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Spark Plasma Sintering of Soft magnetic Materials

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Motivation:

Study the effect of mechanical alloying (MA) and spark plasma sintering (SPS) processing parameters on microstructure, phase formation and microhardness of soft magnetic materials such as Finemet ($Fe_{73.5}Cu_1Nb_3Si_{13.5}B_9$) alloys.

Materials and Methods:

Material: $Fe_{73.5}Cu_1Nb_3Si_{13.5}B_9$

Methods:

- **Planetary Ball Mill:**

Mechanical alloying is a solid-state powder processing technique involving repeated welding, fracturing, and rewilding of powder particles in high-energy ball mill.

Speed: 350 rpm

Ball to powder ratio: 10:1 and 15: 1

- **Spark Plasma Sintering(SPS):**

Spark plasma sintering is a novel tool for processing of metals, alloys, and composites at lower temperatures and shorter processing times, as compared to conventional processing routes.

Pressure: 250 MPa

Temperature.: 550 C

Holding time: 5 min

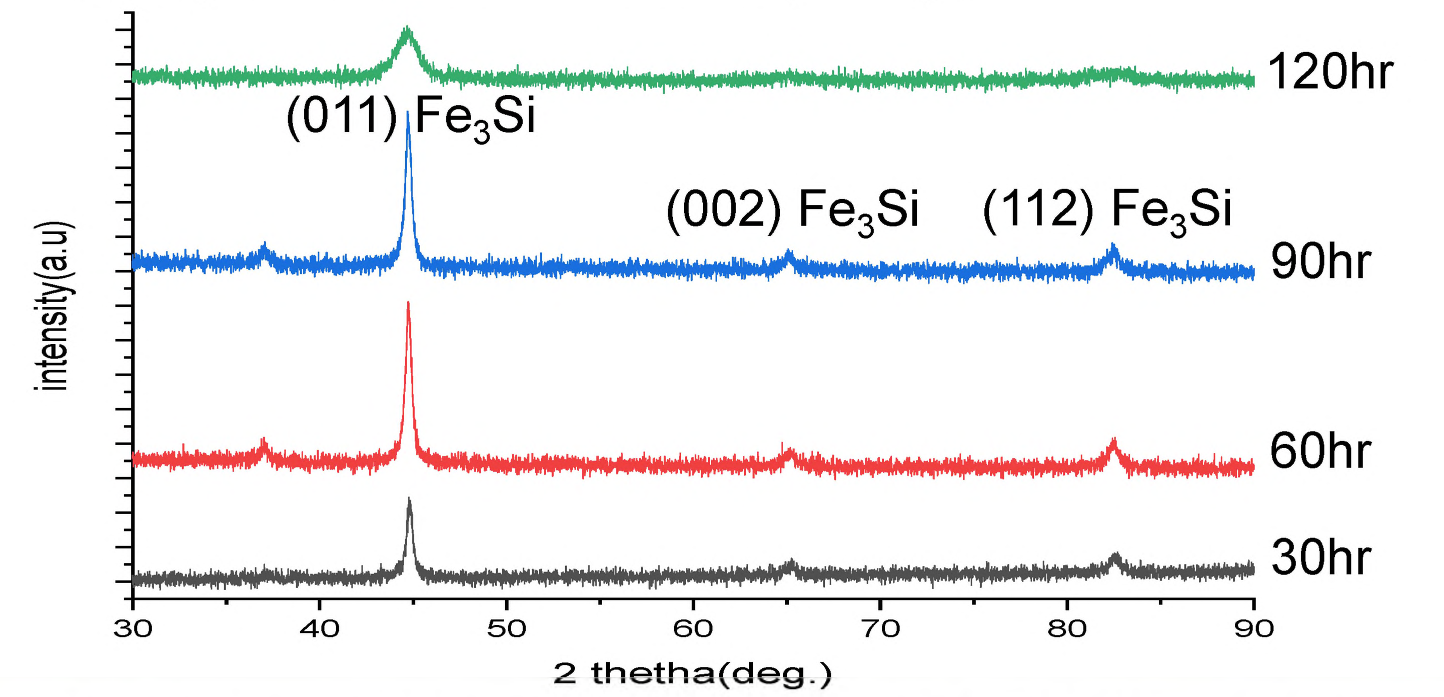
Soft Magnetic Materials:

Soft magnetic materials are essential components in many devices and are indispensable in modern electrical engineering and electronics. There has been significant progress made in the field of soft magnetic materials in recent years. Over the past 3 decades, iron-based soft magnetic alloys such as Finemet ($Fe_{73.5}Si_{13.5}B_9Nb_3Cu_1$ (at%)) have attracted great interest due to their exceptional magnetic properties like high magnetization, low coercivity, and high curie temperature.

