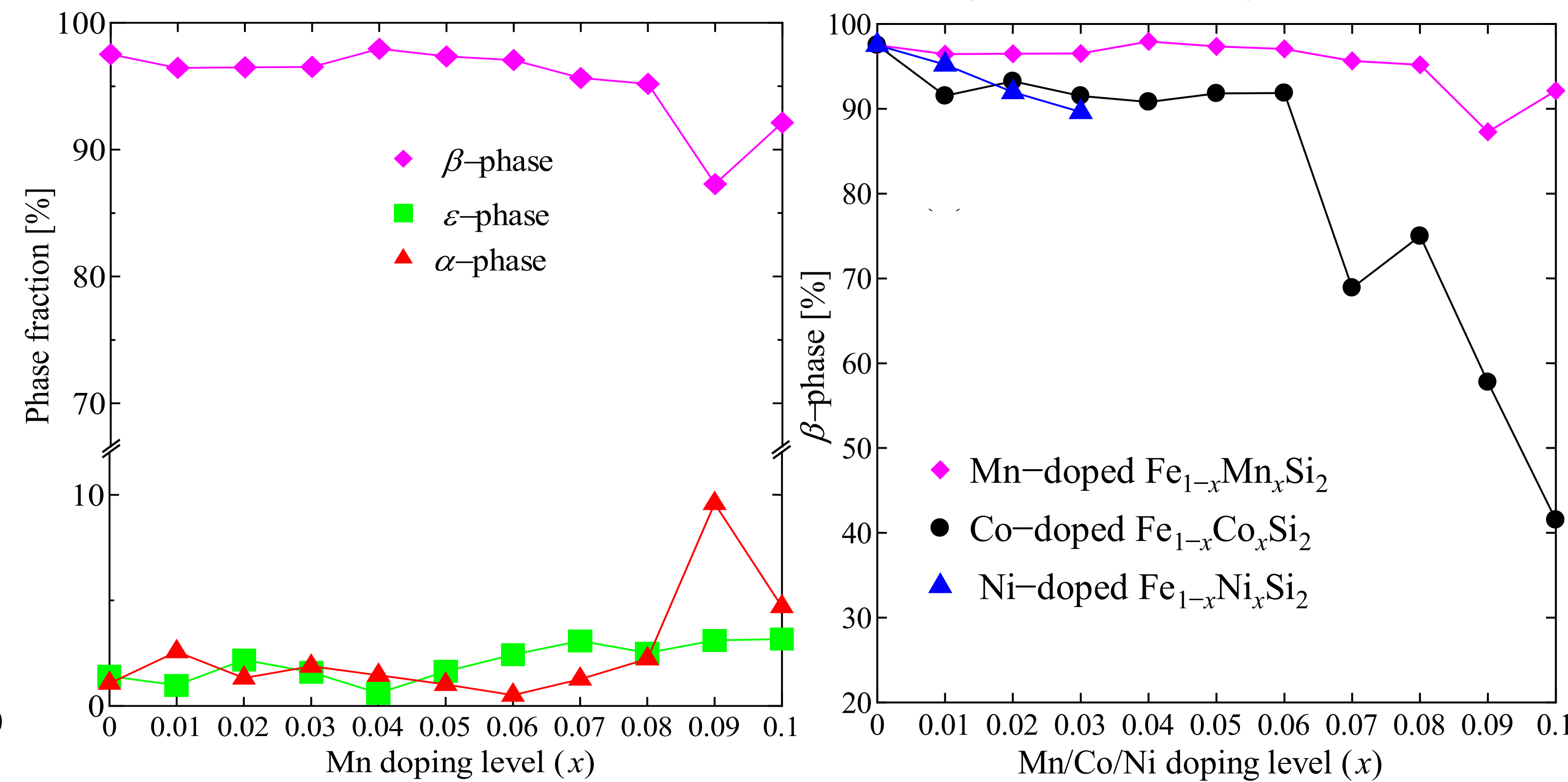


RESULTS & DISCUSSION

