Phase Evolution, Thermal Stability, Mechanical, Wear and Biocompatibility Properties of High Entropy Steels and Fe-based High Entropy Alloys

Thesis submitted in partial fulfillment for the Award of Degree

Doctor of Philosophy

By

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It is certified that the work contained in this thesis titled **"Phase Evolution, Thermal Stability, Mechanical, Wear and Biocompatibility Properties of High Entropy Steels and Fe-based High Entropy Alloys"** by **"Harsh Jain"** has been carried out under my supervision and that this work has not been submitted elsewhere for a degree.

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DECLARATION BY THE CANDIDATE

I, Harsh Jain, certify that the work embodied in this thesis is my own bonafide work and carried out by me under the joint supervision **of Dr. Ashutosh Kumar Dubey and Prof. Nilay Krishna Mukhopadhyay** for a period from **December 2017** to **December 2023**, at the **"Department of Ceramic Engineering"**, Indian Institute of Technology (BHU), Varanasi. The matter embodied in this thesis has not been submitted for the award of any other degree/diploma. I declare that I have faithfully acknowledged and given credits to the research workers wherever their works have been cited in my work in this thesis. I further declare that I have not wilfully copied any other's work, paragraphs, text, data, results, etc., reported in journals, books, magazines, reports dissertations, thesis, etc., or available at websites and have not included them in this thesis and have not cited as my own work.

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ABBREVIATIONS

BMGs	**B**ulk **M**etallic **G**lasses
HEAs	**H**igh **E**ntropy **A**lloys
HES	**H**igh **E**ntropy **S**teel
SS	**S**tainless **S**teel
MA	**M**echanical **A**lloying
MM	**M**echanical **M**illing
SPS	**S**park **P**lasma **S**intering
BCC	**B**ody **C**entred **C**ubic
FCC	**F**ace **C**entred **C**ubic
HCP	**H**exagonal **C**lose **P**acking
VEC	**V**alence **E**lectron **C**oncentration
XRD	**X**-**R**ay **D**iffraction
SEM	**S**canning **E**lectron **M**icroscopy
EDS/EDX	**E**nergy **D**ispersive **X**-ray **S**pectroscopy
SE	**S**econdary **E**lectron
BSE	**B**ack **S**cattered **E**lectron
EPMA	**E**lectron **P**robe **M**icro **A**nalyzer

DSC	**D**ifferential **S**canning **C**alorimeter
DTA	**D**ifferential **T**hermal **A**nalysis
TEM	**T**ransmission **E**lectron **M**icroscopy
PCA	**P**rocess **C**ontrol **A**gent
VAM	**V**acuum **A**rc **M**elting
VIM	**V**acuum **I**nduction **M**elting
PM	**P**owder **M**etallurgy
CALPHAD	**CAL**culation of **PHA**se **D**iagram
CoF	**C**oefficient **o**f **F**riction
ML	**M**achine **L**earning
YS	**Y**ield **S**trength

SYMBOLS

°C	**D**egree **C**entigrade
a	**L**attice **P**arameter
χ	**C**hi
ρ	**D**ensity
at %	**A**tomic **P**ercent
wt %	**W**eight **P**ercent
R	**I**deal **G**as **C**onstant
Hz	**H**ertz
χ^2	**R**educed least square