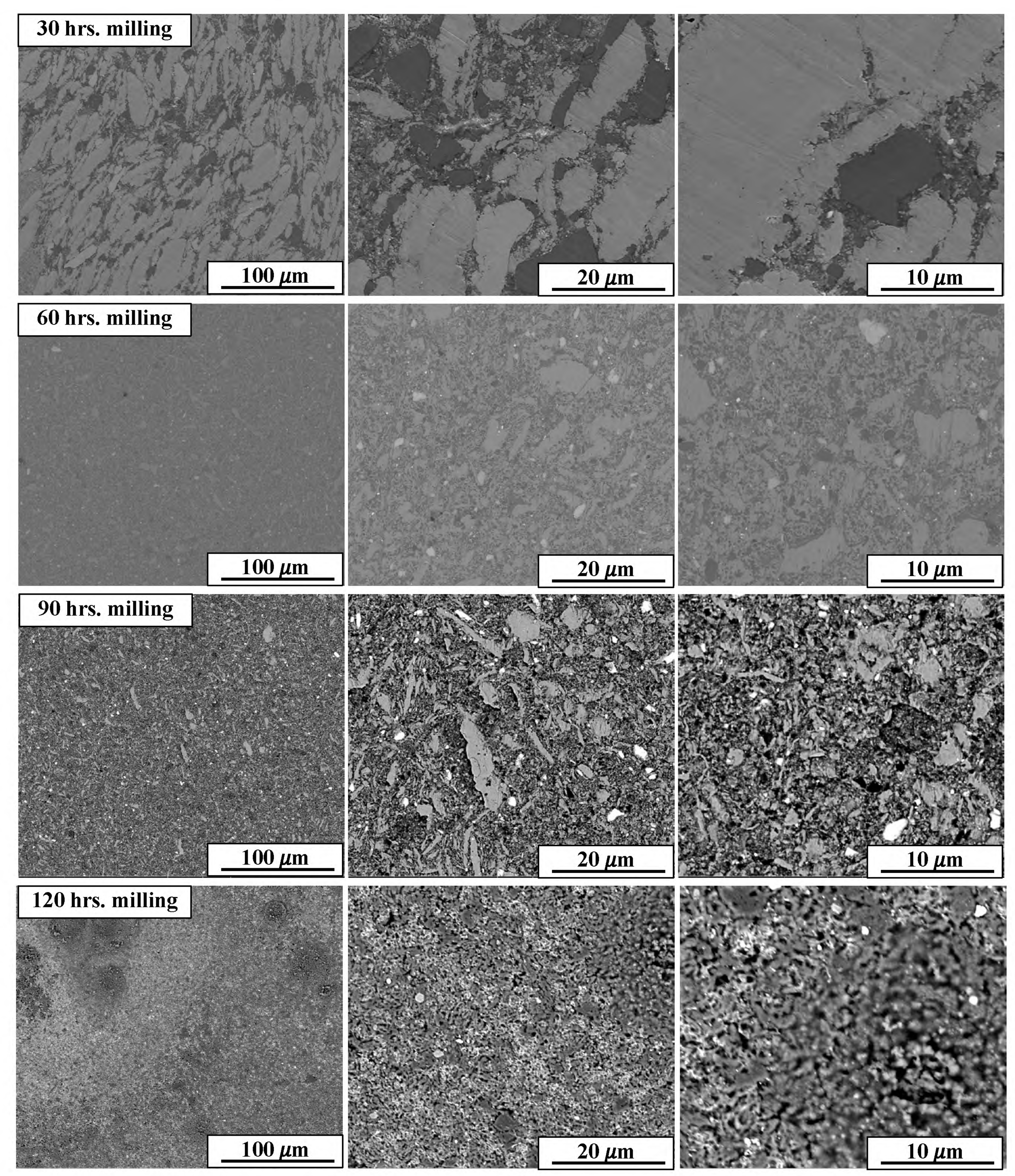
Applications of soft magnetic materials

Results and Discussion:

