國立清華大學 107 學年度碩士班考試入學試題

系所班組別：工程與系統科學系碩士班 甲組(0526)

考試科目（代碼）：物理冶金 (2801)

1. Steven Huang is a R&D manager in charging of development of iron based super alloy turbine as blades in an electronic motor for Tasla model 3 vehicle in China Steel Co ltd. (CSC). A total number of 300k blades with Co/Ni doped steel was placed in the first order and was scheduled to deliver by the end of Feb. 2018. The size of blade is designed in 35 cm long with a cross section of 0.1 by 0.1 cm square. From a physical inspection he notices that hardness of preliminary sample is 15% below the required spec. To meet the requirement, carbon doping and rapid cooling are adopted in thermal history of his second batch. As a project manager working with Steven, please remind the possible phase transitions by adding over loading and insufficient carbon contents in such a rapidly cooled iron base steel. (1) Please describe the typical definition and reaction pathways of such a rapid cooling induced phase transition in carbon added iron (**6%**); (2) describe a typical feature of its Surface Relief by schematic representation (**6%**); (3) compare the formation rate and describe the microstructure of high carbon and low carbon content steel (**6%**); (4) describe the effects of share stress on such a phase transformation with graphical presentation and description (**6%**); (5) over loading of carbon would cause precipitation in grain boundary, please estimate a needle like precipitate shell (β phase) with a diameter and length of R and L) coated with the a shell thickness of T_S. Considering cases for the homogeneous and heterogeneous nucleation of these precipitates, please derive the free energy changes of the system when interface energies of the precipitates are denoted as γ (**14%**) (i) (for example free energy at core-shell interface is $\gamma(\alpha,\beta)$); (6) please describe the shape memory effect of such a metal in details. (**12%**)

<total grade of 50/100>

2. Figure 1 demonstrates a typical binary phase diagram of Cu-Zn alloy. (1) Please describe **all the phase transition pathways** with definition, reaction formula, and point out the reaction temperature with estimated composition (atomic composition of Zn atom). (14%) (2) please draw the microstructure of solid phase product at the end of each reaction pathways mentioned above by graphical representation and explain the reason of corresponding microstructure by thermodynamic energy theory. (15%). **To answer this question, make a copy of phase diagram in answer sheet (3%) and draw the reaction pathways by assigning symbols of a, b, c, ... etc. Each of reaction formula should be written following the assigned symbol (12%).**

<total grade of 79/100>

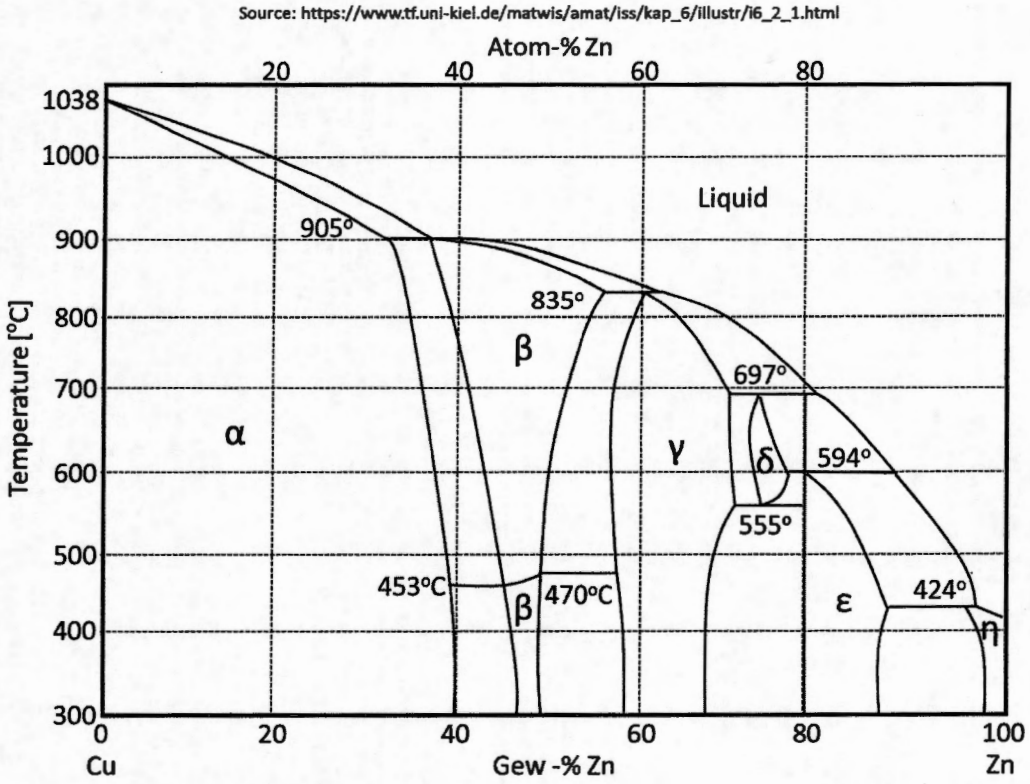

Figure 1 Typical Cu-Zn phase diagram

3. Considering that you are working at tsmc RD diffusion to improve the dopant concentration in SiP epitaxy thin film by ion implantation. Please address the structural parameters of dopant to be concerned in evaluating the possibility of dopant solubility level in this thin film. (6%)

<total grade of 85/100>

4. **(4a)** Please describe the 4 typical types of phase transition cooling reactions (4%).

(4b) draw the equilibrium cooling curve and microstructure evolution of path a and path b in following phase diagram and **explain the mechanisms (reason) for the differences of crystal structure formation in these two paths** (8%)

(4c) estimate the composition of solid phase in pathways a and b at assigned phase points 1, 2, 3 (3%)

<total grade of 100/100>