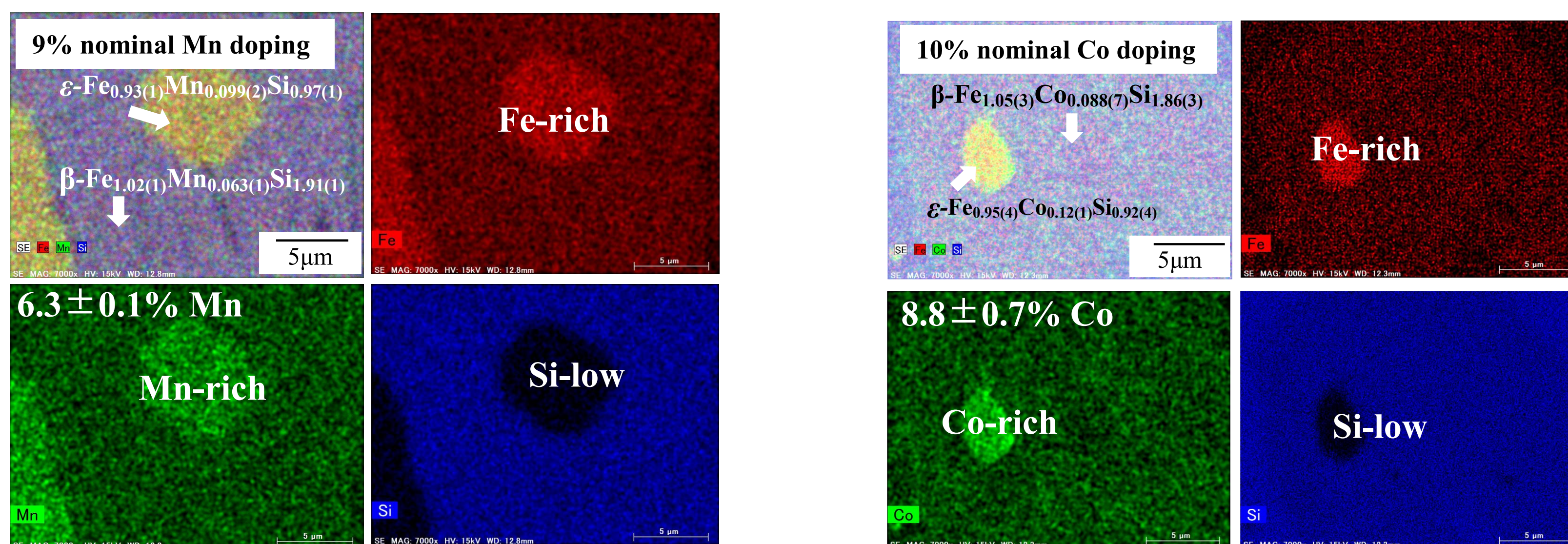
Phase transformation by heat treatment for FeSi₂