X-ray Diffraction Pattern (XRD):

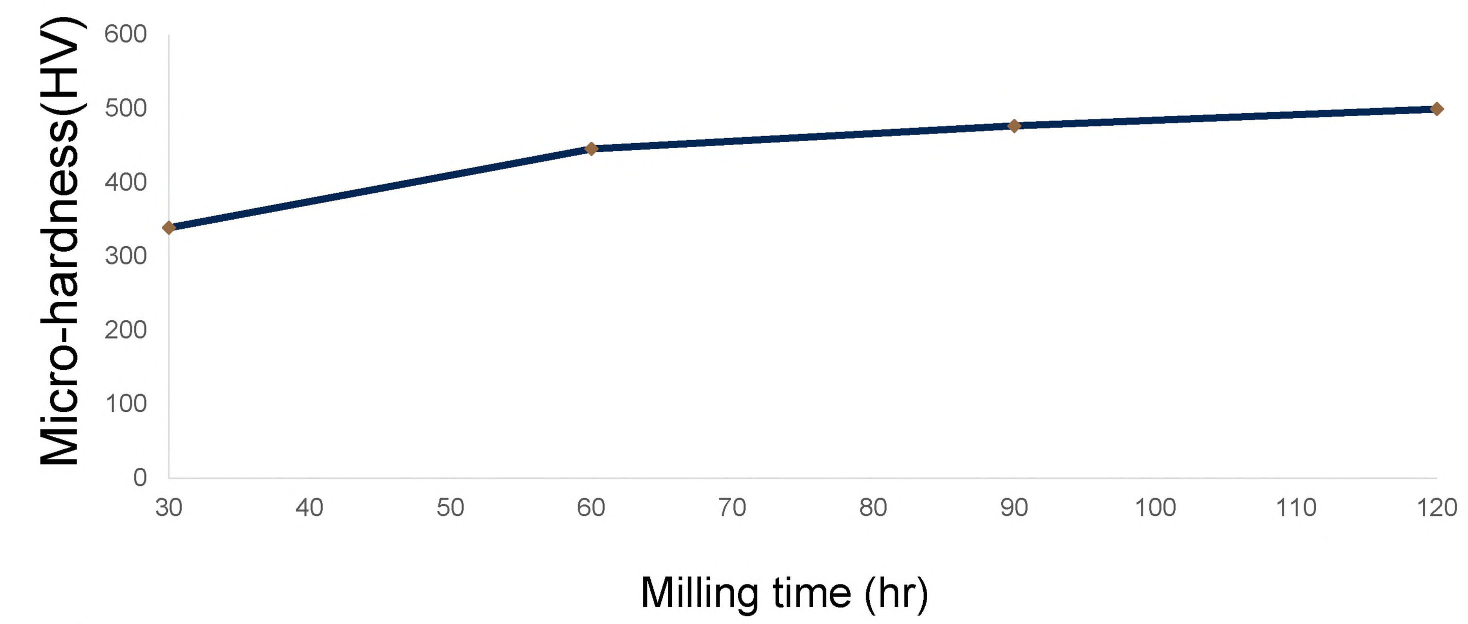


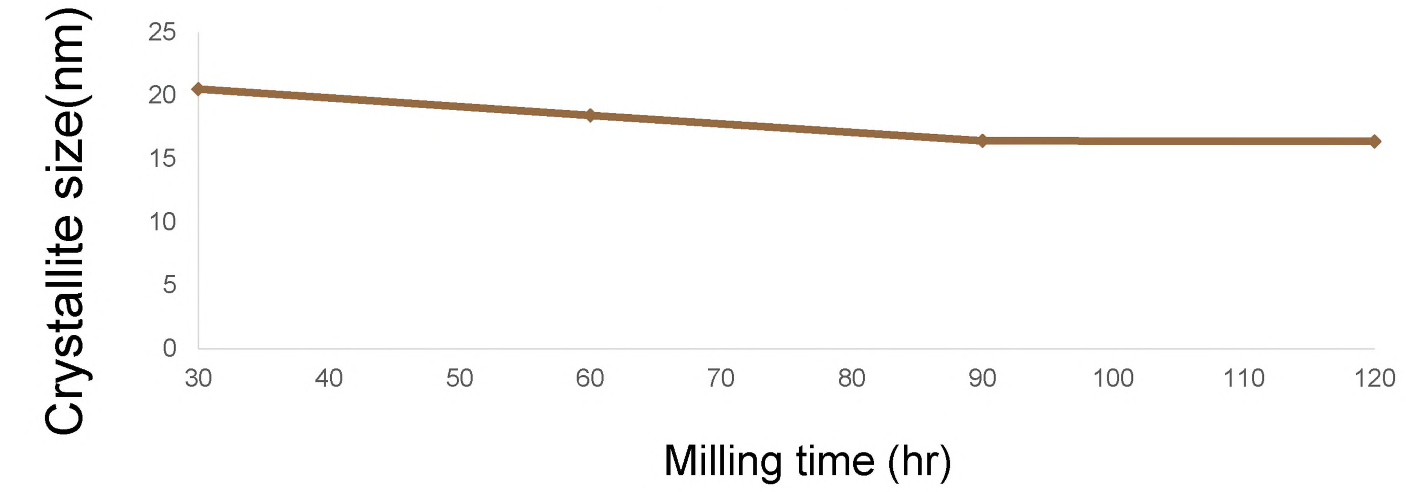
Scanning Electron Microscope (SEM) Analysis :

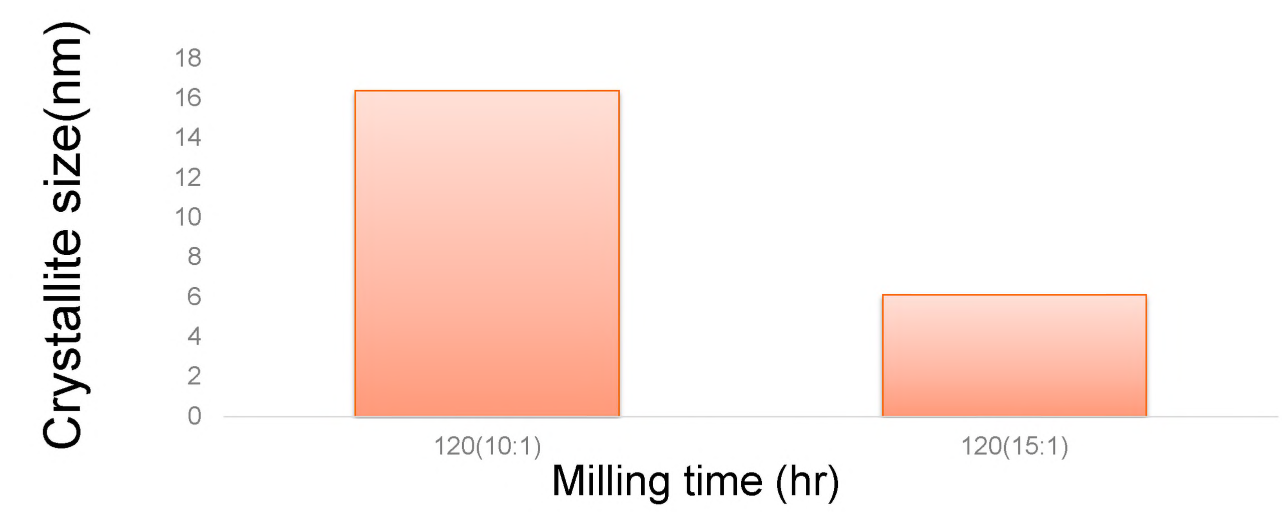


- Grain size decreases with increase in milling time , however micro-hardness increases with increase in milling time.

Micro-hardness and Crystallite Size:







Conclusions:

- X-ray Diffraction pattern (XRD) confirms the presence of α-Fe_3Si phase in Finemet alloys and also, broadening of (110) peak of Fe_3Si observed with increase in milling time which associated with decrease in crystallite size as milling time increases. .
- Scanning Electron Microscope (SEM) further shows that the grain size decreases with increase in milling time.
- Microhardness of Finemet alloys increases with increase in milling time, mainly due to decrease in crystallite size of α-Fe_3Si.
- The ball to powder ratio (BPR) has a significant effect on the microstructure of sample, for example crystallite size decreases with increase in ball to powder ratio.