Phase constituent by Rietveld analysis



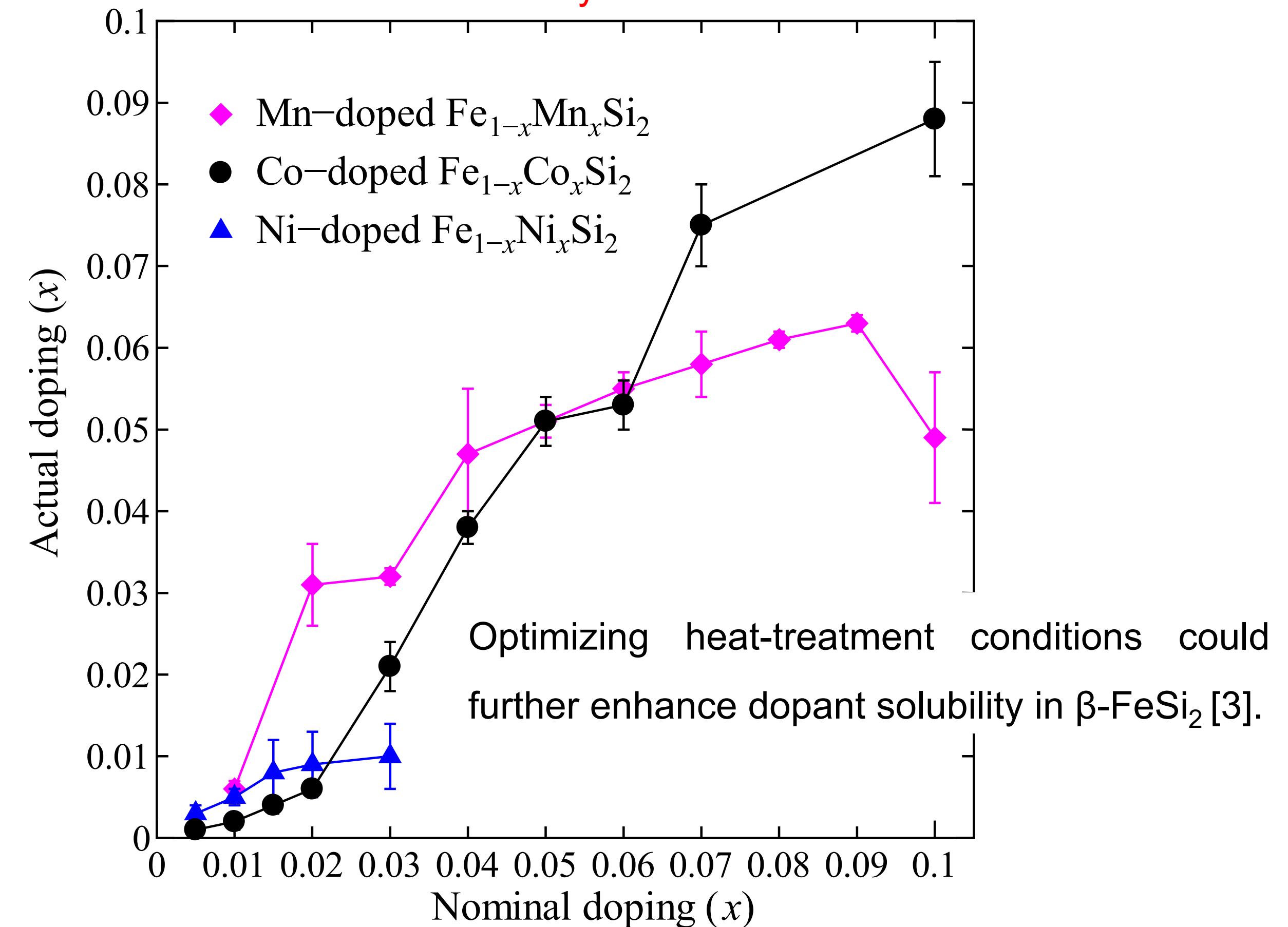
Local elemental distribution analysis by SEM-EDS



Although the nominal Mn doping concentration is 9%, the actual Mn content is only $6.3 \pm 0.1\%$. This result suggests that the solid solubility limit of Mn in β -FeSi₂ is approximately $6.3 \pm 0.1\%$.

The nominal Co doping 10%, but the actual Co doping is only $8.8 \pm 0.7\%$. This result indicates that the solid solubility limit of Co in β -FeSi₂ is approximately $8.8 \pm 0.7\%$.

Local solubility limits



Optimizing heat-treatment conditions could further enhance dopant solubility in β -FeSi₂ [3].

CONCLUSIONS

- β -FeSi₂ remained the dominant phase (>95%) up to Mn doping of $x = 0.08$.
- Solid-solution limits were determined as $6.3 \pm 0.1\%$ for Mn and $8.8 \pm 0.7\%$ for Co, both higher than that of Ni.
- Local solubility saturation occurred before loss of β -phase dominance, particularly in the Mn-doped system.
- Combining bulk and local analyses provides a reliable method for optimizing dopant concentrations in thermoelectric β -FeSi₂.

ACKNOWLEDGMENT/REFERENCES

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